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Age and IQ as Potential Moderators in the Relation Among Endopheonotypes and Expressed Behaviors in Children With Autism Spectrum Disorder

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AGE AND IQ AS POTENTIAL MODERATORS IN THE RELATION AMONG ENDOPHENOTYPES AND EXPRESSED BEHAVIORS IN CHILDREN WITH AUTISM SPECTRUM DISORDER

by

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ABSTRACT

AGE AND IQ AS POTENTIAL MODERATORS IN THE RELATION AMONG ENDOPHENOTYPES AND EXPRESSED BEHAVIORS IN CHILDREN WITH AUTISM SPECTRUM DISORDER

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The current study examined how certain endophenotypes (i.e., local processing ability, mental flexibility, planning, and disinhibition /inhibition) are related to specific expressed behaviors (i.e., acting out behaviors, social insight deficits, social contact problems, anxious/rigid behaviors, and stereotypical behaviors) that are commonly found in children with ASD. In addition, this study examined whether these associations are modified by age or IQ. Participants consisted of 29 children (ages 7 to 16 years) with ASD and their parents. Parents completed the Children's Social Behavior Questionnaire (CSBQ) to assess their child's variety of expressed behaviors. The children were given the Kaufman Brief Intelligence Test—Second Edition to assess IQ, an Embedded Figures Test to assess local processing ability, the Wisconsin Card Sorting Task to assess mental flexibility, the Tower of London task to assess planning ability, and a Go/No Go task to assess disinhibition/inhibition. It was expected that local processing ability would be positively related with social contact problems, social insight problems, anxious/rigid behaviors, and stereotypical behaviors. Mental flexibility was expected to be negatively related with social contact problems, social insight problems, anxious/rigid behaviors, and stereotypical behaviors. Planning abilities were expected to be negatively related with acting out behaviors and social insight problems. Disinhibition was expected to be

positively related with acting out behaviors, and inhibition was expected to be positively related with anxious/rigid behaviors. Also, it was expected that age and IQ would moderate the relations between endophenotypes and expressed behaviors such that older age and higher IQ will attenuate the relations. However, these predictions were unsupported, potentially largely due to a small sample size leading to low power. Limitations of the study and suggestions for further research to better understand underlying factors that relate to these expressed behaviors are discussed.

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CHAPTER I

INTRODUCTION

All children diagnosed with autism spectrum disorder (ASD) exhibit social communication difficulties that include problems with social-emotional reciprocity, nonverbal communication, and social relationships. In addition, these children exhibit restricted interests or repetitive behaviors that may be characterized by stereotyped speech, obsessions, adherence to routines, and sensory sensitivities (American Psychiatric Association, 2013). Despite these commonalities, the specific constellation of symptoms and the degree to which these symptoms are expressed often vary from child to child (American Psychiatric Association, 2013). In addition, children with ASD often differ from each other with respect to other behaviors. For example, some children with ASD are completely nonverbal, whereas others are very verbose; some are preoccupied with certain obsessions, whereas others constantly engage in stereotypies; some have externalizing problems, whereas others struggle with internalizing difficulties, and so on (Mash & Barkley, 2003). Only recently has research turned toward understanding the underlying factors that elicit this variety of behaviors in children with ASD, and examining potential endophenotypes of autism is a primary way that researchers have begun to explore this issue (Hill & Frith, 2003; Viding & Blakemore, 2007). The current study aimed to contribute to this literature by investigating neurocognitive constructs that appear to be associated with various outward behaviors in children with ASD. In addition, the current study examined age and IQ as potential moderators in these associations.

What are Endophenotypes?

An endophenotype can be thought of as a "pre-behavioral phenotype" (Viding & Blakemore, 2007) that helps explain the link between genes and expressed phenotypes like outward behaviors. In many developmental disorders such as ASD, specific genes do not directly "cause" outward symptoms. Rather, these genes interact with environmental factors to create specific outward symptoms. Studying endophenotypes—the link between the genes and the outward symptoms—could prove invaluable in better understanding what causes the symptoms of ASD to emerge and how to best treat the disorder.

Endophenotypes can include "neurophysiological, biochemical, endorcrinological, neuroanatomical, and cognitive processes" (Viding & Blakemore, 2007, p. 52). Viding and Blakemore outlined guidelines that should be used when determining whether a process can be considered to be an endophenotype. These criteria include reliability (it should consistently be shown to be a marker for a phenotype), heritability (it should provide evidence of a genetic basis), and association with a particular behavior (it should provide evidence of a phenotypic association). For these reasons, research has suggested, as outlined below, that cognitive processing style and executive functioning may be two primary endophenotypes of ASD. Thus, these constructs are the focus of the current study.

Local Processing Ability Present in Individuals with ASD

Various research studies have provided evidence that individuals with ASD exhibit a unique cognitive processing style, often referred to as a local processing ability (Bonnel et al., 2003; Joliffe & Baron-Cohen, 1997; Hill & Frith, 2003; Mottron, Peretz,

& Menard, 2000; Shah & Frith, 1993). Individuals with ASD pay great attention to detail and are easily able to mentally segment a design into its parts. Rather than focusing on the whole or the gestalt, these individuals focus on particular aspects of a visual design. In the laboratory, this ability is primarily assessed through an Embedded Figures Test (EFT) or a Block Design Task (BDT). An EFT requires participants to find a particular shape or design embedded within a more complex figure, and the BDT requires participants to mentally segment a cohesive design and then replicate the design using blocks. Some researchers characterize individuals who perform well on these tasks as individuals with weak central coherence (having superior abilities in local processing at the expense of global processing; Happe & Frith, 2006). However, characterizing these individuals as superior local processors is likely more accurate, because some studies suggest that individuals with ASD can still exhibit intact global processing abilities when they are specifically told to use a global processing approach (Happe & Frith, 2006; Mottron et al., 2000). Nonetheless, these individuals appear to have a "default" local processing style and tend to have superior abilities compared to the general population in this area.

Executive Functioning Deficits Present in Individuals with ASD

Research studies have provided evidence that individuals with ASD show deficits in executive functioning (Hill, 2004; Hill & Frith, 2003; Hughes, Russell, & Robbins, 1994; Mash & Barkley, 2003; Pennington & Ozonoff, 1996). Executive functioning refers to "cognitive functions thought to involve the ability to maintain an appropriate problem-solving set to attain a future goal. These functions include planning, impulse control, inhibition of irrelevant responses, and working memory" (Mash & Barkley,

2003, p. 431). Many of these abilities are impaired in individuals with ASD. In particular, individuals with ASD show deficits in planning—which refers to monitoring and re-evaluating a sequence of planned steps (Hill, 2004; Mash & Barkley, 2003), mental flexibility—which refers to shifting behaviors or thoughts when new approaches are needed (Hill, 2004, Mash & Barkley, 2003; Pennington & Ozonoff, 1996), and inhibition—which refers to inhibiting prepotent responses (Hill, 2004).

Various laboratory tests are used to assess these executive functions among various community and clinical populations, including children with ASD (as described below). Planning is often assessed through the Tower of London task which requires participants to strategically move beads on pegs to copy a target design (e.g., Hill, 2004). Mental flexibility is often assessed through the Wisconsin Card Sorting Task (WCST) which requires participants to figure out what sorting strategy should be employed at certain points in the game and recognize when they need to change and adapt their strategy (e.g., South et al., 2007). A lack of such flexibility and adaptation is exhibited through perseverative responses (i.e., continuing to use a response rule that was previously accurate despite feedback that this response rule is no longer accurate). Inhibition is often assessed through a Go/No Go task which requires participants to only respond on certain trials and inhibit their responding on other trials (e.g., Hill, 2004). It is important to note that the Stroop test, another common test of inhibition, often does not show the same results as the Go/No Go task with respect to individuals with ASD. Rather, measured inhibition according to this task appears to be unimpaired in these individuals (Hill, 2004). In fact, a study comparing Stroop-type tests and Go/No Go-type tests in typically-developing children noted that performance on the two tests were very

weakly correlated, suggesting that these tests assess different types of inhibition (Morooka et al., 2012). Therefore, the studies reviewed from the literature with respect to inhibition are studies examining variations of Go/No Go tasks to assess inhibition.

Heritability of Local Processing Bias and Executive Functioning Deficits

Evidence for the heritability of both a local processing bias and executive functioning deficits in individuals with ASD is necessary for these constructs to be considered endophenotypes. Evidence for the heritability of a local processing bias can be found in research conducted by Baron-Cohen and Hammer (1997), who tested parents of children with ASD. These parents performed much faster than parents of typically developing children on an EFT. Similar results were found in a study conducted by Bolte and Poustka (2006) in which parents of children with ASD performed faster on an EFT (albeit not a BDT) than parents of children with schizophrenia and children with mental retardation. However, this study did not reveal differences in executive functioning tasks for the parents of children with autism when compared to the other parents. Unfortunately, this latter finding is contrary to what would be expected if executive functioning were an endophenotype.

Nonetheless, other research provides evidence for the heritability of executive functioning deficits in family members of individuals with ASD. In a study conducted by Hughes (1999), siblings of individuals with ASD, as opposed to siblings of typically-developing individuals or individuals with other developmental delays, performed more poorly on executive functioning tasks. In addition, in another study conducted by Hughes (1997), parents of children with ASD performed worse on executive functioning tasks such as mental flexibility and planning than parents of typically-developing

children. Thus, there is support for the theory that executive functioning deficits among children with ASD are at least partially due to heritability factors.

In summary, the literature shows support for the heritability of a local processing bias and executive functioning deficits in children with ASD; to be considered true endophenotypes, they also must show a phenotypic association. In other words, they must be associated with expressed symptoms or behaviors. However, there are many inconsistencies in research studies examining a link between these endophenotypes and expressed behaviors among children with ASD. Because of these inconsistencies, it is likely that there may be potential moderators (such as age and IQ) influencing these relations.

Local Processing Bias and its ASD Phenotypic Associations

Many researchers have theorized that the presence of a local processing bias is associated with restrictive interests, repetitive behaviors, and/or obsessions with parts of objects (Belmonte et al., 2004; Hill & Frith, 2003). In a research study examining children and adolescents with ASD, Chen, Rodgers, and McConachie (2009) found that mean completion time on an EFT was associated with the total number of "compulsive-like behaviors" (p. 737) in which these children engaged. In other words, participants with ASD who exhibited superior local processing abilities also tended to exhibit significantly more repetitive behaviors in their daily lives. However, in a study conducted by South, Oxonoff, and McMahon (2007), this association was not found. In their study, children and adolescents with and without ASD completed various measures including an EFT. Their repetitive behaviors and circumscribed interests were measured

with two parent-report measures. No significant association was found between performance on an EFT and repetitive behaviors for either group.

The results from these two studies clearly conflict with each other, and a possible explanation for these conflicting findings may be related to IQ differences. Participants in the Chen et al. (2009) study were required to have an IQ of at least 70 to participate, whereas participants in the South et al. (2007) study all had an IQ of at least 90. Therefore, the Chen et al. study, which found a significant association, may have consisted of more participants with lower IQs than the participants in the South et al. study (although without the IQ distribution of the samples, this conclusion cannot be drawn directly). It is possible that a local processing bias is associated with repetitive behaviors in individuals with lower IQs but not in individuals with higher IQs. The current study will address this question by studying individuals with ASD with a broad range of intellectual functioning and examining IQ as a moderator in the relation between endophenotypes and expressed behaviors.

Other researchers have theorized that the presence of a local processing bias may be associated with difficulties in social situations. It is thought that because these individuals tend to focus on parts rather than the whole, they may have difficulties in social situations when they need to understand the "gist" of an entire social scenario and generalize things they have learned from one social situation to the next (Mash & Barkley, 2003). In addition, other researchers suggest that this focus on parts rather than context may lead to problems in understanding others' mental states, thereby negatively impacting the development of joint attention and later social abilities (Bellmonte et al.,

2004). However, the lack of controlled research studies examining these relations reveals a need for further research in this area.

Executive Functioning Deficits and their ASD Phenotypic Associations

Just as research linking the presence of a local processing bias to behavioral symptoms of ASD is inconclusive, research linking executive functioning deficits to expressed behaviors is also inconclusive. Some research studies report a link between deficits in mental flexibility and the presence of restrictive and repetitive behaviors. It is thought that an inflexible cognitive style may be related to inflexible behavior patterns. A study conducted by Lopez, Lincoln, and Ozonoff (2005) found that deficits in mental flexibility (as assessed by the WCST and the California Trails Test) were a unique and significant predictor of restricted, repetitive behaviors [as assessed by a composite measure including the Autism Diagnostic Observation Scale-Generic (ADOS-G), Autism Diagnostic Interview-Revised (ADI-R), Gilliam Autism Rating Scale (GARS), and Aberrant Behavior Checklist – Community (ABC-C)] in adults with ASD. Additionally, a study conducted by Yerys et al. (2009) found a positive association between errors in one of the phases of a set-shifting measure and the presence of repetitive behaviors (as assessed by the ADI-ADI/R) in children with ASD. Taken together, these findings suggest that individuals' tendency to perseverate on laboratory tasks may be related to their tendency to engage in repetitive behaviors in everyday life.

However, a previously mentioned research study conducted by South et al. (2007) revealed a less impressive association between mental flexibility and repetitive behaviors. In this study, the individuals with ASD did exhibit a positive association between perseverations on the WCST and repetitive behaviors as measured by the ADOS and

ADI-R, but there was no significant association between WCST performance and other repetitive behavior variables (the DSM-IV linked repetitive behavior categories from the Repetitive Behavior Interview or the circumscribed interests category of the Yale Special Interests Interview). In addition, effect sizes were very low for all correlation coefficients (less than .20). These results reveal a possibly weaker finding than the studies mentioned previously. Because of the discrepancy in research findings, more research in this area, including an examination of possible mitigating factors, is warranted. No IQ or age differences among participants were necessarily apparent as being related to the differences in findings, but it is possible that these factors may be impacting the different results.

Deficits in mental flexibility have also been linked to poor performance on Theory of Mind (ToM) tests. Because ToM tests measure an individual's ability to infer others' mental states and therefore predict their behavior, performing poorly on these tests suggests a difficulty in relating to others or in performing well in social situations (Baron-Cohen et al., 1985). In a study conducted by Pellicano (2007), researchers tested children with ASD on both the WCST and ToM test and found that their performance on both tests were correlated. Therefore, deficits in mental flexibility appear to be linked to deficits in understanding others' mental states. In addition, Pellicano's study also revealed that whereas it was possible in some cases for participants to have impaired ToM and intact executive functioning, no participants had intact ToM and impaired executive functioning. This set of findings provides evidence that the directionality of the relation appears to be that impairments in executive functioning cause impairments in ToM. A study by Fisher and Happe (2005) trained children with ASD on a modified

version of the WCST and another test tapping mental flexibility. After being trained on mental flexibility, individuals showed better performance on ToM tasks. Taken together, these studies suggest that possessing mental flexibility is an essential component of understanding others. It therefore appears likely that some of the social deficits found in individuals with ASD may be rooted in mental flexibility deficits.

However, the theory that mental flexibility deficits would be associated with social deficits has not been uniformly supported. For example, a previously mentioned research study conducted by Yerys et al. (2009) examined whether there was in fact an association between deficits in mental flexibility and real-life social deficits. This study did not find a correlation between performance on a set-shifting measure and social or communication ASD symptoms. As this finding stands in contrast to what is theorized, more research in this area is needed to determine if deficits in mental flexibility are truly associated with social difficulties, and if so, under what conditions this association exists.

As previously discussed, deficits in planning are often seen in individuals with ASD. However, previous research has not linked this deficit to specific ASD symptoms. In the earlier mentioned study conducted by Lopez et al. (2005), no association between planning ability and repetitive interests was found. A study conducted by Kenworthy, Black, Harrison, Della Rosa, and Wallace (2009) found no association between planning ability and general ASD social symptoms. However, based on theory, it seems likely that planning abilities may be related to specific social insight problems, as planning abilities are needed to understand and think about how to interact well with others. Therefore, it is possible that planning difficulties may be related to this specific ASD difficulty, even if they are not related to overall social difficulties.

Although deficits in inhibition (as measured by Go/No Go tasks) are associated with an ASD diagnosis, research has not provided evidence to link these deficits to a specific ASD symptom. The Kenworthy et al. study (2009) found that deficits in inhibition were related to increased repetitive behaviors in children with ASD, but this relation was no longer significant when the children's age was taken into account. It appears as if repetitive behaviors are linked to age (in that they tend to decrease with age), but repetitive behaviors are not uniquely linked to inhibition difficulties.

Executive Functioning Deficits and their Generalized Phenotypic Associations

As mentioned earlier, one of the goals underlying this study is to help understand what predicts the heterogeneity of expressed behaviors in an ASD diagnosis. Consequently, it is relevant not only to examine the relation between endophenotypes and particular ASD symptoms, but also to examine the relation between endophenotypes and other behaviors that are commonly exhibited by individuals with ASD. For example, some individuals with ASD exhibit externalizing behaviors, whereas others exhibit internalizing problems. What endophenotypes predict these specific behaviors in children with ASD? Although previous research has not answered this question in an ASD sample, previous research has explored underlying executive functioning factors that are associated with externalizing and internalizing behaviors in other children.

Numerous studies have examined the relation between executive functioning and externalizing behavior problems, such as aggression, in children. For example, a study conducted by Ellis, Weiss, and Lochman (2009) found that, in boys, deficits in planning are related to reactive aggression, and this association is mediated by inhibition (albeit as assessed by a Stroop task—therefore, not the same type of inhibition that the current

study assesses). It is unknown, however, if this relation between planning deficits and acting out behaviors holds for children with ASD.

Raaijamakers et al. (2008) studied aggressive preschoolers and found that these children exhibited deficits in inhibition (partially assessed by a Go/No Go task—the type of inhibition found deficit in children with ASD). Specifically, they had more errors of commission (pressing a button when they were not instructed to do so), suggesting that higher levels of disinhibition are linked to aggressive behaviors. Other studies have linked deficits in inhibiting responses to hyperactive behaviors, conduct problems (Berlin & Bohlin, 2002), and externalizing behaviors (Kooijmans, Scheres, & Oosterlaan, 2000) in typically-developing children. Therefore, it seems fairly clear that disinhibition is linked to acting out behaviors in typically-developing children and in aggressive children, but it is unknown whether this association will also occur for children with ASD.

The relation between executive functioning and internalizing problems was studied in typically-developing children by Murray and Kochanska (2002). They found that high levels of effortful control (partially measured by a Go/No Go task) were related to internalizing problems, suggesting that children who exhibit high levels of inhibition may experience more internalizing symptoms such as anxiety. However, a meta-analysis conducted by Oosterlaan, Logan, and Sergeant (1998) reviewed three studies comparing response inhibition in children with anxiety disorders and normal controls. None of these studies found that the groups differed from each other with respect to response in inhibition, suggesting that differences in inhibition are not associated with anxious behaviors. These conflicting findings suggest a need for further research. To address this issue, the current study will examine the relations among endophenotypes and the broad

expressed behaviors of ASD as well as determine if IQ or age may moderate any such relations, thus contributing to the heterogeneity and possibly explaining the discrepancies in findings from different studies using various samples of children with ASD.

The Current Study

Based on the inconsistencies and gaps in knowledge in the many research studies that have been discussed, it is clear that a single comprehensive research study examining the association between various endophenotypes and various expressed behaviors in children with ASD is needed. Therefore, the current study measured local processing ability, mental flexibility, planning ability, and inhibition/disinhibition in children with ASD. In addition, this study assessed these children's acting out behaviors, social insight deficits, social contact problems, anxious/rigid behaviors, and stereotypical behaviors since these behaviors are commonly found to varying degrees in individuals with ASD (Luteijn, Luteijn, Jackson, Volkmar, & Minderaa, 2000). The overarching goal of the current study is to establish whether significant associations exist between any of the endophenotypes and the expressed behaviors.

Additionally, this research study assessed the age and IQ of all participants and examined whether age or IQ moderates any of the endophenotype/expressed behavior relations. The previously reviewed literature included studies that differed from each other with respect to the age and IQ of participants and with respect to whether or not age or IQ was accounted for in the studies. Therefore, it is possible that some of the conflicting findings may be due to modifier variables such as age and IQ.

Also, because age and IQ are related to various expressed behaviors, it is possible that these variables are interacting with various endophenotypes. For example, the

previously mentioned Kenworthy et al. article (2009) noted that with increasing age, expressed ASD behaviors changed. In particular, repetitive behaviors decreased and social difficulties increased. Secondly, a study conducted by Mayes and Calhoun (2011) found that overall ASD symptom severity was negatively related to increasing IQ and increasing age, as were some specific ASD symptoms such as disconnectedness, limited empathy, repetitive play, and stereotypies. Thirdly, symptoms that are not specific to an ASD diagnosis also show an association with age; a study conducted by Biederman, Mick, and Faraone (2000) found that hyperactive behaviors (which are similar to acting out behaviors) in a sample of children with attention-deficit/hyperactivity disorder (ADHD) tended to decrease with age. Overall, it appears that general ASD symptoms and other expressed behaviors of interest tend to decrease with increasing age and IQ.

Age and IQ clearly appear to impact the expression of various ASD symptoms and other expressed behaviors, but it is unknown whether they interact with local processing abilities or executive functioning deficits as they produce these effects. Some research studies have controlled for age and/or IQ when examining the association among executive functioning abilities and expressed behaviors, so the role of these factors is less clear. For example, a study conducted by Sinzig, Morsch, Bruning, Schmidt, and Lehmkuhl (2008) examined the association among many executive functioning tasks and ASD symptoms in children. They found that performance on these tasks improved with increasing age and IQ among an overall sample of children with ASD, ADHD, ASD and ADHD, and children with no diagnosis, so they controlled for age and IQ when examining the correlations. This limits the amount of knowledge we have in understanding how age and IQ may interact with performance on those measures to

predict behavioral outcomes. Therefore, this study examined the possible moderating effect of age and IQ.

Hypotheses

Based on a review of previous research studies, specific endophenotypes were expected to relate to expressed behaviors in particular ways. Therefore, this study hypothesized five findings: Local processing ability in these children was expected to be positively related with social contact problems, social insight problems, anxious/rigid behaviors, and stereotypical behaviors (Hypothesis 1). Mental flexibility was expected to be negatively related with social contact problems, social insight problems, anxious/rigid behaviors, and stereotypical behaviors (Hypothesis 2). Planning abilities were expected to be negatively related with acting out behaviors and social insight problems (Hypothesis 3). Disinhibition was expected to be positively related with acting out behaviors (Hypothesis 4). Inhibition was expected to be positively related with anxious/rigid behaviors (Hypothesis 5).

In addition, it was expected that age and IQ would each moderate the relations between endophenotypes and expressed behaviors such that older age and higher IQ would attenuate the relations. Therefore, the current study hypothesized that increasing age would weaken all of the previously mentioned relations among endophenotypes and expressed behaviors (Hypothesis 6) and also that increasing IQ would weaken all of the previously mentioned relations among endophenotypes and expressed behaviors (Hypothesis 7).

CHAPTER II

METHOD

Participants

A total of 31 children with an ASD diagnosis between the ages of 7 and 16 were recruited into the study. Participants were recruited from the community, outpatient clinics, a school, and a summer camp in two southern cities. One participant was very low functioning and was therefore unable to complete any of the tasks. A second participant's parent only completed the consent form and diagnostic information in the questionnaires before terminating the study for both herself and her child. Therefore, a total of 29 participants are considered the sample for the current study and were included in the final analyses. Of the 29 child participants, some were unable to complete certain tasks due to either low functioning levels or noncompliant behaviors. If it was clear that a participant did not understand a task or if the participant was extremely noncompliant and refused to complete the task, that task was terminated and a score for that particular task was not recorded. Therefore, the number of participants included in subsequent analyses vary from 20 to 28 based on which particular tasks were included in the analyses. Accordingly, when results are reported, the sample size for the analysis is also reported.

The full participant sample ($N = 29$) consisted of children ages 7 to 16 ($M = 9.69$, $SD = 2.41$). All children had a reported previous diagnosis of ASD, which was confirmed through the Demographic and Diagnostic Form completed by the parent. A total of 41% had a reported diagnosis of autism/Autism Spectrum Disorder ($n = 12$), 14% had a diagnosis of Asperger's disorder ($n = 4$), 40% had a diagnosis of pervasive

developmental disorder, not otherwise specified (PDD-NOS; *n* = 11), and 7% reported a diagnosis of "other" (the two participants endorsing "other" specified their child's diagnoses as being autism/Down Syndrome and autism/developmental delay). Regarding the source of diagnosis, 31% of children were reported to have been diagnosed by a psychologist, 21% by a psychiatrist, 14% by a neurologist, and the remaining 35% were reported to have been diagnosed by a pediatrician or team of medical professionals. A total of 76% of the children were males (*n* = 22), and 24% were females (*n* = 7). A total of 69% of the children were identified as white (*n* = 20), 28% were identified as black (*n* = 8), and 3% were identified as biracial (*n* = 1). Many of the children had comorbid diagnoses, and 48% of the sample reported an ADHD diagnosis (*n* = 14), 17% reported an anxiety diagnosis (*n* = 5), 3% reported a conduct disorder diagnosis (*n* = 1), 17% reported a learning disorder diagnosis (*n* = 5), 10% reported an intellectual disability diagnosis (*n* = 3), 3% reported an oppositional defiant disorder diagnosis (*n* = 1), and 41% reported an "other" diagnosis (*n* = 12). The sample's Full Scale IQ, as assessed by the Kaufman Brief Intelligence Test, 2nd edition, ranged from 40 to 122 (*M* = 81.14, *SD* = 26.91). Verbal IQ scores ranged from 40 to 110 (*M* = 77.14, *SD* = 21.13), and Nonverbal IQ scores ranged from 40 to 132 (*M* = 88.11, *SD* = 26.94).

All of the children in the current study were reported to have received some type of therapeutic intervention or service. A total of 28% of the children were reported to have received ABA therapy (*n* = 8), 69% received early intervention services (*n* = 20), 24% received physical therapy services (*n* = 7), 69% received occupational therapy services (*n* = 20), 31% received psychological services (*n* = 9), 86% received speech services (*n* = 25), and 17% received "other" services (*n* = 5).

All parent/guardian respondents who completed questionnaires about the child participants identified as female. A total of 97% of respondents identified themselves as the mother of the child participant (n = 28), and 3% identified as a guardian (n = 1). The age of respondents ranged from 29 to 66 (M = 42.49, SD = 7.14). A total of 62% of respondents identified as being married (n = 18), 21% identified as divorced (n = 6), 7% identified as never married/living alone (n = 2), 3% identified as separated (n = 1), 3% identified as widowed (n = 1), and 3% identified as never married/living with someone (n = 1). A total of 69% of the caregivers identified as white (n = 20), 28% identified as black (n = 8), and 3% identified as biracial (n = 1). A total of 45% of respondents identified as having graduated college (n = 13), 31% reported completing some college (n = 9), 14% reported having a graduate degree (n = 4), 7% reported graduating high school (n = 2), and 3% reported completing junior high school (n = 1). A summary of this demographic information as well as additional demographic information can be found in Table 1.

Table 1

Sample Characteristics: Child and Family Demographics

Child Characteristics	*N* (%)	Mean (*SD*)
Age		9.69 (2.41)
7	7 (24.1)	
8	3 (10.3)	
9	6 (20.7)	
10	4 (13.8)	
11	2 (6.9)	
12	3 (10.3)	
13	2 (6.9)	
14	1 (3.4)	
16	1 (3.4)	

Table 1 (continued).

Child Characteristics	*N* (%)	Mean (*SD)*
Male	22 (75.9)	
Female	7 (24.1)	
Race		
White	20 (69.0)	
Black	8 (27.6)	
Other	1 (3.4)	
Full Scale IQ		81.14 (26.91)
Verbal IQ		77.14 (21.13)
Nonverbal IQ		88.11 (26.94)
ASD diagnosis status		
Autism/Autism Spectrum Disorder	12 (41.4)	
Asperger's Disorder	4 (13.8)	
PDD-NOS	11(37.9)	
Other	2 (6.9)	
Other Psychological Diagnoses		
ADHD	14 (48.3)	
Anxiety disorder	5 (17.2)	
Conduct disorder	1 (3.4)	
Learning disorder	5 (17.2)	
Intellectual disability	3 (10.3)	
Oppositional defiant disorder	1 (3.4)	
Other	12 (41.4)	
Services Received		
Applied behavior analysis	8 (27.6)	
Early intervention	20 (69.0)	
Physical therapy	7 (24.1)	
Occupational therapy	20 (69.0)	
Psychological treatment	9 (31.0)	
Speech therapy	25 (86.2)	
Other	5 (17.2)	
ASD diagnosis determined by		
Psychologist	9 (31.0)	
Psychiatrist	6 (20.7)	
Pediatrician	2 (6.9)	
Psychiatrist	6 (20.7)	
Other	8 (27.6)	

Table 1 (continued).

Child Characteristics	*N* (%)
Currently taking medication	22 (75.9)
Currently not taking medication	7 (24.1)

Parent/Guardian Respondent Characteristics	*N* (%)
Gender	
Male	0 (0)
Female	29 (100)
Race	
White	20(69.0)
Black	8 (27.6)
Other	1 (3.4)
Marital Status	
Married	18(62.1)
Separated	1 (3.4)
Divorced	6 (20.7)
Widowed	1 (3.4)
Never married/living alone	2 (6.9)
Never married/living with someone	1 (3.4)
Education Level	
6th grade or less	0 (0.0)
Junior high school	1 (3.4)
Some high school	0 (0.0)
High school graduate	2 (6.9)
Some college/specialized training	9 (31.0)
College/university graduate	13 (44.8)
Graduate professional degree	4 (13.8)
Income	
$0-$4,999	1 (3.4)
$5,000-$9,999	2 (6.9)
$10,000-$14,999	1 (3.4)
$15,000-$24,999	1 (3.4)
$25,000-$34,999	3 (10.3)

Table 1 (continued).

Parent/Guardian Respondent Characteristics	*N* (%)
$35,000-49,999	1 (3.4)
$50,000-$74,999	10(34.5)
$75,000-$99,999	2 (6.9)
$\geq$ $100,000	7 (24.1)
Age	Mean (*SD)*
	42.49 (7.14)

Measures

Demographic and Diagnostic Form.

Parents completed a demographic form recording information about their child's diagnosis, medical history, age, family background, race, socioeconomic status, etc. The form included diagnostic information and asked parents about their child's specific ASD diagnostic classification and the professional and affiliated facility that made the diagnosis. This information was used as confirmation of a diagnosis to ensure that inclusion criteria (having an ASD diagnosis) was met.

The Children's Social Behavior Questionnaire (CSBQ; Hartman et al., 2006; Luteijn et al., 2000).

The CSBQ is an 82-item parent-report questionnaire that was used to assess expressed behaviors often found in children with ASD. This measure was used to determine that the sample as a whole had scores consistent with an ASD diagnosis and also served as the dependent measure for the research study (assessing acting out behaviors, social contact problems, social insight problems, anxious/rigid behaviors, and

stereotypical behaviors). When completing the questionnaire, parents responded to various statements such as, “Has little or no need for contact with others” or “Is fascinated by certain colors, forms, or moving objects” by checking *0-it does not describe the child*, *1-infrequently describes the child*, or *2-clearly applies to the child*.

This measure consists of items from the five subscales of the CSBQ published by Luteijn et al. in 2000 as well as items from a revised version published by Hartman et al. in 2006. The CSBQ published in 2000 assesses a fairly broad range of expressed behaviors that are often, but not always, found in children with ASD. Because the current study assessed a broad range of expressed behaviors in children with ASD, scores on the items that load onto the five subscales of the CSBQ published in 2000 (described in more detail below) were used to determine expressed behavior scores for the participants in each of these areas. The CSBQ published in 2006 was revised to be more specific to an ASD diagnosis, so the items in this version assess a much more narrow range of behaviors. Scores on items that load onto a composite score for this version were used to establish that scores consistent with an ASD diagnosis were present for the sample as a whole.

The 66 items on the CSBQ (Luteijn et al., 2000) that were used to assess expressed behaviors load onto five subscales:

(1) Acting out behaviors: These were measured by the “acting out” subscale which includes items such as “behaves aggressively” and “quickly gets angry.”

(2) Social contact problems: These were measured by the "social contact problems" subscale and includes items such as "has little or no need for contact with others" and "lives in a world of his/her own."

(3) Social insight problems: These were measured by the "social insight problems" subscale which includes items such as "does things without realizing the aim, e.g., constantly has to be reminded to finish something" and "takes things literally, e.g., does not understand certain expressions."

(4) Anxious/rigid behaviors: These were measured by the "anxious/rigid" subscale which includes items such as "panics in new situations or if change occurs" and "talks over and over again about something that happened in the past."

(5) Stereotypical behaviors: These were measured by the "stereotypical" subscale which includes items such as "flaps arms/hands when excited" and "constantly feels objects."

Based on previous studies, test-retest reliability for four of the five scales is satisfactorily high (ICC ranging from .62 to .90), but the stereotypical scale exhibits a lower level of test-retest reliability (ICC = .32). However, internal consistency for all five of the subscales has been found to be very high (Chronbach's α ranging from .76 to .92 in previous studies). These subscales exhibit evidence of validity in that they correlate with subscales of other measures investigating similar constructs. For example, scores on the Acting Out subscale correlate with the Aggressive Behaviors scale of the Child Behavior Checklist (CBCL; .85); scores on the Social Contact Problems subscale correlate with the "Relating" scale of the Autism Behavior Checklist (ABC; .63) and the

Withdrawn scale of the CBCL (.63); scores on the Social Insight Problems subscale correlate with the Attention scale of the CBCL (.71); scores on the Anxious/Rigid subscale correlate with the Thought Problems scale (.56) and the Anxiety/Depression scale of the CBCL (.56); and scores on the Stereotypical subscale correlate with the Body/Object Use scale of the ABC (.61). Internal consistencies for the five subscales based on the current sample are reported in Table 2.

Table 2

Descriptive Statistics for Expressed Behaviors

	M	*SD*	Potential Range	Actual Range	Cronbach's alpha	Skew	Kurtosis
Total Autistic Traits	45.93	18.34			.94	.11	.22
Social Insight Problems	18.03	6.51	0-32	5-30	.86	-.16	-.24
Acting Out Behaviors	12.73	6.22	0-28	2-24	.88	-.08	-.80
Stereotyped Behaviors	6.00	3.69	0-14	0-13	.78	.25	-1.22
Social Contact Problems	10.01	5.55	0-26	0-23	.87	.52	-.25
Anxious/Rigid Behaviors	14.21	7.14	0-32	0-30	.88	.05	-.17

There are 49 items on the CSBQ (Hartman, 2006) that were used to calculate a total ASD symptom score for each participant (some of these items overlap with items included in the five subscales already mentioned). The purpose of obtaining this total symptom score was to ensure that the average score for the sample for the current study generally matched the average score for samples of children diagnosed with ASD in previous measure development studies for the CSBQ. Internal consistency of this scale is very good (Chronbach's α of .94), as is inter-rater reliability (ICC = .86) and test-retest

reliability (r = .90), based on previous studies. Internal consistency for the current sample is reported in Table 2. In addition, this scale indicates evidence of validity (Hartman, 2006). Hartman and colleagues (2006) administered these items to parents of children with high-functioning autism, PDD-NOS, ADHD, ADHD + PDD-NOS, internalizing disorders (ID), mental retardation (MR), MR + PDD, and controls. Mean scores on the scale were significantly different for each group, with individuals with high-functioning autism having the highest mean score (47.22), and individuals with various forms of PDD having the next highest scores. As reported in the Results section, for the current study, the overall sample mean was compared to these scores to ensure that, as a group, the study sample resembled an ASD sample.

The Kaufman Brief Intelligence Test-Second Edition (KBIT-2; Kaufman & Kaufman, 2004).

The KBIT-2 was used to determine the IQ of each participant. The KBIT-2 is a 20-minute test which provides an overall measure of intellectual functioning as well as a crystalized and fluid reasoning score. The test consists of three subtests: a verbal knowledge subtest (assessing receptive vocabulary and range of general knowledge), a riddles subtest (assessing verbal comprehension, verbal reasoning, and vocabulary knowledge), and a matrices subtest (assessing understanding of relationships, nonverbal reasoning, and problem-solving ability).

The K-BIT-2 was standardized with individuals from a nationally-represented sample who ranged in age from 4 to 90 years. The standardization sample included children from special-education classrooms, suggesting that this measure is appropriate for children with disorders such as ASD. Internal reliability was assessed through the

split-half method, and mean internal reliability across the sample was very high (Verbal = .91, Nonverbal = .88, and IQ composite = .93) as is mean test-retest reliability (Verbal = .91, Nonverbal = .83, IQ composite = .90; Kaufman & Kaufman, 2004). The K-BIT-2 also exhibits a high level of validity, with IQ composite scores on the K-BIT-2 correlating highly with scores on other IQ measures [K-BIT = .84, Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) = .77, Wechsler Adult Intelligence Scale, Third Edition (WAIS-III) = .89; Kaufman & Kaufman, 2004].

The Group Embedded Figures Test (GEFT; Witkin, Oltman, Raskin, & Karp, 1971).

The GEFT was individually administered and was used to assess local processing ability. In this test, participants were shown a target item and instructed to find and trace this target item within a more complex figure. Therefore, this test requires a detail-focused processing ability. As EFTs have been frequently used as a measure of local processing ability in individuals with and without ASD (Chen et al., 2009; Hill & Frith 2003; South et al., 2007), this measure is likely a reliable and valid measure of local processing ability.

Because this test was developed for use by adults, the GEFT was modified for children in two ways (Drake, Redash, Coleman, Haimson, & Winner, 2010). First, instead of instructing the children to complete each part of the test in a specific time limit, participants were allowed to work as long as needed on each item. Secondly, children were allowed to look at the target shape that they had to find in the complex figure throughout the test rather than viewing it intermittently. As dictated by the standardized instructions, participants were instructed to complete the items in the order presented

without skipping items, to trace the shapes completely, and to erase any mistakes before moving on.

This test consists of three parts. The first part is comprised of seven control items, and the second and third parts are comprised of nine items each and are more difficult to complete. Before testing began, it was initially determined that the seven control items would be used as practice items (in addition to two specific practice items that were used as demonstration and practice items to ensure that participants understood the task) and the second and third parts of the measure would be used to determine the local processing abilities of the children. However, as testing progressed, it became evident that these "easy" control items were reasonably difficult for the children, and some of the children were unable to complete many of the more complex items. Therefore, it was determined that a total GEFT score comprised of scores from all three parts of the measure (including the control part) would be the most accurate measure of children's local processing abilities. In addition, although completion time was originally determined to be used as the measure of local processing ability, as testing progressed, completion time did not appear to be a reliable indicator of true mental processing ability. Rather, completion time appeared to indicate motor-skill ability and was a reflection of tracing abilities and tracing time. Therefore, a total GEFT score rather than completion time was used as the indicator of local processing ability in the current study.

The Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948).

The WCST was used to measure mental flexibility and was administered on a laptop via the Inquisit computer program. In this task participants, participants were required to sort cards with different colors, forms, or number of objects. However, the

rule for the correct sorting strategy was not be told to the participant, so the participant had to learn the sorting strategy based on correct/incorrect feedback. Once the participant learned the sorting strategy and sorted correctly ten times in a row, the sorting rule, unbeknownst to the participant, changed. Therefore, the participant had to discover the new rule to sort correctly. This process continued until either six categories were completed or the participant made 128 sorts (whether correct or incorrect). The percentage of perseverative errors (continuing to sort according to the previous strategy instead of adapting to the new sorting strategy) was used as the indicator of mental flexibility. Because perseverative errors indicate mental inflexibility rather than flexibility, to aid in interpretation, scores were multiplied by (-1) to reverse the direction of the distribution. Therefore, a high score on this variable indicated higher levels of mental flexibility. Various editions of this task have been used to measure mental flexibility in a wide range of individuals, including individuals with ASD (Hill, 2004), so this test was considered to be a reliable and valid measure of mental flexibility for the current study.

The Tower of London (Shallice, 1982).

The Tower of London was used to measure planning ability and was administered on a laptop via the Inquisit computer program. In this task, participants were required to move beads, one at a time, on three pegs to replicate a target design. Participants strove to replicate the design in the fewest moves possible. Therefore, they had to take time to plan out their moves and mentally determine the most effective way to replicate the design. If the participants did not succeed in completing an item in the number of moves permitted, that item was marked as incorrect, and the participants had to try again to

solve the item to move on. Participants had three tries to correctly complete each item in the number of moves allowed. If participants correctly completed the item on the first time, they received a score of 3 for that item. If they correctly completed the item on the second try, they received a score of 2, and if they completed it on the third try, they received a score of 1 for that item. If they did not complete the item by the third time, they received a score of 0 for that item. Therefore, planning ability was represented by total Tower of London score, and higher scores indicated better planning abilities.

Before completing test items for this measure, participants were administered a practice item. The practice item was administered to participants as many times as needed until they demonstrated understanding of the task, at which time the full task was administered. The Tower of London task is often used to assess planning ability in children with and without ASD (Hill, 2004; Hill & Frith, 2003), so this test was considered to be a reliable and valid measure of planning abilities for the current study.

Go/No Go (Fillmore, Rush, & Hays, 2006).

The Go/No Go task was used to measure inhibition and disinhibition and was administered on a laptop via the Inquisit computer program. In this version of the Go/No Go task, participants were first required to press a spacebar as quickly as possible when a green rectangle appeared on the screen and to refrain from pressing the key when a blue rectangle appeared on the screen. For each trial of the task, a white rectangle first appeared on the screen. The elapsed time that the white rectangle remained white before turning green or blue varied with each trial, and the orientation of the rectangle on the screen also varied. Rectangles appeared on the screen continuously for 5 minutes. When the white rectangle turned green or blue, the participant either pressed the spacebar or

refrained from pressing the space bar depending on the color of the rectangle. When the participant incorrectly pressed the space bar (i.e., pressing when the rectangle was blue), an error of commission was recorded. Commission errors represent disinhibited responding. When the participant incorrectly refrained from pressing the spacebar when it should have been pressed (i.e., not pressing when the rectangle was green), an error of omission was recorded. Omission errors represent inhibited responding.

In the second portion of this task, the rules were reversed. This was done to increase the difficulty of the task and to measure disinhibition and inhibition when participants have to inhibit an over-learned response. In the second part, participants were instructed to press the spacebar when they saw a blue rectangle and to refrain from pressing the spacebar when they saw a green rectangle. Rectangles again appeared on the screen continuously for 5 minutes. When the participant incorrectly pressed the space bar and the rectangle was green, an error of commission was recorded. This mistake suggests evidence of disinhibition when having to inhibit an over-learned response. When the participant incorrectly refrained from pressing the spacebar when he or she should have pressed the spacebar, an error of omission was recorded. This mistake suggests inhibited responding.

For each part of the Go/No Go task, commission and omission errors were divided by the total number of trials administered for that part to create a percent commission error and a percent omission error variable for both parts. Therefore, each participant had two indicators of disinhibition (commission errors on parts 1 and 2) and two indicators of inhibition (omission errors on parts 1 and 2).

Notably, before completing each set of test items, participants were administered four practice items (i.e., two go and two no go). Practice items were administered to participants as many times as needed until they demonstrated understanding, at which time the full task was administered. If it was clear that a participant is unable to understand the task, the task was not administered. Various editions of this task have been used to assess inhibition in individuals with and without ASD (Hill, 2004), so this test was considered to be a reliable and valid measure for the current study.

Finally, in addition to revealing deficits in inhibition, this measure also was used to further explore mental flexibility abilities. The ability to switch methods of responding when instructions are changed requires mental flexibility in addition to the ability to inhibit responding. Therefore, a higher percentage of correct responses on the second part of the task suggests higher levels of mental flexibility. The details of how this variable of mental flexibility was created is explained in the Results section.

Procedure

Following IRB approval from The University of Southern Mississippi and the University of South Alabama, children were sampled from the community, clinics, a school, and a summer camp via flyers and individualized invitations to participate. Following consent from a parent or guardian and assent from the child participating, child participants were administered the K-BIT-2, the Tower of London task, the Go/No Go task, the Wisconsin Card Sorting Task, and the Group Embedded Figures Task. Each child was administered these tests in this same specific order. Children were tested in the USM Child Externalizing Behaviors Lab, in a school classroom, in a community center, or in a medical clinic.

While children were completing the study, parent respondents completed questionnaires about themselves and their children. These measures were administered electronically via a secure online website. Depending on where the study was conducted, parents either completed the questionnaires at the testing site with their child or completed them from their home. When the parents completed the forms from their home, they first consented to participate in the research study and then either completed the questionnaires a few days or weeks before their child was tested or a few days or weeks after their child was tested. Information was de-identified and stored with a unique participant identification number. Each participant received a $10 gift card to a large store chain as compensation for completing the study.

CHAPTER III

RESULTS

Descriptive Statistics

There are 49 items on the CSBQ (Hartman et al., 2006) that are a good indicator of overall autistic traits. Hartman et al. found that individuals with high-functioning autism (HFA) had a mean score of 47.22 (*SD* = 15.37) and individuals with PDDNOS had a mean score of 37.84 (*SD* = 15.94) on this measure. In the current sample, the mean score of autistic traits based on these 49 items was 45.93 (*SD* = 18.34), which is very similar to the original's sample's HFA mean and is higher than the original sample's PDDNOS group mean. Therefore, it appears as if the current sample as a whole exhibited a significant level of autistic traits. These autistic traits were also found to be normally distributed throughout the sample (Table 2).

The five subscales of the 2000 version of the CSBQ (Luteijin et al., 2000)—acting out behaviors, social contact problems, social insight problems, anxious/rigid behaviors, and stereotyped behaviors—were used as the dependent measures in the primary analyses. Descriptive statistics can be found in Table 2. A review of these data indicates that the five subscales exhibit high levels of reliability and also appear to be normally distributed throughout the sample. The only exception to the normal distribution of any of these traits is a substantial negative kurtosis for stereotyped behaviors, indicating a flatter shape in the distribution.

The predictor constructs for this study were local processing ability, mental flexibility, planning, and inhibition/disinhibition. Mean scores for the variables that represent these constructs are outlined in Table 3. Standard deviations, skewness,

kurtosis information, and sample size information (some participants were unable to understand or complete particular tasks, so measures vary with respect to sample size) are provided as well. There was a substantial positive skew for percent commission and omission errors on the Go/No Go task, revealing that most participants did very well on this measure and that errors were relatively infrequent. There was a substantial negative skew for the mental flexibility perseveration composite, indicating that perseverative errors were relatively infrequent. The other predictor variables—GEFT total score and TOL total score—were normally distributed in the current sample. There was a substantial negative kurtosis for the GEFT score and the TOL score, suggesting a flatter distribution for those scores. There was a substantial positive kurtosis for the WCST perseveration score and for three of the four Go/No Go task scores, suggesting a peaked distribution.

Table 3

Descriptive Statistics for Predictor Variables

	N	*M*	*SD*	Skew	Kurtosis
GEFT total score (local processing ability)	20	7.20	4.41	-.22	.22
WCST Perseverative errors, reversed (mental flexibility)	27	-.09	.09	-1.79	4.26
Go/No Go percent commission errors, Part 1 (disinhibition)	25	.03	3.69	1.80	2.87
Go/No Go percent commission errors, Part 2 (disinhibition)	25	.02	.03	1.22	.48
Go/No Go percent omission errors, Part 1 (inhibition)	25	.04	.04	2.19	6.72
Go/No Go percent omission errors, Part 2 (inhibition)	25	.05	.06	1.26	1.04
TOL total score (planning)	28	22.29	5.39	-.23	-.93

Note. GEFT = Group Embedded Figures Test; WCST = Wisconsin Card Sorting Task; TOL = Tower of London.

The two moderator variables (age and composite IQ) were treated as continuous moderators in all of the analyses. Details regarding these variables can be found in the participant descriptives table (Table 1). The age distribution of the sample exhibited a slight but acceptable positive skew (.81), and the IQ distribution exhibited a very slight but acceptable negative skew (-.41). The kurtosis for age was acceptable (.15), and the kurtosis for IQ was acceptable as well but suggested a somewhat flat distribution.

Besides the previously mentioned instances of skew and kurtosis, no other significant irregularities were found in the data. Therefore, all participants were included in the final dataset. However, sample size does change for specific analyses based on the number of participants able to complete the various tasks assessing the endophenotypes.

Preliminary Correlations

Zero-order correlations among all the variables of interests were run to determine how predictor, outcome, and moderator variables were related (Table 4). These correlations showed that scores on all five of the subscales of the CSBQ were correlated, with correlation coefficients ranging from .37 to .77. Commission errors on parts 1 and 2 of the Go/No Go task were highly correlated, $r(25) = .74$, $p < .001$, as were omission errors on parts 1 and 2, $r(25) = .84$, $p < .001$. This suggests that even though the rules were switched on the second portion of this task, switching the rules may not have significantly affected participants' overall performance. Performance on the Tower of London was negatively correlated with omission errors on part 2 of the Go/No Go task, $r(25) = -.44$, $p = .03$, suggesting that these measures may have tapped fairly opposite constructs. Mental flexibility was found to be marginally correlated with anxious/rigid behaviors, $r(27) = -.34$, $p = .08$, such that higher levels of mental flexibility were related

to fewer anxious/rigid behaviors. Percent commission errors on part 1 of the Go/No Go task, indicating higher levels of disinhibition, were marginally correlated with fewer social insight problems, $r(25) = .39$, $p = .06$. Age was found to positively relate to commission errors on the first part of the Go/No Go task, suggesting that increasing age was linked to more disinhibition $r(25) = .45$, $p = .02$. Similarly, age was found to negatively relate to omission errors on both parts of the Go/No Go task $r(25) = -.44$, $p = .03$, $r(25) = -.41$, $p = .04$, suggesting that increasing age was linked to less inhibition. Age was also found to positively relate to performance on the Tower of London task, $r(28) = .51$, $p = .01$, suggesting that increasing age is linked to better planning abilities. IQ score was marginally correlated with performance on the GEFT, $r(20) = .41$, $p = .07$, suggesting that higher cognitive functioning abilities are linked to more local processing abilities.

Table 4

Zero-Order Correlations Among Variables of Interest

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. SIP	.71***	.44*	.68***	.67***	-.26	-.06	-.38†	-.15	.10	.17	-.12	-.01	.02
2. AO		.49**	.47*	.77***	-.11	-.19	.09	.25	.31	.32	.02	-.17	.16
3. S			.37*	.58**	-.25	-.15	.03	.14	.22	.22	-.09	-.21	-.08
4. SCP				.42*	-.06	.23	-.29	-.15	.23	.23	-.29	-.01	-.15
5. AR					-.15	-.34†	-.14	-.04	.20	.21	-.05	-.12	-.12
6. Loc. Pro.						-.32	.07	-.27	-.09	-.15	.09	.19	.41†
7. M. Flex.							.13	.03	-.31	.20	-.10	.06	-.11
8. Dis. 1								.74***	-.33	-.17	.15	.45*	-.42
9. Dis. 2									-.12	-.01	.11	.32	-.27
10. Inh. 1										.84***	-.35	-.43*	.13
11. Inh. 2											-.44*	-.41*	.18
12. Plan.												.51**	-.06
13. Age													-.31
14. IQ													

Note. SIP = Social Insight Problems; AO = Acting Out Behaviors; S = Stereotyped Behaviors; SCP = Social Contact Problems; AR = Anxious/Rigid Behaviors; Loc. Pro. = local processing ability as assessed by the Group Embedded Figures Test; M. Flex. = mental flexibility as assessed by perseverative errors (reversed) on the Wisconsin Card Sorting Task; Dis. 1 = percent commission errors on part 1 of the Go/No Go task; Dis. 2 – percent commission errors on part 2 of the Go/No Go task; Inh. 1 = inhibition as assessed by percent omission errors on part 1 of the Go/No Go task; Inh. 2 = inhibition as assessed by percent omission errors on part 2 of the Go/No Go task; Plan. = planning ability as assessed by the TOL. For correlations involving Loc. Pro., $N = 20$; M. Flex, $N = 27$; Dis. 1, Dis. 2, Inh. 1, Inh. 2, $N = 25$; Plan., $N = 28$. †trend, $p < .10$. * $p < .05$. ** $p < .01$.*** $p < .001$.

To determine whether demographic variables (gender, race, and income) needed to be used as control variables in subsequent analyses, zero-order correlations between these variables and the outcome variables were conducted (Table 5). Because age was a predicted moderator, it was not included in this analysis for control variables. Race was dichotomized (white and nonwhite) for the analyses. Race and income were not significantly correlated with any of the outcome variables. However, gender was significantly correlated with acting out behaviors, stereotyped behaviors, and anxious/rigid behaviors, with males exhibiting more difficulties in those areas than females. Therefore, gender was entered as a covariate in all subsequent analyses involving those outcome variables.

Table 5

Zero-Order Correlations Among Demographic Variables and Outcomes

	Gender	Race	Income
Social insight problems	-.33	-.23	-.27
Acting out behaviors	-.57**	-.10	-.16
Stereotyped behaviors	-.40*	-.23	-.26
Social contact problems	-.20	-.10	-.35
Anxious/rigid behaviors	-.59**	.11	-.32

Note. Gender coded as Male = 1, Female = 2; Race coded dichotomously as White/Caucasian = 0, Nonwhite = 1.

*$p < .05$. $p < .01$.

Hypothesis Testing: Correlation Analyses

As stated earlier, the current study had seven hypotheses. The first four hypotheses were as follows: Local processing ability in children with ASD was expected to be positively related with social contact problems, social insight problems, anxious/rigid behaviors, and stereotypical behaviors (Hypothesis 1). Mental flexibility was expected to be negatively related with social contact problems, social insight

problems, anxious/rigid behaviors, and stereotypical behaviors (Hypothesis 2). Planning abilities were expected to be negatively related with acting out behaviors and social insight problems (Hypothesis 3). Disinhibition was expected to be positively related to acting out behaviors (Hypothesis 4), and inhibition was expected to be positively related with anxious/rigid behaviors (Hypothesis 5). Because previous analyses showed that gender was significantly correlated with acting out behaviors, stereotyped behaviors, and anxious/rigid behaviors, gender was entered as a covariate for correlations involving those three outcomes. Thus, these five hypotheses were tested with bivariate correlations for social insight problems and social contact problems and were tested with partial correlations for acting out behaviors, stereotyped behaviors, and anxious/rigid behaviors (Table 6).

Table 6

Bivariate and Partial Correlations Among Endophenotypes and Expressed Behaviors: Test of Hypotheses 1 through 5

	Acting Out Behaviors	Social Insight Problems	Social Contact Problems	Anxious/ Rigid Behaviors	Stereotyped Behaviors
Local Processing Ability	-	-.26	-.06	-.35	-.38
Mental Flexibility	-	-.06	.23	-.26	-.07
Planning Ability	.09	-.12	-	-	-
Disinhibition (part 1)	-.05	-	-	-	-
Disinhibition (part 2)	.51	-	-	-	-
Inhibition (part 1)	-	-	-	.19	-
Inhibition (part 2)	-	-	-	.29	-

Note: Bivariate correlations were conducted for all correlations involving Social Insight Problems and Social Contact Problems. Partial Correlations, with gender as a control variable, were conducted for all correlations involving Acting Out Behaviors, Anxious/Rigid Behaviors, and Stereotyped Behaviors. For correlations involving Local Processing Ability, $N = 20$; Mental Flexibility, $N = 27$; Planning Ability, $N = 28$; Disinhibition 1, Disinhibition 2, Inhibition 1, Inhibition 2, $N = 25$.

None of the hypotheses were supported. Local processing ability was not significantly positively associated with social contact problems or social insight problems; it also was not significantly positively associated with anxious/rigid behaviors or stereotypical behaviors when accounting for gender (Hypothesis 1). In fact, all examined correlations between local processing ability and expressed behaviors were negative, albeit not significant. Mental Flexibility was not significantly negatively associated with social contact problems or social insight problems; it also was not significantly negatively associated with anxious/rigid behaviors or stereotypical behaviors when accounting for gender (Hypothesis 2). However, three of four examined correlations between mental flexibility and expressed behaviors were negative (all but social contact problems). Although these correlations were not significant, they were in the expected direction. Planning abilities were not significantly negatively related with acting out behaviors (accounting for gender) or social insight problems (Hypothesis 3); the nonsignificant correlation between planning ability and acting out behaviors was actually positive. When accounting for gender, the correlation between disinhibition and acting out behaviors was a small, negative relation for part 1 and a large, positive relation for part 2. Although in the right direction, the relation found for part 2 was still not significant, $pr = .51$, $p = .14$ (Hypothesis 4). Finally, accounting for gender, inhibition was not significantly positively related with anxious/rigid behaviors; however, the correlations were moderate in size and in the right direction for both parts (Hypothesis 5).

Hypothesis Testing: Moderated Multiple Regression Analyses

Hypotheses 6 and 7 (that increasing age and IQ would moderate all associations between predictor and outcome variables by weakening the association) were tested by

conducting 28 moderated multiple regression analyses. These analyses were conducted using the statistical tool *PROCESS* (Hayes, 2013). For analyses involving the outcome variables of acting out behaviors, stereotyped behaviors, and anxious/rigid behaviors, gender was entered as a control variable in step 1. This was done because gender was found to relate to those outcome variables. In the next step of the model (or the first step if there were no control variables needed), each predictor variable (local processing ability, planning ability, mental flexibility, disinhibition, and inhibition) and the moderator variable (age or IQ) were entered individually. In the final step of the model, the interaction term was entered into the model. All variables were centered by the *PROCESS* procedure to reduce multicollinearity and to facilitate interpretation of the findings. Despite the fact that most predictor variables were not found to be associated with an outcome variable, all hypothesized interactions were examined, as an interaction effect can occur in the absence of a main effect.

Local Processing Ability and Expressed Behaviors: Age and IQ as Moderators

Eight moderated multiple regression analyses were conducted with local processing ability entered as the predictor variable, and social insight problems, social contact problems, stereotyped behaviors, and anxious/rigid behaviors, each individually entered as the outcome variables. In the first four analyses, age was entered as the moderator variable, and in the next four analyses, IQ was entered as the moderator. Due to the complex nature of the local processing task, only 20 participants were able to understand and complete the task. Therefore, all eight moderation analyses were conducted with a sample size of 20.

The results of the four moderated multiple regression analyses examining age as a moderator between local processing ability and expressed behaviors are presented in Table 7. The models examining age as a moderator of the associations between local processing ability and social insight problems as well as social contact problems were not significant. The first two steps (control and main effects) of the model examining age as a moderator of the association between local processing ability and stereotyped behaviors were not significant. However, when the interaction term (local processing ability X age) was entered into the third step, the overall interaction model was significant, $R^2 = .48$, F (4, 15) = 3.45, $p = .03$. In this model, gender accounted for a significant amount of variance in stereotyped behaviors, $B = -3.39$, $SE = 1.52$, $p = .04$, as did the interaction term, $B = -.16$, $SE = .06$, $p = .01$. The addition of the interaction term accounted for a significant increase in variance explained in stereotyped behaviors, $R^2\Delta = .28$, F (1, 15) = 7.92, $p = .01$. A plot of this interaction indicated that in older children, but not in younger children, local processing ability significantly predicted stereotyped behaviors, with higher levels of local processing abilities being associated with lower levels of stereotyped behaviors (Figure 1). This finding is contrary to what was predicted. The first step of the model examining age as a moderator of the association between local processing ability and anxious/rigid behaviors was significant, $R^2 = .32$, F (1, 18) = 8.32, $p = .01$, showing gender as a significant predictor. The main effects model was significant and interaction model was marginally significant overall, $R^2 = .40$, F (3, 16) = 3.62, $p = .04$ and $R^2 = .44$, F (4, 15) = 2.91, $p = .058$, respectively. However, the increase in variance in each of these steps was not significant, $R^2\Delta = .09$, F (2, 16) = 1.18, $p = .33$ and $R^2\Delta = .03$, F (1, 15) = 1.27, $p = .36$, respectively. Only gender emerged as a

significant predictor in either step, B = -9.17, SE = 2.96, p = .007 in step 2 and B = -9.39, SE = 2.98, p = .006 in step 3. The interaction term did not add unique variance and, thus, age did not significantly moderate the association between local processing ability and anxious/rigid behaviors.

Table 7

Results of Moderated Multiple Regression Analysis of Local Processing Ability and Age Predicting Expressed Behaviors

Predictors	Outcome Variables			
	Social Insight Problems	Social Contact Problems	Stereotyped Behaviors	Anxious/Rigid Behaviors
Control Model R^2	--	--	**.10**	**.32***
Gender	--	--	-2.47 (1.77)	-8.40 (2.91)*
Main Effects Model R^2 (or $R^2\Delta$)	**.10**	**.01**	**.11**	**.09**
Gender	--	--	-3.05 (1.81)	-9.17 (2.96)**
Local Processing Ability	-.41 (.33)	-.10 (.31)	-.26 (.19)	-.45 (.30)
Age	.40 (.56)	.08 (.53)	-.05 (.31)	-.29 (.51)
Interaction Model $R^2\Delta$	**.01**	**.02**	**.28***	**.03**
Gender	--	--	-3.39 (1.52)*	-9.39 (2.98)**
Local Processing Ability (LPA)	-.43 (.35)	-.06 (.32)	-.18 (.16)	-.40 (.31)
Age	.37 (.59)	.13 (.54)	.07 (.26)	.37 (.52)
LPA X Age	.04 (.13)	-.06 (.12)	-.16 (.06)*	-.11 (.11)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects models show either R^2 (if there is no control in step 1) or $R^2\Delta$ (if a control was used in step 1); and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 20$. * $p < .05$. ** $p < .01$.

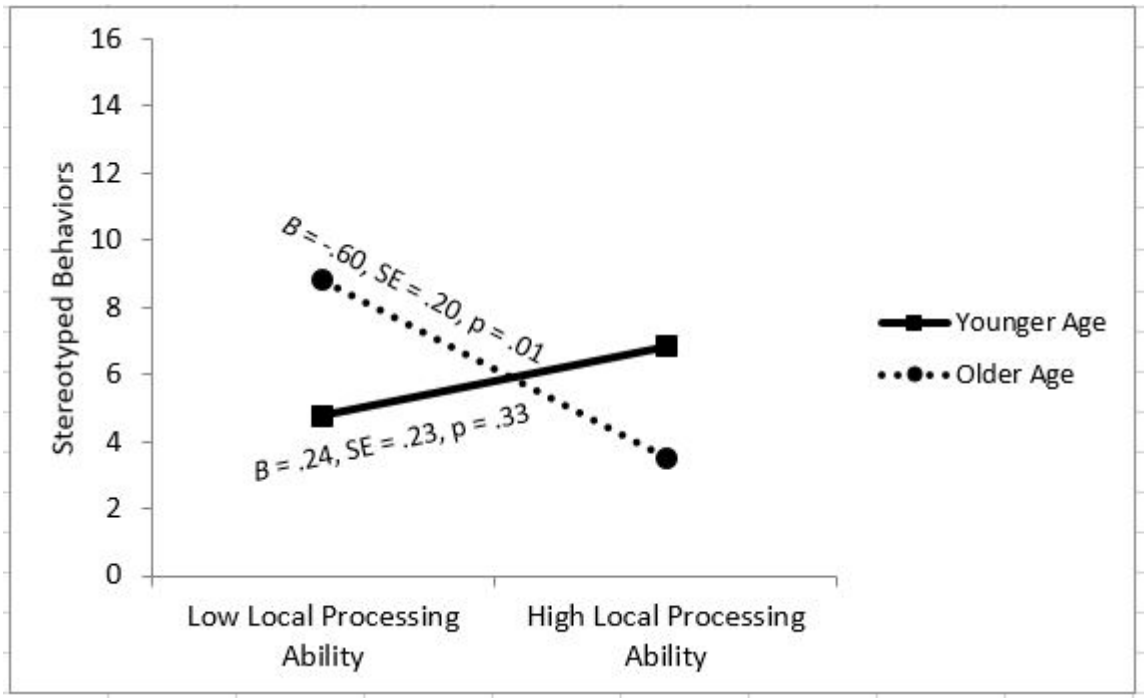

Figure 1. Interaction Between Local Processing Ability and Age Predicting Stereotyped Behaviors

The results of the four moderated multiple regression analyses examining IQ as a moderator between local processing ability and expressed behaviors are presented in Table 8. The models examining IQ as a moderator of the associations between local processing ability and social insight problems, social contact problems, and stereotyped behaviors were not significant. As indicated above when examining age as a moderator, the first step of the model examining IQ as a moderator of the association between local processing ability and anxious/rigid behaviors was significant, $R^2 = .32$, F (1, 18) = 8.32, $p = .01$, showing gender as a significant predictor. Both the main effects and interaction models were significant overall, $R^2 = .47$, F (3, 16) = 4.70, $p = .02$ and $R^2 = .51$, F (4, 15) = 3.90, $p = .02$, respectively. However, the increase in variance in each of these steps was not significant, $R^2\Delta = .15$, F (2, 16) = 2.29, $p = .13$ and $R^2\Delta = .04$, F (1, 15) = 1.27, $p = .28$, respectively. Only gender emerged as a significant predictor in either step, B = -

9.81, *SE* = 2.80, *p* = .003 in step 2 and *B* = -10.42, *SE* = 2.84, *p* = .002 in step 3. The interaction term did not add unique variance and, thus, IQ did not significantly moderate the association between local processing ability and anxious/rigid behaviors.

Table 8

Results of Moderated Multiple Regression Analysis of Local Processing Ability and IQ Predicting Expressed Behaviors

Predictors	Outcome Variables			
	Social Insight Problems	Social Contact Problems	Stereotyped Behaviors	Anxious/Rigid Behaviors
Control Model R^2	--	--	**.10**	**.32***
Gender	--	--	-2.47 (1.77)	-8.40 (2.91)
Main Effects Model R^2 (or $R^2\Delta$)	**.07**	**.04**	**.12**	**.15**
Gender	--	--	-3.16 (1.80)	-9.81 (2.81)**
Local Processing Ability	-.36 (.36)	.02 (.33)	-.22 (.20)	-.24 (.31)
IQ	-.001 (.08)	-.05 (.07)	-.03 (.04)	-.10 (.07)
Interaction Model $R^2\Delta$	**.07**	**.14**	**.03**	**.04**
Gender	--	--	-3.42 (1.86) †	-10.42 (2.84)**
Local Processing Ability (LPA)	-.39 (.36)	-.02 (.31)	-.24 (.20)	-.28 (.30)
IQ	-.02 (.08)	-.08 (.07)	-.03 (.05)	-.12 (.07)
LPA X IQ	-.02 (.02)	-.03 (.02)	-.01 (.01)	-.02 (.02)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects models show either R^2 (if there is no control in step 1) or $R^2\Delta$ (if a control was used in step 1); and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 20$. †trend, $p < .10$. * $p < .05$. ** $p < .01$.

Mental Flexibility and Expressed Behaviors: Age and IQ as Moderators

Eight moderated multiple regression analyses were conducted with mental flexibility entered as the predictor variable, and social insight problems, social contact problems, stereotyped behaviors, and anxious/rigid behaviors, each individually entered as the outcome variables. In the first four analyses, age was entered as the moderator variable, and in the next four analyses, IQ was entered as the moderator. A total of 27 participants were able to complete the mental flexibility task. Therefore, all eight moderation analyses were conducted with a sample size of 27.

The results of the four moderated multiple regression analyses examining age as a moderator between mental flexibility and expressed behaviors are presented in Table 9. The models examining age as a moderator of the associations between mental flexibility and social insight problems as well as social contact problems were not significant. The first step of the model examining age as a moderator of the association between mental flexibility and stereotyped behaviors was marginally significant, $R^2 = .14$, F (1, 25) = 4.11, $p = .053$, but when mental flexibility and age were entered into the second step, the model was no longer significant. In addition, when the interaction term was entered into the third step, the overall interaction model was not significant, and the interaction term did not add unique variance. The first step of the model examining age as a moderator of the association between mental flexibility and anxious/rigid behaviors was significant, $R^2 = .35$, F (1, 25) = 13.43, $p = .001$, showing gender as a significant predictor. Both the main effects and interaction models were significant overall, $R^2 = .40$, F (3, 23) = 5.14, $p = .007$ and $R^2 = .42$, F (4, 22) = 3.95, $p = .01$, respectively. However, the increase in variance in each of these steps was not significant, $R^2\Delta = .05$, F (2, 23) = 1.00, $p = .38$

and $R^2\Delta = .02$, F (1, 22) = .63, $p = .44$, respectively. Only gender emerged as a significant predictor in either step, $B = -8.80$, $SE = 2.71$, $p = .004$ in step 2 and, $B = -8.90$, $SE = 2.73$, $p = .004$ in step 3. The interaction term did not add unique variance and, thus, age did not significantly moderate the association between mental flexibility and anxious/rigid behaviors.

Table 9

Results of Moderated Multiple Regression Analysis of Mental Flexibility and Age Predicting Expressed Behaviors

Predictors	Outcome Variables			
	Social Insight Problems	Social Contact Problems	Stereotyped Behaviors	Anxious/Rigid Behaviors
Control Model R^2	--	--	**.14***	**.35****
Gender	--	--	-2.87 (1.42)	-9.64 (2.63)**
Main Effects Model R^2 (or $R^2\Delta$)	**.004**	**.05**	**.04**	**.05**
Gender	--	--	-2.71 (1.48)	-8.80 (2.71)**
Mental Flexibility	-4.33 (15.07)	13.80 (.31)	-2.40 (7.76)	-18.01 (14.19)
Age	-.04 (.52)	.08 (11.99)	-.27 (.26)	-.26 (.47)
Interaction Model $R^2\Delta$	**.05**	**.03**	**.0004**	**.02**
Gender	--	--	-2.72 (1.51) †	-8.90 (2.73)**
Mental Flexibility (MF)	-11.97 (8.29)	8.50 (13.29)	-2.01 (8.77)	-12.65 (15.82)
Age	-.07 (.51)	-.10 (.41)	-.27 (.26)	-.24 (.48)
MF X Age	-8.93 (8.29)	-6.20 (6.63)	.44 (4.26)	6.11 (7.70)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects models show either R^2 (if there is no control in step 1) or $R^2\Delta$ (if a control was used in step 1); and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 27$. †trend, $p < .10$. * $p < .05$. ** $p < .01$.

The results of the four moderated multiple regression analyses examining IQ as a moderator between mental flexibility and expressed behaviors are presented in Table 10. The models examining IQ as a moderator of the associations between mental flexibility and social insight problems as well as social contact problems were not significant. As indicated above when examining age as a moderator, the first step of the model examining IQ as a moderator of the association between mental flexibility and stereotyped behaviors was significant, $R^2 = .14$, F (1, 25) = 4.11, $p = .053$, indicating gender as a significant predictor. However, the second step main effects) and third step (interaction) were nonsignificant. As indicated above when examining age as a moderator, the first step of the model examining IQ as a moderator of the association between mental flexibility and anxious/rigid behaviors was significant, $R^2 = .35$, F (1, 25) = 13.43, $p = .001$, indicating gender as a significant predictor. Both the main effects and interaction models were significant overall, $R^2 = .44$, F (3, 23) = 5.96, $p = .004$ and $R^2 = .49$, F (4, 22) = 5.31, $p = .004$, respectively. However, the increase in variance in each of these steps was not significant, $R^2\Delta = .09$, F (2, 23) = 1.80, $p = .19$ and $R^2\Delta = .05$, F (1, 22) = 2.34, $p = .14$, respectively. Only gender emerged as a significant predictor in either step, $B = -9.17$, $SE = 2.63$, $p = .002$ in step 2 and $B = -9.53$, $SE = 2.57$, $p = .001$ in step 3. The interaction term did not add unique variance and, thus, IQ did not significantly moderate the association between mental flexibility and anxious/rigid behaviors.

Table 10

Results of Moderated Multiple Regression Analysis of Mental Flexibility and IQ Predicting Expressed Behaviors

Predictors	Outcome Variables			
	Social Insight Problems	Social Contact Problems	Stereotyped Behaviors	Anxious/Rigid Behaviors
Control Model R^2	--	--	**.14**†	**.35***
Gender	--	--	-2.87 (1.42)†	-9.64 (2.63)**
Main Effects Model R^2 (or $R^2\Delta$)	**.004**	**.06**	**.01**	**.09**
Gender	--	--	-2.73 (1.52)†	-9.12 (2.63)**
Mental Flexibility	-4.21 (15.13)	13.13 (12.00)	-2.76 (7.95)	-19.99 (13.79)
IQ	.01 (.05)	-.02 (.04)	-.003 (.03)	-.06 (.05)
Interaction Model $R^2\Delta$	**.06**	**.01**	**.01**	**.05**
Gender	--	--	-2.80 (1.55)†	-9.53 (2.57)**
Mental Flexibility (MF)	4.28 (16.53)	15.03(13.49)	-.79 (8.96)	-10.22 (.05)
IQ	.01 (.05)	-.02(.04)	-.003 (.03)	-.06 (.05)
MF X IQ	.72 (.59)	.16(.48)	-.16 (.31)	.79(.52)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects models show either R^2 (if there is no control in step 1) or $R^2\Delta$ (if a control was used in step 1); and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 27$. †trend, $p < .10$. * $p < .05$. ** $p < .01$.

Planning and Expressed Behaviors: Age and IQ as Moderators

Four moderated multiple regression analyses were conducted with planning ability entered as the predictor variable, and social insight problems and acting out behaviors as the outcome variables. In the first two analyses, age was entered as the moderator variable, and in the next two analyses, IQ was entered as the moderator. Only one participant was unable to complete this task, so the sample size for all analyses was 28.

The results of the two moderated multiple regression analyses examining age as a moderator between planning ability and expressed behaviors are presented in Table 11. The model examining age as a moderator of the association between planning ability and social insight problems was not significant. The first step of the model examining age as a moderator of the association between planning ability and acting out behaviors was significant, $R^2 = .33$, F (1, 26) = 13.05, $p = .001$, indicating gender as a significant predictor. Both the main effects and interaction models were significant, $R^2 = .38$, F (3, 24) = 4.90, $p = .009$ and $R^2 = .39$, F (4, 23) = 3.72, $p = .02$, respectively. However, the increase in variance in each of these steps was not significant, $R^2\Delta = .05$, F (2, 24) = .88, $p = .43$ and $R^2\Delta = .01$, F (1, 23) = .50, $p = .49$, respectively. Only gender emerged as a significant predictor in either step, $B = -8.37$, $SE = 2.32$, $p = .001$ in step 2 and $B = -7.82$, $SE = 2.47$, $p = .004$ in step 3. The interaction term did not add unique variance and, thus, age did not significantly moderate the association between planning ability and acting out behaviors.

Table 11

Results of Moderated Multiple Regression Analysis of Planning Ability and Age Predicting Expressed Behaviors

	Outcome Variables	
Predictors	Social Insight Problems	Acting Out Behaviors
Control Model R^2	--	**.33***
Gender	--	-8.29 (3.03)
Main Effects Model R^2 (or $R^2\Delta$)	**.02**	**.05**
Gender	--	-8.37 (2.29)**
Planning Ability	-.19 (.28)	.23 (.22)
Age	.20 (.63)	-.60 (.49)
Interaction Model $R^2\Delta$	**.09**	**.01**
Gender	--	-7.82 (2.47)**
Planning Ability (PA)	-.08 (.28)	-.26 (.23)
Age	-.53 (.76)	-.87 (.62)
PA X Age	.21 (.13)	.08 (.11)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects models show either R^2 (if there is no control in step 1) or $R^2\Delta$ (if a control was used in step 1); and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 28$. * $p < .05$. ** $p < .01$.

The results of the two moderated multiple regression analyses examining IQ as a moderator between planning ability and expressed behaviors are presented in Table 12. The model examining IQ as a moderator of the association between planning ability and social insight problems was not significant. As indicated above when examining age as a moderator, the first step of the model examining IQ as a moderator of the association between planning ability and acting out behaviors was significant, $R^2 = .33$, F (1, 26) = 13.05, $p = .001$, showing gender as a significant predictor. The main effects and interaction models were significant overall, $R^2 = .35$, F (3, 24) = 4.28, $p = .02$ and $R^2 = .36$, F (4, 23) = 3.22, $p = .03$, respectively. However, the increase in variance at each of

these steps was not significant, $R^2\Delta = .01$, F (2, 24) = .26, $p = .77$ and $R^2\Delta = .01$, F (1, 23) = .39, $p = .54$, respectively. Only gender emerged as a significant predictor in either step, $B = -8.25$, $SE = 2.38$, $p = .002$ at step 2 and $B = -7.95$, $SE = 2.46$, $p = .004$ at step 3. The interaction term did not add unique variance and, thus, IQ did not significantly moderate the association between planning ability and acting out behaviors.

Table 12

Results of Moderated Multiple Regression Analysis of Planning Ability and IQ Predicting Expressed Behaviors

	Outcome Variables	
Predictors	Social Insight Problems	Acting Out Behaviors
Control Model R^2	--	**.33***
Gender	--	-8.29 (2.29)**
Main Effects Model R^2 (or $R^2\Delta$)	**.01**	**.05**
Gender	--	-8.25 (2.38)**
Planning Ability	-.14 (.25)	.09 (2.38)
IQ	.01 (.06)	.03 (.04)
Interaction Model $R^2\Delta$	**.01**	**.01**
Gender	--	-7.95 (2.46)**
Planning Ability (PA)	-.15 (.25)	.09 (.20)
IQ	.01 (.06)	.03 (.05)
PA X IQ	-01 (.01)	-.01 (.01)

Note. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects models show either R^2 (if there is no control in step 1) or $R^2\Delta$ (if a control was used in step 1); and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 28$. * $p < .05$. ** $p < .01$.

Disinhibition and Acting Out Behaviors: Age and IQ as Moderators

Four moderated multiple regression analyses were conducted with disinhibition entered as the predictor variable and acting out behaviors as the outcome variable. In the first two analyses, age was entered as the moderator variable, and the predictor variables

were disinhibition as assessed by commission errors on parts 1 and 2 of the Go/No Go task. In the third and fourth analyses, IQ was entered as the moderator variable, and the predictor variables for disinhibition remained the same. Four participants were unable to complete this task, so the sample size for all analyses was 25.

The results of the two moderated multiple regression analyses examining age as a moderator between disinhibition and acting out behaviors are presented in Table 13, whereas the results of the two moderated multiple regression analyses examining IQ as a moderator between disinhibition and acting out behaviors are presented in Table 14 . In all four analyses, the first step of the model accounted for a significant amount of variance in acting out behaviors, $R^2 = .30$, $F\ (1, 23) = 9.85$, $p = .005$, indicating gender as significant predictor, $B = -7.35$, $SE = 2.34$, $p = .005$. As with the previous moderated multiple regression analyses, subsequent steps in each of the four analyses were only significant because gender was significant. There was no unique variance contributed by the main effects or interactions.

Table 13

Results of Moderated Multiple Regression Analysis of Disinhibition and Age Predicting Acting Out Behaviors

	Disinhibition: Part 1 versus Part 2	
Predictors	Part 1	Part 2
Control Model R^2	**.30****	**.30****
Gender	-7.35 (2.34)	-7.35 (2.34)
Main Effects Model $R^2\Delta$ (or $R^2\Delta$)	**.04**	**.03**
Gender	-7.82 (2.48)**	-7.09 (2.49)*
Disinhibition	-21.13 (32.00)	18.65 (42.26)
Age	-.48 (.47)	-.27 (.44)
Interaction Model $R^2\Delta$	**.03**	**.03**
Gender	-7.99 (2.48)*	-7.11 (2.49)**
Disinhibition	-52.51 (44.36)	45.36 (49.99)

Table 13 (continued).

Predictors	Part 1	Part 2
Age	-.86 (.60)	-.08 (.48)
Disinhibition X Age	-22.46 (22.01)	21.23 (21.22)

Note. Outcome variable for both analyses is acting out behaviors. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 25$. * $p < .05$. ** $p < .01$.

Table 14

Results of Moderated Multiple Regression Analysis of Disinhibition and IQ Predicting Acting Out Behaviors

	Disinhibition: Part 1 versus Part 2	
Predictors	Part 1	Part 2
Control Model R^2	**.30****	**.30****
Gender	-7.35 (2.34)**	-7.35 (2.34)**
Main Effects Model R^2 (or $R^2\Delta$)	**.002**	**.02**
Gender	-7.49 (2.52)**	-6.93 (5.36)*
Disinhibition	-7.95 (31.96)	28.62 (41.74)
IQ	.01 (.05)	-.01 (.05)
Interaction Model $R^2\Delta$	**.003**	**.01**
Gender	-7.49 (2.58)**	-7.11 (2.56)*
Disinhibition	3.36 (51.32)	40.03 (47.30)
IQ	-.01 (.07)	-.02 (.06)
Disinhibition X IQ	-.74 (2.60)	-1.48 (2.71)

Note. Outcome variable for both analyses is acting out behaviors. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 25$.

* $p < .05$. ** $p < .01$.

Inhibition and Anxious/Rigid Behaviors: Age and IQ as Moderators

Four moderated multiple regression analyses were conducted with inhibition entered as the predictor variable and anxious/rigid behaviors as the outcome variable. In the first two analyses, age was entered as the moderator variable, and the predictor variables were inhibition as assessed by omission errors on parts 1 and 2 of the Go/No Go task. In the third and fourth analyses, IQ was entered as the moderator variable, and the predictor variables for inhibition remained the same. Four participants were unable to complete this task, so the sample size for all analyses was 25.

The results of the two moderated multiple regression analyses examining age as a moderator between inhibition and anxious/rigid behaviors are presented in Table 15, whereas the results of the two moderated multiple regression analyses examining IQ as a moderator between inhibition and anxious/rigid behaviors are presented in Table 16. In all four analyses the first step of the model accounted for a significant amount of variance in acting out behaviors, $R^2 = .34$, $F\ (1, 23) = 11.62$, $p = .002$, indicating gender as significant predictor, $B = -9.79$, $SE = 2.87$, $p = .002$. As with the previous moderated multiple regression analyses, subsequent steps in each of the four analyses were only significant because gender was significant. There was no unique variance contributed by the main effects or interactions.

Table 15

Results of Moderated Multiple Regression Analysis of Inhibition and Age Predicting Anxious/Rigid Behaviors

	Inhibition: Part 1 versus Part 2	
Predictors	Part 1	Part 2
Control Model R^2	**.34****	**.34****
Gender	-9.79 (2.87)**	-9.79 (2.87)**

Table 15 (continued).

Predictors	Part 1	Part 2
Main Effects Model R^2 (or $R^2\Delta$)	**.02**	**.06**
Gender	-9.58 (2.97)**	-9.97 (2.88)**
Inhibition	-24.80 (34.20)	30.58 (23.48)
Age	-.07 (.56)	.05 (.54)
Interaction Model $R^2\Delta$	**.01**	**.00**
Gender	-9.74 (3.06)**	-9.95 (3.05)**
Inhibition	41.54 (55.36)	30.25 (31.23)
Age	.13 (.76)	.04 (.67)
Inhibition X Age	7.95 (20.40)	-.21 (12.50)

Note. Outcome variable for both analyses is anxious/rigid behaviors. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor. Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 25$. * $p < .05$. ** $p < .01$.

Table 16

Results of Moderated Multiple Regression Analysis of Inhibition and IQ Predicting Anxious/Rigid Behaviors

	Inhibition: Part 1 versus Part 2	
Predictors	Part 1	Part 2
Control Model R^2	**.34****	**.37****
Gender	-9.79 (2.87)**	-9.79 (2.87)**
Main Effects Model R^2 (or $R^2\Delta$)	**.13**	**.20***
Gender	-9.75 (2.72)**	-10.30 (2.58)**
Inhibition	34.03 (28.52)	37.81 (19.45)
IQ	-.11 (.06)	-.01 (.05)
Interaction Model $R^2\Delta$	**.02**	**.04**
Gender	-9.52 (2.75)**	-10.63 (2.56)***
Inhibition	62.41 (44.57)	47.80 (20.74)
IQ	-.13 (.06)	-.14 (.05)
Inhibition X IQ	-2.01 (2.52)	-1.37 (1.08)

Note. Outcome variable for both analyses is anxious/rigid behaviors. R^2 and $R^2\Delta$ statistics are shown in **bold** for each model. Control models show R^2; main effects and interaction models show $R^2\Delta$. Unstandardized regression coefficients reported for each predictor.

Standard errors are shown in parentheses. Gender entered as a control variable in step 1 for stereotyped behaviors and anxious/rigid behaviors. $N = 25$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Exploratory Analyses

Although this study conceptualized mental flexibility by examining perseverative errors, there are additional ways that mental flexibility could be conceptualized. Some exploratory analyses were conducted by conceptualizing this construct in two alternative ways. The first of these alternative methods was done by creating a composite score of two raw scores obtained on the WCST: percentage of correct sorts and the number of completed categories. Both of these scores indicate mental flexibility by showing that participants are able to think flexibly and figure out an unknown sorting strategy. To create this composite, raw scores were converted to standardized *z*-scores so that both variables would be on the same scale. The mean of the two *z*-scores was then calculated, and this mean score was used as the second mental flexibility variable. To ensure that this computed *z*-score was a cohesive measure of mental flexibility, correlation analyses were conducted with the two variables comprising it. These two measures were highly and significantly correlated $r(27) = .81$, $p < .001$.

The second alternative mental flexibility variable was created by assessing participants' ability to change their pattern of responding on the Go/No Go task. To compute this variable, first, participants' percent error on the second part of the Go/No Go task (the part in which the rules were reversed) was calculated. This score was created by dividing the total number of errors by the total number of trials administered in the second part of the task. Next, the participants' percent error on the first part of the task was calculated by dividing the total number of errors by the total number of trials administered in the first part of the task. Because this percent error represents

participants' baseline responding abilities on the task, this percentage error score was subtracted from the participant's percentage error score on the second part of the task. Therefore, the resulting score would indicate participants' performance abilities after the rules have been switched (and, therefore, after mental flexibility skills are required). To aid in interpretation of this variable, the error score was multiplied by -1 to reverse the sign of the variable so that the variable to indicate mental flexibility rather than mental inflexibility.

When these variables were correlated with the outcome variables of social insight problems, social contact problems, acting out behaviors, and anxious/rigid behaviors, the negative association between mental flexibility as assessed by performance on the Go/No Go switch task and social insight problems was found to approach significance, $r(25) = -.37$, $p = .067$. In addition, when controlling for gender, the negative association between mental flexibility as assessed by performance on the Go/No Go switch task and anxious/rigid behaviors was found to approach significance, $r(25) = -.40$, $p = .052$.

Interaction models were tested with these variables (examining the association between these mental flexibility variables and social insight problems, social contact problems, acting out behaviors, and anxious/rigid behaviors with age or IQ as a moderator). One interaction emerged as significant, and one interaction emerged as marginally significant. Mental flexibility as conceptualized by performance on the Go/No Go switch task was found to significantly predict stereotyped behaviors for older children, but not for younger children (Figure 2). This is contrary to what would have been expected based on the hypotheses. However, it was hypothesized that higher levels

of mental flexibility would be associated with fewer stereotyped behaviors, and that was true for this model, B = -80.26, SE = 27.41, p = .008.

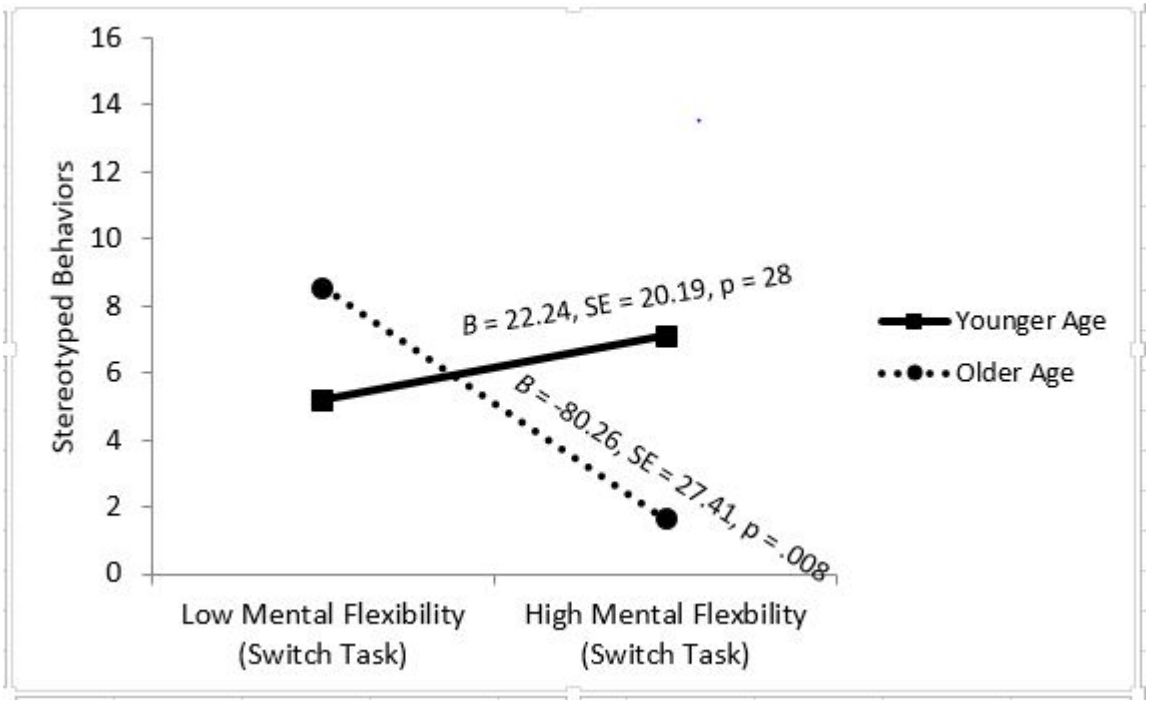

Figure 2. Interaction Between Mental Flexibility and Age Predicting Stereotyped Behaviors

Mental flexibility as conceptualized by performance on the WCST composite was found to marginally predict social insight problems for older children, but not for younger children (Figure 3). This is contrary to what would have been expected based on the hypotheses. In addition, it was hypothesized that higher levels of mental flexibility would be associated with lower social insight problems, but that is not what the model found. Higher levels of mental flexibility were associated with more social insight difficulties, B = 3.94, SE = 2.15, p = .008.

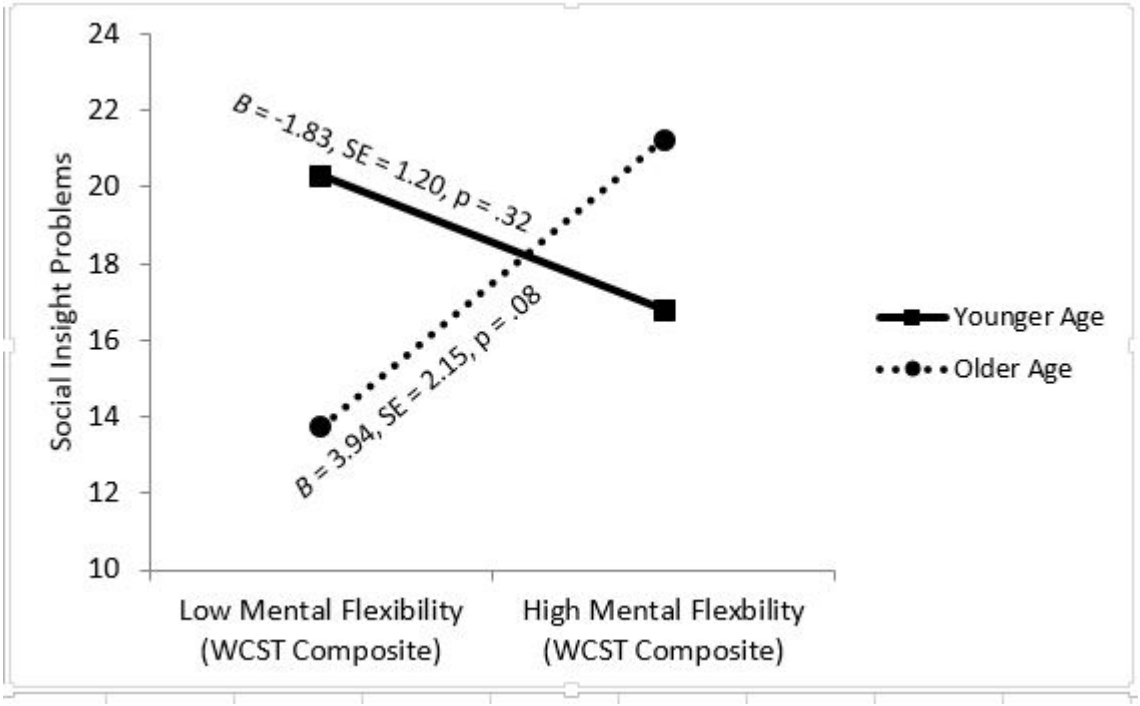

Figure 3. Interaction Between Mental Flexibility and Age Predicting Social Insight Problems. Note. WCST = Wisconsin Card Sorting Task .

Although planned exploratory analyses were to be conducted to examine the possibility of a three-way interaction (endophenotype X age X IQ) in predicting expressed behaviors, these analyses were not conducted given the small sample size in the current study and the unlikelihood that a three-way interaction would be found, given no main effects or two-way interactions were supported.

CHAPTER IV

DISCUSSION

Goals of the Current Study

The current study examined associations among endophenotypes and expressed behaviors in children with ASD. In addition, the study examined two potential moderators of these associations: age and IQ. Hypothesis 1 was that local processing ability, as assessed by performance on an embedded figures task, would be positively associated with social insight problems, social contact problems, stereotyped behaviors, and anxious/rigid behaviors in children with ASD. However, the current study did not find any significant associations between local processing ability and any of the outcome variables. Hypothesis 2 was that mental flexibility, as assessed by less perseverative errors on the Wisconsin Card Sorting Task, would be negatively associated with social insight problems, social contact problems, stereotyped behaviors, and anxious/rigid behaviors. However, the study did not find any significant associations between mental flexibility and any of the outcome variables. Hypothesis 3 was that planning abilities would be negatively associated with acting out behaviors and social contact problems. However, the study did not find any significant associations between mental flexibility and those two outcome variables. Hypothesis 4 was that disinhibition would be positively associated with acting out behaviors, and Hypothesis 5 was that inhibition would be positively associated with anxious/rigid behaviors. However, the study did not find any significant associations between those predictor or outcome variables.

These nonsignificant findings suggest a few different interpretations. The first interpretation is related to sample size limitations. Depending on the particular endophenotype task being completed, only 20 to 28 participants were included in the

analyses. It is likely that the study's small sample size did not provide adequate power to detect the presence of significant relations among variables even if such relations truly exist.

Another possible interpretation of the nonsignificant findings is that laboratory-based measures of local processing ability, mental flexibility, planning ability, and disinhibition/inhibition do not relate well to real-life expressions of behavior. As discussed in the literature review, previous findings linking lab-based measures of these variables to expressed behaviors have been mixed (i.e., Hill, 2004). It is possible that these endophenotypes are not easily captured by lab-based tests. For example, a study conducted by Chan, Shum, Toulopoulou, and Chen (2008) discussed the limitations that are present in lab-based measures of executive functioning abilities and emphasized the importance of utilizing more context-specific or ecologically valid measures of executive functioning.

A third possibility for the nonsignificant findings is that the expressed behaviors being assessed in this study may have been more significantly impacted by variables other than endophenotypes, such as life experiences or environmental factors. All the children in the sample had received some type of intervention or therapy, so it is possible that those environmental factors impacted any possible associations among endophenotypes and expressed behaviors. An additional explanation for these findings is related to the medication usage of the children. A total of 76% of the children in the sample were reported to be taking medications. These medications may have impacted the participants' performance on the neuropsychological tasks, and/or they may have impacted the presentation of the participants' expressed behaviors. It is possible that if

the participants had not been taking medications, associations may have been found among the endophenotypes and expressed behaviors.

Another factor that may have influenced the results of this study was the presence or absence of other diagnoses. A research study conducted by Sinzig et al. (2008) found that correlations between various executive functioning measures--including mental flexibility, planning, and inhibition— and ASD symptomatology often differed depending on whether the sample group solely had ASD, had ASD and ADHD, solely had ADHD, or were typically-developing. For example, the association between stereotyped behaviors and mental flexibility differed depending on whether the sample was limited to the pure ASD group or the ASD + ADHD group. Therefore, the comorbidity of an ADHD diagnosis (which was true for 48% of the sample) may have affected some of the results of this study.

Ultimately, it is possible that these nonsignificant findings reflect the fact that these potential endophenotypes are in fact not related to the expressed behaviors and therefore may not be best conceptualized as true endophenotypes.

All but one of the primary (i.e., non-exploratory) tested moderation models were found to be nonsignificant. One likely explanation for these nonsignficant moderation findings is the small sample size of the current study. The moderation analyses in this study ranged from having a sample size from 20 to 28 participants, so the analyses were therefore greatly underpowered. The current study was proposed to have a total of 60 participants, but due to recruitment difficulties, only a total of 29 participants were able to be tested. Increasing the number of participants at a later date would make it much more likely to find a significant effect if one is in fact present. The many large effect sizes that

were found across many of the analyses suggest that with a larger sample size, statistically significant findings may be found.

It is also possible that the reason there were so many nonsignificant moderation findings is that the proposed moderators do not in fact influence the relation between endophenotypes and the expressed behaviors in the manner hypothesized. For example, age may not interact with endophenotypes to influence the expression of behaviors as significantly as other factors interact, such as therapy services or interventions. Research suggests that interventions and therapy services can greatly impact the symptom presentation in children with ASD (Corsello, 2005). Although age would likely be a proxy for the amount of interventions an individual received, examining the role of therapy services directly may be more beneficial. In addition, it is possible that the IQ variable used in the study was not the most appropriate variable to use to assess cognitive functioning level. As individuals with ASD often have verbal deficits, using a nonverbal IQ score composite may have been a better method to conceptualize cognitive abilities in these children.

It is also worth noting that gender was found to be a significant predictor of stereotyped behaviors, anxious/rigid behaviors, and acting out behaviors. The effect of gender tended to hold across steps in the various models, even when other predictors (endophenotypes, age, IQ, and interaction terms) were entered. Thus, gender was a robust predictor of these expressed behaviors. Specifically, being male rather than being female was associated with these outcomes. This finding may suggest different symptom expression for boys versus girls and also may highlight the gender discrepancy present in ASD (with boys being much more commonly diagnosed than girls).

The one significant interaction that was found in this study was as follows: in older children, but not in younger children, local processing ability significantly predicted stereotyped behaviors, with higher levels of local processing abilities being associated with lower levels of stereotyped behaviors. This is contrary to what was predicted. One explanation for this finding may be that using the GEFT as a measure of local processing was not the most appropriate measure to assess this construct. Completing the GEFT requires abilities other than local processing, such as concentration, problem-solving abilities, and the ability to sustain attention on a task. In addition, the GEFT was the one measure found to be marginally associated with IQ, suggesting that it may better reflect cognitive functioning abilities than local processing abilities. It is possible that individuals who score higher on the GEFT have higher levels of concentration and cognitive functioning abilities, and are therefore less likely to exhibit stereotyped behaviors, which are often indicative of lower functioning abilities. Additionally, using a measure like the GEFT to assess local processing ability rather than using a measure to directly assess deficits in central coherence may not have been a suitable measure to use to examine real-life social difficulties. Difficulties understanding the context of social situations may be more closely linked to direct difficulties with perceiving the gestalt or the whole.

In general, it is possible that many of the study's nonsignificant findings may be related to the methods used to conceptualize various endophenotypes. Although the measures used in the current study have been reliably used in previous research and have been shown to assess these particular constructs, it is also true that these measures tap into a wide variety of abilities other than the constructs that are being directly measured.

Therefore, it is possible that constructs such as “mental flexibility” or “inhibition” were not being fully assessed by the measures used in this study. In addition, as mentioned in the exploratory analysis section, there are multiple ways of conceptualizing particular constructs within an individual measure. For example, latencies could be used, percent correct could be used, etc. It is possible that scoring the measures in alternative ways may have provided better ways of conceptualizing particular constructs.

There was one significant and one marginally significant moderation finding when exploratory interaction analyses were conducted. When mental flexibility was conceptualized as performance on the switch-task portion of the Go/No Go task (having to switch response patterns), higher levels of mental flexibility were associated with fewer stereotyped behaviors for older rather than younger children. It is expected that higher levels of mental flexibility would be associated with fewer repetitive and stereotyped behaviors. However, it is unexpected that this association would occur for older children rather than for younger children. Perhaps in younger children stereotyped behaviors are less a reflection of mental flexibility capabilities and instead are related to developmentally expected repetitive behaviors or sensory-seeking activities.

In the exploratory analyses, mental flexibility as conceptualized by overall performance on the WCST was found to marginally predict social insight problems for older children, but not for younger children. This is contrary to what would have been expected based on the hypotheses. In addition, it was hypothesized that higher levels of mental flexibility would be associated with lower social insight problems, but the model found that higher levels of mental flexibility were associated with more social insight difficulties. Although unexpected, it is possible that this finding reflects the fact that

individuals with more mental flexibility capabilities may be less sure of how to respond in social situations or how to pay attention in their environment due to a very adaptable and flexible mindset.

Limitations of the Current Study

The most significant limitation of this study is the small sample size. To adequately test for correlations and for moderations, a larger sample size would be needed. Before beginning testing, a power analysis was completed to determine an appropriate sample size for this study, yielding a projected sample size of 60. A post-hoc power analysis based on 4 predictors (control, main effects, and interaction term), an average effect size of $R^2\Delta = .04$ (the average found in this study), an alpha level set at .05, and a maximum sample size of 28 for any given analysis, average power across this study was only .17.

Thus, this study was substantially underpowered. Because of significant recruitment difficulties, it was only possible to test 29 participants at the time that the analyses for the current report were conducted. As such, recruitment should continue for this study to increase the sample size and further test for significant effects. Clinics, schools, and camps should be contacted to aid in recruitment. The study design requires that the researcher physically meet with the child participant for testing. It is not possible for the testing to be completed online or electronically due to the need for an IQ test and neuropsychological testing, which can create a data collection barrier. In addition, the testing session is rather long (1.5 to 2 hours), so participants may hesitate to participate due to the time involved. It is possible that the study could be shortened by eliminating

some of the neuropsychological testing measures, but that would limit the findings of the study and would make it impossible to test some of the research questions.

Another limitation of the study is the difficulty to separate particular endophenotypes from other abilities. For example, it is impossible to test planning abilities without somewhat tapping into other constructs such as attention, motivation, and impulsivity. Therefore, it is not always clear what particular construct is relating or not relating to a particular expressed behavior. Although this is a limitation that cannot be completely eradicated, adding additional measures that have been shown to tap into a particular construct may make that predictor a more robust measure of a construct. For example, creating a composite score for planning abilities that is made up of three tests that tap into planning ability may be a better indicator of planning ability than one test. However, even this strategy would not completely address the problem. Furthermore, increasing the tests included in the study would also add to the time it takes to complete the study and may increase fatigue or make it less likely that participants would agree to participate in the study.

A final limitation of the study is that the expressed behaviors of social insight problems, social contact problems, stereotyped behaviors, acting out behaviors, and anxious/rigid behaviors were all assessed through one measure and were only assessed via parent report. Increasing the number of questionnaires that the parents complete and creating a composite score of overall difficulties in these areas may better assess children's true difficulties in these areas. In addition, assessing child behaviors through methods other than parent report, such as teacher report or even direct behavioral coding,

would likely create a more comprehensive picture of the participants' true behavioral profile.

Future Directions of Study

Given that significant associations between these endophenotypes and expressed behaviors were not found, further research should examine other factors that may relate to the presence of these expressed behaviors. For example, research should examine the association between medication, therapy services, and educational services on these expressed behaviors.

As gender was found to relate to stereotyped behaviors, anxious/rigid behaviors, and acting out behaviors in this sample, it may also be beneficial to further explore the role of gender in the presentation of these expressed behaviors. Further research should examine whether and to what extent symptoms differ in children with ASD based on their gender. In addition, the impact of gender on treatment should be further explored as it is possible that boys and girls may respond differentially to particular treatment approaches.

Given that the proposed moderation models did not hold for this sample, further research should examine other potential moderators. As previously mentioned, examining medication usage, therapy services, nonverbal IQ, or gender as moderators may be beneficial.

Conclusions

Examining underlying factors that relate to expressed behaviors in children with ASD is crucial to better understand this disorder as well as to better develop treatment methods to target behavioral difficulties. This study examined the association between the potential endophenotypes of local processing ability, mental flexibility, planning ability, and disinhibtion/inhibition and the expressed behaviors of social insight

problems, social contact problems, anxious/rigid behaviors, acting out behaviors, or stereotyped behaviors. The study also examined whether these associations were moderated by the age or cognitive functioning level of the child. The current study did not find any association between lab-based measures of the potential endophenotypes or any of the expressed behaviors. In addition, age and IQ were not systematically found to influence any of the associations with the exception of two instances (local processing ability predicting less stereotyped behaviors in older children and mental flexibility predicting less stereotyped behaviors in older children). The nonsiginficant findings of this study are likely attributable to the small sample size of the study ($N = 29$). Further research should continue to examine this question with a larger sample size to determine if there is in fact an association to be found in an adequately powered sample. However, if associations are still not found within a larger sample, further research should examine the impact of other variables on these expressed behaviors, such as treatment history or other executive functioning or processing abilities.

APPENDIX A

THE CHILDREN'S SOCIAL BEHAVIOR QUESTIONNAIRE ITEMS

The following are a number of statements about children's behaviors. Please rate each item as to how child in the preceding two months. The possible answers are Does Not Apply (0), Sometimes or Somewhat Applies (1), and Clearly or Often Applies (2). PLEASE ANSWER ALL ITEMS.

	Does Not Apply	Sometimes or Somewhat Applies	Clearly or Often Applies
1. Talks confusedly; jumps from one subject to another in speaking	0	1	2
2. Only talks about things that are of concern for himself/herself	0	1	2
3. Does not fully understand what is being said to him/her i.e., tends to miss the point	0	1	2
4. Frequently says things that are not relevant to the conversation	0	1	2
5. Does not understand jokes	0	1	2
6. Takes things literally e.g., does not understand certain expressions	0	1	2
7. Is exceptionally naive; believes anything you say	0	1	2
8. Over-reacts to everything and everyone	0	1	2
9. Draws excessive attention to him/herself	0	1	2
10. Flaps arms/hands when excited	0	1	2
11. Makes odd, fast movements with fingers or hands	0	1	2
12. Sways to and fro	0	1	2
13. Does not look up when spoken to	0	1	2
14. Acts as if others are not there	0	1	2
15. Lives in a world of his/her own	0	1	2
16. Makes little eye contact	0	1	2
17. Dislikes physical contact	0	1	2
18. Does not seek comfort	0	1	2
19. Does not initiate play with other children	0	1	2
20. Has little or no need for contact with others	0	1	2

21. Does not respond to initiatives by others e.g., does not play along when asked	0	1	2
22. Is unusually sensitive to certain sounds (e.g., always hears certain sounds earlier than other people)	0	1	2
23. Is extremely pleased by certain movements and keeps doing them e.g., turning around and around	0	1	2
24. Smells objects	0	1	2
25. Constantly feels objects	0	1	2
26. Is fascinated by certain colors, forms, or moving objects	0	1	2
27. Has difficulties doing two things simultaneously e.g., he/she cannot dress and listen to parent at the same time	0	1	2
28. Does things without realizing what stage of the activity he/she has reached (beginning, middle, ending)	0	1	2
29. Does things without realizing the aim e.g., constantly has to be reminded to finish things	0	1	2
30. Shows sudden changes of mood	0	1	2
31. Quickly gets angry	0	1	2
32. Stays angry for a long time e.g., when he/she does not get his/her way	0	1	2
33. Cannot be made enthusiastic about anything; does not particularly like anything	0	1	2
34. Does not show his/her feelings in facial expressions and/or bodily posture	0	1	2
35. Does not appreciate danger	0	1	2
36. Barely distinguishes between strangers and familiar people e.g., readily goes with strangers	0	1	2
37. Is disobedient	0	1	2
38. Cannot be corrected in situations in which he/she has done something wrong	0	1	2
39. Takes in information with difficulty	0	1	2
40. Makes inconsiderate remarks e.g., remarks that are painful to others	0	1	2
41. Does not appreciate it when someone else is hurt or sad	0	1	2
42. Makes a fuss over little things; “makes a mountain out of a mole-hill”	0	1	2

43. Does not know when to stop, e.g., goes on and on about things	0	1	2
44. Is extremely stubborn	0	1	2
45. Panics in new situations or if change occurs	0	1	2
46. Remains clammed up in new situations or if change occurs	0	1	2
47. Opposes change	0	1	2
48. Gets lost easily e.g., when out with someone	0	1	2
49. Has no sense of time	0	1	2
50. Behaves inappropriately in public places	0	1	2
51. Cannot imitate other people's behavior; cannot "pretend to be"	0	1	2
52. Has difficulties in concentrating on something for more than a short period of time	0	1	2
53. Makes a point of doing certain things in the same way all the time	0	1	2
54. Cries for incomprehensible reasons	0	1	2
55. Reacts in an excessively scared or jumpy fashion to loud noises	0	1	2
56. Does not bother to keep a conversation going	0	1	2
57. Talks too loudly	0	1	2
58. Behaves aggressively	0	1	2
59. Compared to peers, is particularly afraid of certain animals or situations	0	1	2
60. Does not begin to play with other children	0	1	2
61. Talks over and over again about something that happened in the past	0	1	2
62. Has strange or bizzare thoughts	0	1	2
63. Stands too close to strangers when talking to them	0	1	2
64. Has few or no real friends	0	1	2
65. Has difficulties in concentrating, e.g. on games	0	1	2
66. Is oversensitive to pain	0	1	2
67. Cannot sit still; some part or other of him/her is always moving	0	1	2
68. Discards things from the past too easily, e.g., major events have not touched him/her	0	1	2

69. Has difficulties finding the way or the exit in other surroundings	0	1	2
70. Is excessively precise	0	1	2
71. Is afraid to be separated from father/mother	0	1	2
72. Pronounces words unclearly	0	1	2
73. Has difficulties associating with peers	0	1	2
74. Is unable to get certain things out of his/her mind	0	1	2
75. Beats, bites or scratches him/herself	0	1	2
76. Is overconcerned that something might happen to father/mother	0	1	2
77. Does not understand that certain things are “not done”	0	1	2
78. Literally repeats words or sentences that have (just) been used by someone else	0	1	2
79. Acts like “a clown,” e.g. in front of others	0	1	2
80. Is overactive, runs and flits to and fro	0	1	2
81. Gets worried about things, long before it is necessary to be so	0	1	2
82. Is clumsy in very fine work, e.g., buttoning up clothes	0	1	2

APPENDIX B

THE UNIVERSITY OF SOUTHERN MISSISSIPPI IRB APPROVAL

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: R-CH13062703
PROJECT TITLE: Age and IQ as Potential Moderators in the Relation among Endophenotypes and Expressed Behaviors in Children with an Autism Spectrum Disorder
PROJECT TYPE: Renewal of a Previously Approved Project
RESEARCHER(S): Elizabeth Fair
COLLEGE/DIVISION: College of Education and Psychology
DEPARTMENT: Psychology
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 01/08/2015 to 01/07/2016
Lawrence A. Hosman, Ph.D.
Institutional Review Board

APPENDIX C

THE UNIVERSITY OF SOUTH ALABAMA IRB APPROVAL

UNIVERSITY OF SOUTH ALABAMA

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INSTITUTIONAL REVIEW BOARD
October 23, 2014

Principal Investigator:	Hanes Swingle		
IRB # and Title:	IRB PROTOCOL: 14-191 [631449-1] Age and IQ as Potential Moderators in the Relation among Endophenotypes and Expressed Behaviors in Children with an Autism Spectrum Disorder		
Status:	APPROVED	Review Type:	Expedited Review
Approval Date:	October 10, 2014	Submission Type:	New Project
Initial Approval:	October 10, 2014	Expiration Date:	October 9, 2015
Review Category:	Category: 45 CFR 46.110 (7): Research on individual or group characteristics or behavior		
DHHS/FDA Subpart D:	45 CFR 46.404: FDA 50.51 - Research not involving greater than MINIMAL RISK to children		

This panel, operating under the authority of the DHHS Office for Human Research and Protection, assurance number FWA 00001602, has reviewed the submitted materials for the following:

1. *Protection of the rights and the welfare of human subjects involved.*
2. *The methods used to secure and the appropriateness of informed consent.*
3. *The risk and potential benefits to the subject.*

The regulations require that the investigator not initiate any changes in the research without prior IRB approval, except where necessary to eliminate immediate hazards to the human subjects, and that **all problems involving risks and adverse events be reported to the IRB immediately!**

Subsequent supporting documents that have been approved will be stamped with an IRB approval and expiration date (if applicable) on every page. Copies of the supporting documents must be utilized with the current IRB approval stamp unless consent has been waived.

Notes:

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