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THEORY OF MIND, EXECUTIVE FUNCTION, AND SOCIAL SKILLS IN HIGH-FUNCTIONING CHILDREN WITH AUTISM SPECTRUM DISORDERS

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Dissertation under the direction of Professor Wendy L. Stone

One very striking feature of high-functioning individuals with autism spectrum disorders (ASD) is the severity of their social impairment despite average or above average intelligence and good outcome in academics. Although there have been strong theoretical arguments linking theory of mind (ToM) deficits to the social impairments seen in ASD, empirical evidence has been equivocal. Interestingly, some researchers have suggested that performance on ToM tasks might relate only to those social skills that require understanding mental states, termed Interactive social skills, but not to more routinized social skills, termed Active social skills. However, results of previous research indicate that some individuals who pass ToM tasks exhibit Interactive social skills as poor as those who fail ToM tasks. The purpose of this study was to examine the hypothesis that additional cognitive deficits in the area of executive function explain the inconsistent relation between ToM and social skills in high-functioning individuals with ASD. Results indicated that executive function and Nonverbal IQ, rather than ToM, were significant predictors of social skills. Future research examining the relation between

nonverbal cognitive skills and social-perceptual abilities may provide more insight into the development and remediation of social skills deficits in high-functioning individuals with ASD.

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CHAPTER I

INTRODUCTION

Autism Spectrum Disorders is an umbrella term referring to a group of developmental disorders characterized by impaired social functioning, disordered communication skills, and stereotyped behaviors and interests. This term comprises five diagnostic categories: Autistic Disorder (autism), Asperger Syndrome (AS), Pervasive Developmental Disorder Not Otherwise Specified (PDDNOS), Rett Disorder, and Childhood Disintegrative Disorder (Filipek et al., 1999). While the latter two diagnoses tend to occur in association with severe mental retardation (Volkmar & Cohen, 1988), autism, AS, and PDDNOS can occur in association with a wider range of intellectual abilities (Ehlers, Gillberg, & Wing, 1999).

Of particular interest to some researchers are high-functioning autism spectrum disorders (ASD). It is thought that this subgroup of ASD allows researchers to observe "pure" autism symptoms, that is, symptoms of autism which occur in the absence of mental retardation (Heavy, Phillips, Baron-Cohen, & Rutter, 2000). Although the specific scores used to classify individuals as high-functioning vary widely across studies, for example, use of Verbal vs. Nonverbal IQ scores and standard score cut-offs ranging from 65 to 85, there is a general consensus that "high-functioning" individuals have at least one IQ score in the borderline range or above (Bacon, Fein, Morris, Waterhouse, & Allen, 1998; Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Bowler, 1997; Buitelaar & Van der Wees, 1997; Capps, Sigman, & Yirmiya, 1995;

Capps, Yirmiya, & Sigman, 1992; Dahlgren & Trillingsgaard, 1996; Freeman, Lucas, Forness, & Ritvo, 1985; Jaedicke, Storoschuk, & Lord, 1994; Ozonoff, Rogers, & Pennington, 1991; Tsai, 1992; Yirmiya & Sigman, 1991).

The term "high-functioning", then, refers to cognitive ability, not reduced severity of autism symptoms. In fact, one very striking feature of high-functioning individuals with ASD is the severity of their social impairment despite their average or above average intelligence and good outcome in academics (Klin, 2000; Klin, Jones, Schultz, & Volkmar, 2003; Shah & Wing, 1986; Wing, 1992; Yirmiya & Sigman, 1991). Although some high-functioning individuals with ASD are socially disinterested or aloof, for many it is lack of social skills, rather than lack of social interest, that hinders formation of social relationships (Rumsey, Rapoport, & Sceery, 1985; Szatmari, 1991; Volkmar, Klin, Marans, & McDougle, 1996; Wing, 1981). High-functioning individuals with ASD usually fail to develop normal peer friendships (Szatmari, Bremner, & Nagy, 1989; Tsai, 1992; Tsai & Scott-Miller, 1988), often forming their closest relationships with parents and teachers (Kanner, Rodriguez, & Ashenden, 1972; Schopler & Mesibov, 1983), or maintaining peer social relationships only within structured activities or organizations (Rumsey et al., 1985). Often high-functioning individuals with ASD are aware of their social limitations and differences (Green, 1990; Tantam, 1988; Wing, 1981), and make a conscious effort to compensate for their difficulties (Volkmar et al., 1996). They attempt to navigate social interactions by memorizing extensive rules and social scripts which are overly specific and generalize poorly to other situations (Rumsey et al., 1985; Volkmar et al., 1996).

One popular theory to explain the social skill deficits of individuals with ASD is that they have a specific cognitive impairment affecting their ability to understand mental states, i.e., an impaired "theory of mind". Theory of mind (ToM) refers to the ability to attribute internal mental states, such as beliefs, desires, and intentions, to one's self and others and to use those attributions to understand and predict behavior (Premack & Woodruff, 1978; Wellman, 1993). A multitude of evidence suggests that lower-functioning persons with autism have severe deficits in ToM ability (Baron-Cohen, Leslie, & Frith, 1985; Happé & Frith, 1995; Leekam & Perner, 1991; Leslie & Frith, 1988; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998), and there have been strong theoretical arguments linking ToM deficits to the social impairments seen in ASD (Baron-Cohen et al., 1985; Leslie & Frith, 1988). However, until recently this hypothesized relation has received surprisingly little empirical attention, and results across studies examining this relation have been equivocal (Fombonne, Siddons, Achard, Frith, & Happe, 1994; Frith, Happe, & Siddons, 1994; Hillier & Allinson, 2002; Joseph & Tager-Flusberg, 2004; Losh & Capps, 2003; Oswald & Ollendick, 1989; Prior, Dahlstrom, & Squires, 1990; Travis, Sigman, & Ruskin, 2001).

Furthermore, the possible contribution of additional areas of cognitive deficit to social impairment has also received little attention. One proposed area of deficit that may affect social skills is executive function. "Executive function" is a broad construct that refers to the cognitive processes related to complex, goal-directed behavior (Duncan, 1986; Ozonoff & Griffith, 2000). It encompasses many skills, such as cognitive shifting, working memory, inhibition, and planning (Ozonoff & Griffith, 2000; Ozonoff, Strayer, McMahon, & Filloux, 1994; Pennington & Ozonoff, 1996). Individuals with ASD

demonstrate impairments on a wide range of executive function tasks (Ozonoff, 1998), and there is some empirical evidence demonstrating a relation between executive function and social skills for this population (Joseph & Tager-Flusberg, 2004; Liss et al., 2001).

The following sections of this paper will: 1) summarize the findings of ToM research with high-functioning individuals with ASD, 2) summarize research examining the relation between ToM and social skills in individuals with ASD, 3) discuss potential explanations for the equivocal research findings, including the possible role of executive function deficits, and 4) describe results from the current study designed to examine the relation between ToM, executive function, and social skills in high-functioning children and adolescents with ASD.

ToM Deficits in High-Functioning Individuals with ASD

Theory of mind (ToM) refers to the ability to attribute internal mental states, such as beliefs, desires, and intentions, to one's self and others and to use those attributions to understand and predict behavior (Premack & Woodruff, 1978; Wellman, 1993). Complexity of these attributions has been categorized theoretically into first-order, second-order, third-order, and "advanced" ToM (Baron-Cohen, Jolliffe et al., 1997; Happé, 1994a; Perner & Wimmer, 1985). ToM tasks of varying levels of difficulty have been developed to explore these different levels of ToM ability in individuals with ASD. First-, second-, and third-order ToM tasks typically measure understanding of false beliefs, while other "advanced" ToM tasks measure a variety of other forms of mental state understanding. Researchers refer to these tasks as "advanced" to indicate that they

are likely more challenging for higher-functioning individuals with ASD than the first and second-order ToM tasks commonly used in studies with this population (Baron-Cohen, Jolliffe et al., 1997).

Lower-functioning persons with ASD are usually tested on first- and second-order ToM tasks, and a multitude of evidence indicates that this group demonstrates significant deficits relative to matched controls (Baron-Cohen, 1989; Baron-Cohen et al., 1985; Happé & Frith, 1995; Leekam & Perner, 1991; Leslie & Frith, 1988; Yirmiya et al., 1998). However, results from studies involving high-functioning individuals with ASD using first- and second-order tasks have been mixed. Although some individuals demonstrate impairment relative to matched controls (Baron-Cohen, Leslie, & Frith, 1986; Ozonoff, Pennington, & Rogers, 1991; Sicotte & Stemberger, 1999), others do not (Bowler, 1992; Bowler, 1997; Buitelaar, Van der Wees, Swabb-Barneveld, & Van der Gaag, 1999a; Dahlgren & Trillingsgaard, 1996; Ozonoff, Rogers et al., 1991). Results from studies using advanced tasks, however, are clearer, with individuals with ASD demonstrating impairments relative to matched controls (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999; Brent, Rios, Happe, & Charman, 2004; Happé, 1994a, 1994b; Heavy et al., 2000; Jolliffe & Baron-Cohen, 1999; Losh & Capps, 2003). Examples of each type of ToM task are described below, and results from studies involving high-functioning individuals with ASD are summarized.

First-order ToM tasks

First-order ToM involves attribution of mental states to self or others about events or objects (e.g., "Sally *thinks* her marble is in the basket.") (Perner & Wimmer,

1985). False-belief paradigms are commonly used to measure first-order ToM in high-functioning individuals with ASD. Success with these tasks hinges on the ability to attribute false beliefs to others and to use those attributions to explain and predict behavior which cannot be accurately explained or predicted based on one's own thoughts or the true state of the world (Frith & Happe, 1999).

One prototypical first-order false belief task is the Sally-Anne task (Baron-Cohen et al., 1985). In this task a scenario is enacted for the participant (usually using dolls) by the end of which the Sally doll should hold a false belief about the location of her marble. Sally places her marble in a basket and leaves the scene. While she is gone, the Anne doll removes the marble from the basket and places it in a box. Sally returns and the participant is asked a "belief" question, "Where does Sally think her marble is?" A Reality and Memory Question ensure that incorrect responses are not due to inaccurate knowledge of the marble's current location or original location. This task is theorized to measure first-order ToM because to answer correctly the participant must have awareness of Sally's (false) belief that her marble is still in the basket.

Although in some studies high-functioning individuals with ASD demonstrate deficits on first-order false belief tasks relative to comparison groups (Baron-Cohen et al., 1985; Ozonoff, Pennington et al., 1991; Sicotte & Stemberger, 1999), in other studies they do not (Buitelaar et al., 1999a; Dahlgren & Trillingsgaard, 1996; Ozonoff, Rogers et al., 1991). While the reason for these discrepant findings is not clear, several researchers have noted that performance on ToM tasks relates strongly to verbal ability (Buitelaar et al., 1999a; Dahlgren & Trillingsgaard, 1996; Eisenmajer & Prior, 1991; Happé, 1994a, 1994b; Ozonoff, Pennington et al., 1991), and comparison across studies reveals that

studies finding ToM deficits usually involve individuals with weaker verbal abilities than studies finding no ToM deficits (Coonrod, 2000; Dahlgren & Trillingsgaard, 1996).

Second-order ToM tasks

While first-order false belief tasks measure attribution of mental states about events or objects (e.g., "Sally *thinks* that her marble is in the basket"), second-order false belief tasks measure attribution of mental states about mental states ("Mary *thinks* that John *thinks* the ice cream man is in the park."). Ability to make second-order attributions is considered necessary for successful social interactions and relationships (Perner & Wimmer, 1985; Tager-Flusberg & Sullivan, 1994). Like first-order false belief tasks, success with second-order ToM tasks requires attributions of other's false beliefs to explain and predict behavior which cannot accurately be explained or predicted based on one's own thoughts or the true state of the world.

In a prototypical second-order false belief task, two characters are independently informed about an unexpected event, resulting in one character's false belief about the other character's knowledge of that event. For example, in the Ice Cream task (Baron-Cohen, 1989; Perner & Wimmer, 1985), a scenario is enacted for the participant (usually using dolls and a miniature town) by the end of which one doll in the story (Mary) should hold a false belief about the thoughts of another doll in the story (John). John and Mary are in the park and see the ice cream man. John does not have enough money to buy ice cream, but the ice cream man tells John in front of Mary that he can go home and get some money because he is going to be selling ice cream in the park all day. John goes home to get some money, leaving Mary in the park. The ice cream man changes his

mind and tells Mary he has decided to leave the park and go sell ice cream at the school. He leaves the park for the school, and, without Mary's knowledge, on his way stops at John's house and tells John that he is now selling ice cream at the school. Later, Mary goes to John's house. John's mother tells Mary that John has gone to buy ice cream. The participant is then asked a belief question, "Where does Mary think John has gone to buy ice cream?"

Given that these stories are typically longer and more complex than those used to test first-order ToM, participants are usually asked comprehension questions throughout the story and memory and reality questions at the end to ensure that incorrect responses on the belief question do not result from a lack of understanding of the story. In addition, second-order ToM false belief tasks sometimes require the participant to justify their response on the belief question by explaining why the person with the false belief thought as he or she did. However, use of the "justification question" is controversial, with researchers disagreeing about whether it measures a higher level of social understanding (Bauminger & Kasari, 1999), or simply a higher level of expressive language skills (Ozonoff & McEvoy, 1994).

Although in some studies high-functioning individuals with ASD demonstrate deficits on second-order false belief tasks relative to matched comparison groups (Ozonoff, Pennington et al., 1991), in others they do not (Bowler, 1992; Bowler, 1997; Dahlgren & Trillingsgaard, 1996; Ozonoff, Rogers et al., 1991). In other studies results are less clear, with individuals with ASD performing more poorly than typically developing, but not disabled, comparison groups (Buitelaar et al., 1999a), or demonstrating deficits on justification, but not belief, questions (Bauminger & Kasari,

1999). Again, in general those individuals with ASD who have stronger verbal skills tend to perform better on second-order ToM tasks than those individuals with weaker verbal skills (Bauminger & Kasari, 1999; Buitelaar et al., 1999a; Dahlgren & Trillingsgaard, 1996; Ozonoff, Pennington et al., 1991).

Third-order ToM tasks

Similar to first- and second- order tasks, third-order tasks involve attributions of mental states about mental states about mental states (e.g., what someone *thinks* others *think* about his *thoughts*) (Happé, 1994a, 1994b; Perner & Wimmer, 1985). "Double bluff" scenarios, scenarios in which an individual presents truthful information that is meant to be seen as incorrect, are one measure of third-order ToM (Happé, 1994a, 1994b). One example is the Prisoner Story in which a "brave and clever" army prisoner tells his captors the exact location of his army's tanks. Correctly explaining the reasons behind this action involves third-order attributions, "The prisoner *knows* that the captors *think* he *intends* to lie."

The Double Bluff scenarios have more frequently been administered only as part of a larger ToM battery (i.e., the Strange Story task described below) and studies using this battery do not report performance separately for the Double Bluff scenarios (Happé, 1994a; Jolliffe & Baron-Cohen, 1999). Only one study has evaluated ToM abilities of high-functioning individuals with ASD using the Prisoner Story alone. Instead of asking the participants to explain why the prisoner responded as he did, or asking where the prisoner thought the captors would look for the tanks, these researchers asked participants to predict where the captors would look for the tanks (Ozonoff & McEvoy, 1994). There

was no comparison group, but pass rates for the individuals with ASD were below chance levels. However, as these authors presented it, this task may only require second-order ToM ("The captors *think* he *intends* to lie"), so the abilities of high-functioning individuals with ASD on third-order ToM tasks remains relatively unexamined.

"Advanced" ToM tasks

In an attempt to uncover the limits of ToM abilities in high-functioning individuals with ASD, researchers have designed tasks that they believe are more sensitive measures of the understanding of mental states in real-life social interaction (Happé, 1994a, 1994b). These tasks deal with more naturalistic, real-life social situations and problems that require understanding of mental states. These tasks are often referred to as "advanced" tasks because they tend to be more challenging than first- and second-order ToM tasks (Baron-Cohen, Jolliffe et al., 1997).

For example, one task was designed to assess the ability to detect faux pas in social situations (Baron-Cohen et al., 1999). Participants are asked a series of questions about short stories presented on an audiotape in which one character says something that is socially inappropriate or embarrassing (e.g. mentioning a party to someone who is not invited). Responses to the questions are used to determine whether the participants can identify the content of the faux pas and whether or not they understood that the faux pas was committed as a result of a false belief (e.g., mistakenly thinking that someone had been invited to a party). Similarly, on the Awkward Moments Test individuals are presented with short videos taken from television commercials of people experiencing socially uncomfortable moments (e.g., a man returns to the wrong seat in a dark movie

theater and accidentally puts his arm around another man instead of his date) and asked to explain the intentions behind the people's behavior (Heavy et al., 2000). Finally, in the Strange Stories task participants are presented with a series of stories in which characters make statements that are not literally true (e.g., "You have a frog in your throat.") and asked to explain why the character has said that. In order to perform successfully on this task, participants must be able to understand the mental intent behind the non literal communication (e.g., figure of speech, white lie, persuasion, joke, etc.) (Brent et al., 2004; Happé, 1994a, 1994b; Jolliffe & Baron-Cohen, 1999; Losh & Capps, 2003).

Results for studies using the advanced ToM tasks reveal that high-functioning individuals with ASD demonstrate difficulty with these advanced tasks relative to matched comparison groups, despite performing well on first- or second- order ToM tasks (Baron-Cohen et al., 1999; Brent et al., 2004; Happé, 1994a, 1994b; Jolliffe & Baron-Cohen, 1999; Losh & Capps, 2003). Interestingly, variability in performance on these advanced tasks does not appear to be closely tied to language ability in higher functioning individuals (Brent et al., 2004; Heavy et al., 2000; Losh & Capps, 2003).

Summary

In general, studies examining the ToM abilities of high-functioning individuals with ASD find that they demonstrate more deficits as the tasks become more complex. Results from studies involving high-functioning individuals with ASD using first- and second-order ToM tasks have been mixed. Although some individuals demonstrate impairment relative to matched controls (Baron-Cohen et al., 1986; Ozonoff, Pennington et al., 1991; Sicotte & Stemberger, 1999), others do not (Bowler, 1992; Bowler, 1997;

Buitelaar et al., 1999a; Dahlgren & Trillingsgaard, 1996; Ozonoff, Rogers et al., 1991). Results from studies using the advanced ToM tasks reveal that high-functioning individuals with ASD consistently demonstrate difficulty with these tasks relative to comparison groups (Baron-Cohen et al., 1999; Brent et al., 2004; Happé, 1994a, 1994b; Heavy et al., 2000; Jolliffe & Baron-Cohen, 1999; Losh & Capps, 2003). Verbal ability is a strong predictor of performance on first- and second-order ToM tasks (Bauminger & Kasari, 1999; Buitelaar et al., 1999a; Dahlgren & Trillingsgaard, 1996; Eisenmajer & Prior, 1991; Happé, 1994a, 1994b; Ozonoff, Pennington et al., 1991) although this relation has not been substantiated for performance on advanced tasks for high-functioning individuals (Brent et al., 2004; Heavy et al., 2000; Losh & Capps, 2003).

Relation Between ToM and Social Impairment

It makes intuitive sense that the ability to attribute thoughts and beliefs to another person would be important to successful social interaction (Perner & Wimmer, 1985; Tager-Flusberg & Sullivan, 1994), and studies involving typically developing preschoolers have found that first-order ToM tasks are concurrently and predictively related to conversational skills, cooperative pretend play skills, and other prosocial behaviors (Astington & Jenkins, 1995; Hughes & Dunn, 1997; Jenkins & Astington, 2000; Slomkowski & Dunn, 1996; Taylor & Carlson, 1997; Watson, Nixon, Wilson, & Capage, 1999; Youngblade & Dunn, 1995). There have been strong theoretical arguments linking ToM deficits to social impairments in ASD (Baron-Cohen et al., 1985; Leslie & Frith, 1988), but research examining this relation has been equivocal.

Many studies have failed to find a relation between ToM and social skills in individuals with ASD. First-order ToM tasks did not predict parent report of social skills (Prior et al., 1990), Vineland Socialization scores (Fombonne et al., 1994; Frith et al., 1994) or frequency of peer interaction and prosocial behaviors (Travis et al., 2001); nor did a composite of first- and second-order ToM tasks predict parent and teacher reports of social skills (Ozonoff & Miller, 1995). Performance on a version of the Strange Stories task did not correlate with narrative ability in high-functioning children with ASD (Losh & Capps, 2003). Furthermore, studies evaluating intervention programs designed to teach individuals with autism ToM skills indicate that although it is possible to teach many of these individuals to pass specific false-belief tasks (Hadwin, Baron-Cohen, Howlin, & Hill, 1996; Ozonoff & Miller, 1995; Swettenham, 1996), improvements in these tasks do not predict improvements in social skills (Hadwin, Baron-Cohen, Howlin, & Hill, 1997; Ozonoff & Miller, 1995).

However, other studies have found a relation between performance on ToM tasks and social skills. First-order ToM task performance has been demonstrated to predict teacher report of social skills (Oswald & Ollendick, 1989), and first- and second- order ToM tasks were related to understanding of embarrassment (Hillier & Allinson, 2002). Performance on first-order and perception knowledge tasks (measuring the ability to infer knowledge from perceptual access) correlated with the Social Interaction and Communication scales from the Autism Diagnostic Observation Scale (ADOS; Lord et al., 2000), an autism diagnostic instrument (Joseph & Tager-Flusberg, 2004). However, the relation between ToM and Social Interaction was no longer significant after controlling for language ability.

Interestingly, some researchers have suggested that performance on ToM tasks might relate only to those social skills that require understanding of others' mental states, such as choosing an appropriate gift for someone, but not to more routinized social skills of convention, such as saying "please" (Frith et al., 1994; Happé, 1994b; Ozonoff & Miller, 1995). Support for this idea has been found in two separate studies (Fombonne et al., 1994; Frith et al., 1994). In these studies, individuals with autism (low- and high-functioning children and adults) were separated into two groups based on their ability to pass first-order ToM tasks, ToM "passers" and ToM "failers". These groups were then compared on a parent report social skills measure developed by the researchers. This measure evaluated two separate types of social skills, those social skills that require ToM ability, termed Interactive social skills, and those social skills that are learned routines and do not require an appreciation of others' thoughts and beliefs, termed Active social skills. The researchers predicted that the ToM passers would demonstrate higher scores on the Interactive scale than the ToM failers, but that the two groups would not be different on the Active scale since these skills do not relate to ToM. In both studies, this prediction was confirmed.

At first glance, results from these studies seemed to suggest that ToM skills relate to Interactive social skills in individuals with ASD. However, after examining each participant's performance individually, Frith and colleagues suggested that there were actually three subtypes of individuals: 1) ToM failers who demonstrated poor Interactive social skills, 2) ToM passers who demonstrated better Interactive social skills, and 3) ToM passers who demonstrated Interactive social skills as poor as the ToM failers (Fombonne et al., 1994; Frith et al., 1994). Performance of the first two groups is

consistent with the prediction that ToM ability relates to Interactive social skills. However, an explanation is needed for the performance of the third group, the group which passed ToM tasks yet demonstrated social skills as poor as the group that failed. Three possible explanations for these findings are described below.

Compensatory Strategy

One explanation for these findings, also the explanation favored by Frith and colleagues (Fombonne et al., 1994; Frith et al., 1994), is that the ToM passers with poor social skills used a "compensatory ToM strategy" to pass the ToM tasks (Frith, Morton, & Leslie, 1991). The researchers propose that these individuals have ToM impairments similar to those found in the first group, but have developed compensatory, task-specific strategies that are sufficient for solving some ToM problems. However, these strategies do not generalize to real-life social situations, thus resulting in the poor Interactive social skills.

However, the available empirical evidence, though scant, does not offer much support for this explanation. Bowler (1997) examined the reaction times of high-functioning adults with ASD on second-order ToM tasks. He hypothesized that if individuals with ASD were using a compensatory strategy to process mental state information, their reaction times should be longer than typically developing participants on the mental state (i.e., belief) questions, but not on the non-mental state (i.e., memory control) questions. Results indicated that individuals with ASD had longer processing times on both types of questions and, therefore, did not support the compensatory strategy hypothesis.

Insensitive ToM tasks

A second possible explanation for the finding that some ToM passers demonstrated social skills as poor as ToM failers is that the first-order ToM tasks used by Frith and colleagues (Fombonne et al., 1994; Frith et al., 1994), due to their simplicity, were relatively insensitive measures of ToM deficits and more advanced measures of ToM would yield clearer results. This argument has been used by researchers to explain why high-functioning individuals with ASD who pass both first- and second- order ToM measures still demonstrate severe social impairments (Baron-Cohen, 1989; Baron-Cohen, Wheelwright, & Jolliffe, 1997; Happé, 1994b; Happé & Frith, 1995). However, the only study to date examining the relation between an advanced ToM task and social skills in high-functioning individuals, specifically, the relation between the Strange Stories task and narrative ability, did not find a significant relation (Losh & Capps, 2003).

However, a possible limitation of using more advanced ToM tasks is that they may measure, more so than simpler ToM tasks, a variety of other skills in addition to ToM. For example, Russell et al. (1999) note that most normal adults would probably have difficulty with a fifth-order ToM task, but because of the executive function demands of such a task, not the ToM demands. Likewise, Heavy et al. (2000) acknowledge that the Awkward Moments Test, which uses television commercials as stimuli, probably taps cognitive processes such as executive function in addition to ToM.

Executive Function Deficit

Understanding and navigating real-life social situations undoubtedly requires cognitive processes besides ToM (Green, Gilchrist, Burton, & Cox, 2000; Heavy et al.,

2000) and ToM may be "necessary but not sufficient" for the development of social competence (Klin, 2000). Bowler (1992) has suggested that the continuing social deficits demonstrated by high-functioning adults with ASD who had passed first- and second-order ToM tasks are the result of a failure of application of ToM ability, rather than an absence of ToM ability. In other words, high-functioning individuals with ASD have the ability to attribute mental states to others but have difficulty applying this ability in real-life social situations. Thus, a third possible explanation for the finding that some ToM passers demonstrated social skills as poor as ToM failers is the presence of an additional area of cognitive deficit that affects the relation between ToM and Interactive social skills for individuals with ASD.

One possibility is that deficits in executive function contribute to this failure to apply ToM ability to real-life social situations. "Executive function" is a broad construct that refers to the cognitive processes related to complex, goal-directed behavior (Duncan, 1986; Ozonoff & Griffith, 2000). It encompasses many skills, such as cognitive flexibility, planning, working memory, and inhibition (Ozonoff & Griffith, 2000; Ozonoff et al., 1994; Pennington & Ozonoff, 1996). In general, tasks that are sensitive to executive function deficits require disengaging from the immediate environment and guiding behavior according to internally generated plans while inhibiting incorrect behavior (Ozonoff et al., 1994; Pennington & Ozonoff, 1996). Many kinds of tests are used to measure executive function skills in both typically developing and disabled populations. Most tests do not measure a single skill but rather tap a variety of executive and nonexecutive processes (Ozonoff et al., 1994; Pennington & Ozonoff, 1996). However, to some degree, tests can be classified according to the executive function skill

they tap most heavily (Ozonoff, 1998; Ozonoff et al., 1994). Skills examined most often in high-functioning individuals with ASD are cognitive flexibility, planning, working memory, and inhibition. The following section describes tests used to evaluate each skill area and summarizes results of research with high-functioning individuals with ASD[1].

Cognitive flexibility. The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993) measures cognitive shifting and flexibility in problem solving, i.e., the ability to modify incorrect responses and strategies. Participants are given cards depicting shapes in various colors and numbers and must deduce the correct way to sort the cards (e.g., by color) based on feedback given by the examiner (being told whether each response is correct or incorrect). The sorting principle changes throughout the test without warning. Participants are scored on their ability to deduce correct sorting principles and their ability to switch sorting principles according to the examiner's feedback. Although a few studies find no evidence of deficits (Minshew, Goldstein, Muenz, & Payton, 1992; Minshew, Goldstein, & Siegel, 1997; Nyden, Gillberg, Hjelmquist, & Heiman, 1999; Schneider & Asarnow, 1987), and one study found deficits for individuals with high-functioning autism but not for individuals with Asperger Syndrome (Szatmari, Tuff, Finlayson, & Bartolucci, 1990), several studies involving high-functioning individuals with ASD find that they perform more poorly on this task than typically developing or disabled comparison groups (Bennetto, Pennington, & Rogers, 1996; Berthier, 1995; Ciesielski & Harris, 1997; Garcia-Villamisar & Della Sala, 2002; Geurts, Verté, Oosterlann, Roeyers, & Sergeant, 2004; Ozonoff & Jensen, 1999; Ozonoff & McEvoy, 1994; Ozonoff, Pennington et al., 1991; Ozonoff, Rogers et

[1] See also Ozonoff (1998) and Hill (2004) for summaries of this area of research.

al., 1991; Prior & Hoffmann, 1990; Rumsey & Hamburger, 1988, 1990; Rumsey et al., 1985), particularly when perseverative errors and/or responses were examined (Liss et al., 2001; Ozonoff, 1995). Although some research has suggested that format of administration of the WCST, i.e., computerized vs. standard, may affect performance by individuals with autism (Ozonoff, 1995), other studies have not replicated these findings (Shu, Lung, Tien, & Chen, 2001).

Other tests have been used less commonly to measure cognitive flexibility in high-functioning individuals with ASD. On the Goldstein–Scheerer Object Sorting Test (Goldstein & Scheerer, 1941), individuals are presented with a variety of objects and must shift between various conceptual (e.g., function of the object) and perceptual (e.g., color of the object) sorting strategies. Individuals with ASD perform more poorly than matched typically developing individuals (Minshew et al., 1992). Trail Making B (Reitan & Wolfson, 1985) measures the speed with which participants can shift between numerical and alphabetical sequencing strategies by having them connect numbers and letters in an alternating sequence. Findings for this measure have been mixed, with some studies indicating deficits relative to typically developing comparison groups (Ciesielski & Harris, 1997; Rumsey & Hamburger, 1988), and others not (Minshew et al., 1992; Minshew et al., 1997). Finally, the performance of high-functioning individuals with ASD has been evaluated using the Intradimensional/Extradimensional Shift Subtest from the Cambridge Neuropsychological Test Automated Battery (CANTAB; Ozonoff et al., 2004; Robbins et al., 1994). On this task participants are presented with multidimensional stimuli on a computer and tested on their ability to make "intradimensional" cognitive shifts (e.g., learning to respond to a specific shape out of a group of shapes and lines and

then learning to respond to a new shape when presented with novel shapes and lines) as well as "extradimensional" cognitive shifts (e.g., no longer responding to shapes and learning to respond to a specific line). Results indicated that the individuals with autism preformed more poorly than did the matched typically developing comparison group (Ozonoff et al., 2004).

Planning. Two similar tests thought to measure planning that are commonly used with high-functioning individuals with ASD are the Tower of Hanoi and Tower of London tests (Borys, Spitz, & Dorans, 1982; Spreen & Strauss, 1998). In these tests participants must arrange disks on pegs in a specified configuration within a certain number of moves. Successful responding depends on the participants' ability to plan and carry out a sequence of moves that will result in the desired disk arrangement (Ozonoff, 1998). Studies involving high-functioning individuals with ASD find that they perform more poorly than matched typically developing and disabled comparison groups on the Tower of Hanoi (Bennetto et al., 1996; Berthier, 1995; Ozonoff & Jensen, 1999; Ozonoff & McEvoy, 1994; Ozonoff, Pennington et al., 1991; Ozonoff, Rogers et al., 1991), the Tower of London (Geurts et al., 2004; Hughes, Russell, & Robbins, 1994), and on a computerized version of the Tower of London, the Stockings of Cambridge (Ozonoff et al., 2004).

Working Memory. Working memory tasks require the individual to simultaneously store and manipulate information. Results from studies investigating possible deficits in this area of executive functioning for high-functioning individuals with ASD have been equivocal. High-functioning individuals with ASD performed more poorly than a matched disabled comparison groups on a sentence span task and on a

counting span task, a task in which participants were required to count dots on a series of cards and then recall, in order, the number of dots on each card in a series (Bennetto et al., 1996). However, deficits have not been found on backwards digit span tasks (Bennetto et al., 1996; Minshew et al., 1992) or on visual working memory tasks (Ozonoff & Strayer, 2001).

Inhibition. In contrast to the significant deficits found on tests of cognitive flexibility and planning, and the potential deficits associated with working memory, tests of inhibition reveal that this may be an area of relative strength for high-functioning individuals with ASD. For example, on the Stroop Color-Word Test (Golden, 1978), participants are given a list of words printed in mismatching ink (e.g., the word "red" printed in green ink) and asked to name the color of the ink, requiring them to inhibit the "automatic" response of reading the word. Studies using this measure with high-functioning individuals with ASD find that they perform as well as typically developing comparison groups matched on reading speed (Eskes, Bryson, & McCormick, 1990), and typically developing and disabled comparison groups matched on chronological age and IQ (Ozonoff & Jensen, 1999). Similarly, high-functioning individuals with ASD do not demonstrate impairments relative to a matched typically developing comparison group on a task measuring ability to inhibit motor responding following an auditory stimulus (i.e., Stop-Signal task), or on a task measuring ability to inhibit processing of irrelevant visual stimuli (i.e., Negative Priming task) (Ozonoff & Strayer, 1997).

In studies where deficits on "inhibition" tasks are found it appears that the deficits may be attributable to the cognitive flexibility requirements in these tasks rather than to deficits in inhibition per se. For example, studies using inhibition tasks requiring

participants to shift responding from one stimulus to another or to rapidly switch response patterns in accordance with presentation of different stimuli find that high-functioning individuals with ASD demonstrate impairments relative to matched typically developing comparison groups (Nyden et al., 1999; Ozonoff et al., 1994). Tasks such as these measure cognitive flexibility as well as inhibition, making it difficult to isolate the particular area of deficit (Ozonoff & Strayer, 1997; Ozonoff et al., 1994).

Relation Between Executive Function and Social Impairment

Given the complexity of social behavior and interaction, executive function skills are likely required for competent participation in the social world (Pennington & Ozonoff, 1996), and both theory and empirical work with typically developing and disabled populations support this assumption. Studies involving typically developing preschoolers find that executive function has a significant positive relation with behavioral control (specifically, ability to resist a forbidden object) (Cole, Usher, & Cargo, 1993), and a significant negative relation with frequency of antisocial behavior (Hughes, White, Sharpen, & Dunn, 2000). Studies involving individuals with schizophrenia find that performance on executive function tasks relates to social skills (Smith et al., 1999; Velligan, Bow-Thomas, Mahurin, Miller, & Halgunseth, 2000) and social-problem solving (Addington & Addington, 1998, 2000). Measures of executive function have been found to correlate with a parent report measure of social understanding in a group of individuals with Turner's Syndrome (Skuse et al., 1997). In addition, executive function deficits are thought to be related to the social impairments

demonstrated by individuals with traumatic brain injury or attention deficit/hyperactivity disorder (Barkley, 2000; Godfrey & Shum, 2000; Ylvisaker, 2000).

Similarly, clinical observations of social behavior in individuals with ASD seem to reflect executive function impairment (Ozonoff, 1998). Individuals with ASD often use highly routinized strategies for navigating social interaction, and seem unable to adapt these strategies to continually changing social contexts (Berger et al., 1993; Rumsey et al., 1985; Volkmar et al., 1996). Individuals with ASD may have very focused and perseverative interests which they share with others through lengthy monologues (Ozonoff, 1998). They may behave most appropriately and maintain peer social relationships only within very structured environments or activities (Berger et al., 1993; Rumsey et al., 1985).

However, few studies have examined the relation between executive function and social ability in high-functioning individuals with ASD, and indirect measures of social abilities are often utilized. For example, Ozonoff and colleagues (Ozonoff & McEvoy, 1994; Ozonoff, Pennington et al., 1991; Ozonoff, Rogers et al., 1991) found that executive function was related to performance on ToM tasks for high-functioning individuals with ASD, however, actual social skills were not examined. Both the WCST and the Stockings of Cambridge task were significant correlates of parent report of adaptive behavior in high-functioning individuals with ASD (Ozonoff et al., 2004; Szatmari, Bartolucci, Bremner, Bond, & Rich, 1989). Although the measure of adaptive behavior used in these studies, the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984), includes a social subscale, this scale was not examined separately. A study by Berger et al. (1993) found that measures of cognitive shifting and flexibility

predicted improvements in social understanding over a two-year period for a group of high-functioning individuals with ASD better than measures of IQ or initial social understanding performance. However, the social measures used by Berger et al. evaluated understanding of social situations rather than social skills per se.

Studies that used more direct measures of social skills have yielded mixed results when examining the relation between executive function and social skills for high-functioning individuals. Measures of working memory, planning, and inhibition did not correlate with the ADOS Social Interaction scale, although measures of planning and inhibition did correlate significantly with the Communication scale which contains items such as conversational skills and use of gestures (i.e., pragmatics) (Joseph & Tager-Flusberg, 2004). However, the correlations were no longer significant when controlling for verbal ability. Scores from the Stockings of Cambridge task failed to correlate with social and communication scores from the ADOS and ADI-R (an informant report autism diagnostic interview) as did the computerized Intradimensional/Extradimensional Shift task measuring mental flexibility (Ozonoff et al., 2004). Although one study found that scores from the WCST correlated significantly with the Social subscale of the Vineland Adaptive Behavior Scales as well as the Social subscale from the Wing Autistic Disorder Interview Checklist (a measure of autism symptom severity), these correlations were no longer significant when controlling for Verbal IQ (Liss et al., 2001).

Thus, although theory and empirical work with typically developing and disabled populations support the hypothesis that executive function relates to social skills, empirical findings in high-functioning individuals with ASD present an unclear picture. While studies using less direct measures of social skills find executive function to be a

significant predictor, the few studies that have examined social skills more directly have not consistently found a relation. In addition, there is some evidence that controlling for verbal ability may affect the relation between executive function and social skills. However, no study has examined the possible different relations between executive function and social skills that "require" mentalizing abilities and those that do not. Significant relations between executive function and the social and communication subscales from diagnostic measures such as the ADOS and the Wing Autistic Disorder Interview Checklist have not been found consistently (Joseph & Tager-Flusberg, 2004; Liss et al., 2001; Ozonoff et al., 2004). The social skills measured by these diagnostic scales tend to be higher level behaviors and possibly more likely to require mentalizing (i.e., ToM) skills. It may be that executive function would show a stronger direct relation to more routinized social skills that do not require ToM.

Summary and Current Study

In sum, research has found evidence of ToM deficits in high-functioning individuals with ASD, particularly on more advanced ToM tasks. In addition, some findings from research examining the relation between ToM and social skills in individuals with ASD suggest that ToM relates only to a specific kind of social skills, Interactive social skills. However, examination of individual performances indicates the possibility of three groups, those that fail ToM tasks and have poor Interactive social skills, those that pass ToM tasks and have better Interactive social skills, and those that pass ToM tasks and have Interactive social skills as poor as those who failed. It is

possible that the presence of an additional cognitive deficit, such as deficits in executive function, affects the relation between ToM ability and Interactive social skills.

The purpose of the current study was to examine the relation between ToM, executive function, and social skills in high-functioning individuals with ASD. Such a study could help answer questions about the hypothesized relation between ToM and social skills and the relation between executive function and social skills. In addition, this study could provide clinically useful information about appropriate areas toward which to direct intervention and environmental supports for high-functioning individuals with ASD. In recent years, increasing numbers of interventions for individuals with ASD have focused on improving ToM skills. However, although studies examining the efficacy of these types of interventions have found that specific ToM skills can be taught, generalization of these skills is poor and corresponding improvements in social skills nonsignificant (Hadwin et al., 1996, 1997; Ozonoff & Miller, 1995; Swettenham, 1996). Results from this study could help interpret these findings and provide practical information about the extent to which changes in specific types of social skills might be expected based on a ToM intervention. In addition, results may provide information about the potential utility of interventions or environmental supports focusing on addressing executive function deficits.

In the current study, measures of ToM included first-, second-, and third- order false belief tasks as well as an "advanced" ToM task in order to measure the potential wide range of ToM abilities in the higher functioning participants. Measures of executive function included tests of mental flexibility, planning, and working memory because previous studies have indicated that these are areas of executive function in which high-

functioning individuals are most likely to demonstrate deficits. Social skill measures designed to evaluate Interactive and Active social skills, as well as overall social skills, were included to learn more about the relation between ToM, executive function, and the degree to which various social skills "require" an understanding of others' thoughts and feelings.

Hypotheses

Based on the findings of previous research, it is expected that ToM and executive function will each predict a significant proportion of the variance for overall social skills but will demonstrate differential associations with Interactive and Active social skills. In addition, it is expected that executive function will moderate the relation between ToM and Interactive social skills. A moderated relation is one in which a variable (the moderator) affects the strength of the relation between the predictor and the outcome. In other words, there is an interaction between the moderator variable and the predictor variable (Baron & Kenny, 1986; Frazier, Tix, & Barron, 2004; Holmbeck, 1997). A mediated relation is one in which the predictor variable affects the mediator variable which in turn affects the outcome variable (Holmbeck, 1997). In the current study, it is hypothesized that the strength of the relation between ToM and Interactive social skills will differ depending on executive function ability, rather than that ToM affects executive function skills which in turn affect social skills. Thus, a moderated relation, rather than a mediated relation, is expected in which the interaction term "ToM × executive function" will be a significant predictor of Interactive social skills. Hypotheses 1 through 3 are detailed below.

1. ToM and executive function will each predict a significant proportion of the variance for overall social skills.
2. ToM and executive function will demonstrate differential associations with Interactive and Active social skills such that:
    a. ToM, but not executive function, will contribute to the prediction of Interactive skills.
    b. Executive function, but not ToM, will contribute to the prediction of Active social skills.
3. The interaction term "ToM × executive function" will explain a significant proportion of variance in Interactive social skills beyond what is accounted for by the independent effects of ToM and executive function.

This study will also examine the above relations when controlling for verbal ability. Some research indicates that ToM and executive function account for little of the variance associated with social skills once verbal ability is controlled (Fombonne et al., 1994; Joseph & Tager-Flusberg, 2004; Liss et al., 2001). It is predicted that controlling for difference in verbal ability will significantly lessen the strength of the direct relation between ToM and executive function and social skills. Because interactions can be significant in the absence of significant main effects for the predictor (i.e., ToM) and moderator (i.e., executive function) (Baron & Kenny, 1986), and because verbal ability is not expected to account for all of the variance in Interactive social skills, the interaction

term “ToM × executive function” is expected to continue to explain a significant proportion of variance in Interactive social skills. Hypothesis 4 is detailed below.

4. When controlling for individual differences in verbal ability, the relation between ToM, executive function, and social skills is predicted to change such that:
    a. Verbal ability, and not ToM or executive function, will predict a significant proportion of the variance in overall social skills.
    b. Verbal ability, and not ToM, will explain a significant proportion of the variance in Interactive social skills. However, the interaction term “ToM × executive function” is expected to continue to explain a significant proportion of variance in Interactive social skills.
    c. Verbal ability, and not executive function, will explain a significant proportion of the variance in Active social skills.

Because parents and teachers have the opportunity to observe children in different contexts, separate analyses will be conducted for Hypotheses 1 through 4 for parent and teacher report of social skills. However, the above hypothesized relations are not expected to differ for parent and teacher report.

CHAPTER II

METHOD

Participants

Twenty-two high-functioning children and adolescents (18 boys, 4 girls) with previous diagnoses of autism spectrum disorders participated in this study. Participants were recruited between 2001 and 2003 in middle Tennessee and surrounding areas from a regional autism society and from a university-based autism spectrum disorders program. Eligibility requirements for participation included: 1) chronological age between 8 and 17 years, 2) absence of severe visual, hearing, or motor impairments, 3) a previous diagnosis of an autism spectrum disorder made by a licensed psychologist or a psychiatrist, 4) a current classification of autism or PDDNOS on the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al., 2000), and 5) current Verbal IQ scores of 70 or above on the Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991) or the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997). Prior to the testing session, parents were interviewed via telephone to screen children for general verbal ability and criteria 1 through 3; ADOS-G classification and Verbal IQ scores were obtained during the testing session.

Initially, 49 potential participants were screened for eligibility criteria via the parent telephone interview. Based on the telephone screening, 12 children did not meet criteria (6 did not meet verbal ability requirements, 2 did not meet diagnostic requirements, and 4 did not meet age requirements), and 37 were invited to the research

clinic for further testing. Of those 37, 5 could not be scheduled or parents indicated that they were no longer interested in participating. Following additional testing, 10 children did not meet inclusion criteria for Verbal IQ scores (n = 5), ADOS-G classification (n = 3), or both (n = 2).

The remaining 22 children completed the research battery and were enrolled in the study. Of these children, 10 (45%) had a previous diagnosis of autism, 5 (23%) had a previous diagnosis of Asperger Syndrome, and 7 (32%) had a previous diagnosis of PDDNOS. Twenty-one (95%) children were diagnosed previously by a licensed psychologist and one (5%) was diagnosed by a psychiatrist. Previous autism spectrum diagnoses were confirmed in this study using the Autism Diagnostic Observation Scale – Generic (ADOS-G; (Lord et al., 2000). The ADOS-G is a standardized, semi-structured, interactive diagnostic assessment that provides opportunities for the evaluation of participants' social behaviors and communicative skills. The ADOS-G diagnostic algorithm classifies participants into categories of autism, PDDNOS, or nonautism spectrum. Each participant received either Module 3 (n = 15) or Module 4 (n = 7) of the ADOS-G depending on his or her age and developmental level. Of the 22 children enrolled in the study, 13 children received an autism classification and 9 children received a PDDNOS classification. Participant demographics and diagnostic information for the total sample are presented in Table 1.

Parents of children participating in the study completed questionnaires providing information about child and family demographics, child social skills, and child behavior. Biological mothers (n = 15) or adoptive mothers (n = 1) completed the measures in 73% of the cases, biological fathers (n = 2) or adoptive fathers (n = 1) completed the measures

Table 1. Sample characteristics.

Chronological age (years)	
M (SD)	12.1 (3.0)
Range	8.2 – 17.7
Full scale IQ	
M (SD)	95.9 (16.3)
Range	71 – 123
Verbal IQ	
M (SD)	99.0 (17.8)
Range	74 – 139
Performance IQ	
M (SD)	93.4 (18.8)
Range	57 – 130
Caucasian (%)	95
Male (%)	82
Mothers with high school education or beyond (%)	95

in 14% of the cases, and both biological parents (n = 2) or both adoptive parents (n = 1) completed the measures in 14% of the cases[2].

At the time of their evaluation, four children were either home schooled or on summer vacation from school; therefore, teacher questionnaires were not obtained for these children. All parents of the remaining 18 children agreed to provide questionnaires to their child's teacher. Of that group, 72% of teachers (n = 13) returned the questionnaire packets. The majority of these respondents (77%) (n = 10) were classroom/academic subject teachers or teacher's aides. The remaining 23% (n = 3) were therapists, resource teachers, and/or case managers.

Measures

Demographic information. Demographic information was obtained for each participant via a brief parent report questionnaire. Data obtained included date of birth, race, gender, diagnosis, and mother's level of education.

Cognitive and verbal skills. Cognitive and verbal skills were measured using either the Wechsler Intelligence Scale for Children – Third Edition (WISC-III;Wechsler, 1991) (n = 21) or the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997) (n = 1). These measures yield 3 standardized scores: VIQ, a Verbal IQ score, PIQ, a Performance (Nonverbal) IQ score, and FSIQ, a full-scale (general Verbal and Nonverbal) IQ score.

Executive Function. Four measures of executive function were given, the Wisconsin Card Sorting Test (WCST; Heaton et al., 1993), the Tower of Hanoi (Borys et

[2] Percentage total does not equal 100 due to rounding.

al., 1982), Backwards Digit Span from the WISC-III and WAIS-III, and the Counting Span Test (Case, Kurland, & Goldberg, 1982).

The WCST was used to measure cognitive flexibility in problem solving, i.e., the ability to modify incorrect responses and strategies. Participants are given up to 128 cards depicting shapes in various colors and numbers and must deduce the correct sorting principle (e.g., sort by color) based on feedback given by the examiner (i.e., being told whether each response is correct or incorrect). The sorting principle changes throughout the test without the participants' knowledge.

Total number of perseverative responses was used in data analysis. This number reflects the number of times a participant continues to use the same incorrect sorting principle despite feedback from the examiner that it is incorrect. Several previous studies have used this score from the WCST to examine executive function skills in high-functioning individuals with ASD (Bennetto et al., 1996; Ozonoff & McEvoy, 1994; Ozonoff, Pennington et al., 1991; Schneider & Asarnow, 1987) and have found the reliability of this score to be high (Ozonoff, 1995). In addition, in a study using the computerized version of the WCST, group differences between perseverative responses approached significance (i.e., $\underline{p} < .06$) for high-functioning children with autism as compared to a matched comparison group when no differences were found for other WCST scores (Ozonoff, 1995).

Eighteen participants completed the WCST; four participants requested to terminate this measure after completing at least the first 64 cards. These four participants were significantly younger than the rest of the sample, $\underline{t}\ (20) = 2.3$, $\underline{p} < .05$, but did not differ on measures of IQ. To retain data from all participants in analyses, z-scores (mean

= 0, SD = 1) for total number of perseverative responses were calculated for 18 participants using their performance on the complete WCST and for the four participants using their performance on the first 64 cards. Deriving total number of perseverative responses from the first 64 cards has been shown to have good reliability and a strong correlation with total number of perseverative responses from a complete administration of the WCST (Kongs, Thompson, Iverson, & Heaton, 2000). In the current study, number of perseverative responses from the first 64 cards was significantly correlated with the total number of perseverative responses from the complete administration of the WCST (r = .81). In addition, repeating the study analyses (presented in the next section) excluding the four participants who only completed the first 64 cards did not significantly change results.

The Tower of Hanoi was administered to measure planning ability. In this task, participants are presented with 2 identical peg board and disk sets consisting of boards with 3 vertical pegs and 3 or 4 disks arranged by size on the left-most peg. For each problem the examiner re-arranges the disks on one of the peg boards and instructs participants to return the disks to their original arrangement (modeled on the second peg board) while following two rules: only one disk can be moved (i.e., off a peg) at a time, and larger disks can never be placed on top of smaller disks. Successful performance depends on the participants' ability to plan and carry out a sequence of moves that will result in the desired disk arrangement.

Administration and scoring procedures developed by Borys, Sptiz, and Dorans (1982) and Welsh (1991) and used in research with high-functioning individuals with ASD (Bennetto et al., 1996; Ozonoff, Pennington et al., 1991) were used in this study.

Participants were administered items of increasing difficulty as determined by the number of moves required to return the disks to their original arrangement. To receive credit for an item, participants had to solve each item correctly on two consecutive trials. They were allowed 6 trials total for each item. Trials were considered failed if the participant broke a rule (e.g., placed a smaller disk on a larger disk) or if the participant was not able to correctly solve the item within the allotted number of moves. Items solved correctly on the first and second trials were awarded a score of 6; on the second and third trials, a score of 5, on the third and fourth trials, a score of 4, on the fourth and fifth trials, a score of 3, and on the fifth and sixth trials, a score of 2. Scores of 0 were given for any item not scored correctly on the fifth trial and this measure was discontinued. Up to six three-disk problems and up to three four-disk problems were administered. A "planning efficiency" score was calculated for use in data analysis by summing the scores received across problems, with total possible raw scores ranging from 0- 54.

Backward Digit Span from the WISC-III and the WAIS-III and the Counting Span test developed by Case et al. (1982) were administered to measure working memory. On Backward Digit Span participants were asked to repeat a series of digits in the reverse order of their presentation. The number of digits increases by one until the participant fails two trials of the same digit span length. The digit series range in length from 2 to 8 digits with total possible raw scores ranging from 0-14. Administration and scoring procedures developed by Case et al. (1982) for the Counting Span Test were also used in this study. In this task the child is asked to count dots on a series of cards and to report at the end of a set of cards the number of dots seen on each card (e.g., a set of three

cards having six, eight, and three dots, respectively). Credit is given for an item when a child is able to recall, in order, the number of dots counted on each card in a set. Sets with increasing numbers of cards (2 cards up to 6 cards) were administered with 3 sets given at each level (i.e., 3 sets of 2 cards, 3 sets of 3 cards, 3 sets of 4 cards, etc.) The tasks was discontinued when a child failed all the items at one level. Total scores were calculated by summing the number of items for which a child received credit, with total possible raw scores ranging from 0 – 15.

Preliminary data analyses indicated that raw scores from the Backward Digit Span task correlated very highly with raw scores from the Counting Span task ($r = .75$, $p < .001$). Due to this high correlation and similarity between task demands (i.e., both involved mental manipulation of numeric sequences) a composite working memory variable for use in data analysis was created using the average of the computed z-scores for each measure.

Theory of mind. Participants received a battery of first-order, second-order, and third-order false belief tasks as well as selected items from the Strange Stories task (Happé, 1994a, 1994b; Happé, Brownell, & Winner, 1999; Happé et al., 1996; Happé, Winner, & Brownell, 1998). All false belief tasks were similar to those commonly used by researchers examining the ToM abilities of individuals with ASD; minor content and wording changes were made to some tasks to make the tasks more age and/or culturally appropriate for participants in this study. See Appendix A for ToM task scripts. Three first-order tasks were administered, two based on the Sally-Ann task (Baron-Cohen et al., 1985), and one based on the Smarties/M&M's task (Perner, Frith, Leslie, & Leekam, 1989). Three second-order tasks were administered, one based on the Birthday Puppy

Story (Sullivan, Zaitchik, & Tager-Flusberg, 1994), one based on the Ice Cream Story (Baron-Cohen, 1989; Perner & Wimmer, 1985), and one based on the Overcoat Story (Bowler, 1992). Three third-order tasks were administered, two based on the Prisoner Story (Happé, 1994a) and one developed by the examiner. Visual aids (pictures or small scale models) were presented while false belief task stories were read aloud to the participants by the examiner.

Despite the popularity of false belief tasks in both typical development and disability research, very few studies have examined the reliability of these tasks and findings have been equivocal. For example, test-retest reliability for first-order false belief measures has been found to be poor to moderate in typically developing children (Mayes, Klin, Tercyak, Cicchetti, & Cohen, 1996) and reliability of performance across different first-order false belief tasks has been found to be moderate in individuals with disabilities (Charman & Campbell, 1997). However, when standardized administration procedures and aggregate scores summarizing performance across multiple individual tests are used, reliability improves for first-order and second-order tasks (Hughes, Adlam et al., 2000). Reliability for third-order tasks has not yet been reported in the literature.

To maximize reliability in the current study, administration and scoring procedures for false belief tasks similar to those used by Hughes et al. (2000) were followed. First-order tasks were presented first, with the order of the individual tasks counterbalanced across participants, followed by second-order tasks, etc. Only participants passing at least 2 out of the 3 first-order tasks received the second- and third-order tasks. Test questions were presented in an open response format and forced choice prompts were used when participants did not respond.

Preliminary data analyses indicated that scores from first-, second-, and third-order ToM were highly correlated with one another with coefficients ranging from .56 to .75. In addition, using aggregate scores, rather than scores from a single task, greatly improves reliability (Rushton, Brainerd, & Pressley, 1983), which is particularly important to a study such as this examining individual differences in ToM ability (Hughes, Adlam et al., 2000). Thus, an aggregate score for performance across all false belief ToM tasks was calculated for use in data analysis to provide for a more reliable measure of the construct. Participants had to answer both the test and control questions correctly in order to receive credit for a correct test question; those failing control questions after answering a test question correctly received a score of 0 for that test question. Those participants not receiving second- and third- order tasks because they failed first-order tasks received scores of 0 for those test questions. Possible scores for the first-order tasks ranged from 0 – 3 based on prediction of other's false belief on the 3 first-order tasks. Prediction of own false belief on the Crayon Box task was not included in the aggregate score due to low levels of reliability found for this score by Hughes et al. (2000). Possible scores for second-order tasks ranged from 0 – 3 based on prediction of other's false belief in the 3 second-order tasks. Responses to justification questions were not included in the aggregate score due to concerns about their validity as a measure of ToM (Bowler, 1992; Hughes, Adlam et al., 2000; Ozonoff & McEvoy, 1994). Possible scores for third-order tasks ranged from 0 – 3 based on prediction of other's false belief in the 3 third-order tasks. Thus, total scores for the ToM false belief aggregate ranged from 0 – 9.

Selected stories from the Strange Stories task (Happé, 1994a, 1994b; Happé et al., 1999; Happé et al., 1996; Happé et al., 1998) were also administered. Previous research indicates that higher functioning individuals with ASD demonstrate difficulty with these advanced tasks despite performing well on first- or second- order ToM tasks (Baron-Cohen et al., 1999; Brent et al., 2004; Happé, 1994a, 1994b; Jolliffe & Baron-Cohen, 1999; Losh & Capps, 2003). The Strange Stories task, along with the third-order ToM false belief items, were administered to ensure that the ToM measures used in this study were sensitive to a wide range of ToM ability. In addition, relative to other "advanced" ToM tasks the Strange Stories task has been used in a number of previous research studies.

In the Strange Stories task, participants are presented with a series of stories in which characters make statements that are not literally true (e.g., "You have a frog in your throat.") and asked to explain why the character has said that. In order to perform successfully on this task, participants must be able to understand the mental intent behind the non literal communication (e.g., figure of speech, white lie, persuasion, joke, etc.) (Happé, 1994a, 1994b). Six stories were administered, four measuring understanding of persuasion, white lie, sarcasm, and misunderstanding and two stories measuring understanding of a "double bluff" scenario (i.e., a scenario in which an individual presents truthful information that is meant to be seen as incorrect). Minor content and wording changes were made to make the stories more culturally appropriate for participants in this study. The examiner presented the written stories and questions one at a time to participants and then read the story and questions aloud. If the participant

indicated that he or she preferred to read the story, they were instructed to read it aloud so that the examiner could confirm that they were able to read the story in its entirety.

Consistent with previous research using the Strange Stories, participants' responses to the question "Why did X say what he/she said?" were credited 2 points for a complete and explicitly correct answer and 1 point for a partial or implicit answer. Incorrect or "don't know" responses were credited no points (Happé et al., 1999; Happé et al., 1996; Happé et al., 1998), with total possible scores ranging from 0 – 12. Interrater reliability was evaluated by having participants' responses rescored by a second coder with graduate training in psychology blind to participants' performance on other research measures. Eighty-seven percent agreement was achieved with disagreements recoded according to consensus decision. A description of the Strange Stories used in this study along with sample scoring criteria are available in Appendix B.

Social Skills Measures. Four measures of social skills were administered, the Social Skills Rating System – Parent Questionnaire (SSRS-P; Gresham & Elliott, 1990), the Social Skills Rating System – Teacher Questionnaire (SSRS-T; Gresham & Elliott, 1990), the Social Skills Questionnaire-Parent form (SSQ-P), and the Social Skills Questionnaire-Teacher form (SSQ-T).

The SSRS-P is a standardized parent report questionnaire of social skills and was included to assess participants' overall social skills. Elementary ($n = 14$) or Secondary ($n = 8$) forms were administered depending upon the grade level of the participant being evaluated. Both forms yield a total standard score as well as descriptive behavior levels ("fewer", "average", and "more") for four domains of prosocial behavior including cooperation, assertion, responsibility, and self-control. In general, raw scores for each

domain within one standard deviation of the standardization sample mean are labeled as "average" while raw scores below or above one standard deviation of the standardization sample mean are labeled "fewer" or "more", respectively.

Empirical examination of the SSRS-P indicates that it has good psychometric properties (Gresham & Elliott, 1990). Internal consistency is strong with alpha coefficients of .87 and .90 for the total score on the Elementary and Secondary forms, respectively, and all but one alpha coefficient for the domain scores (the Responsibility domain on the Elementary form) were greater than .70. The test-retest reliability coefficients for the total and domain scores on the Elementary form range from .77 to .87. In addition, validity studies indicate that the total score from the Elementary form correlates with the Social Competence total of the Child Behavior Checklist-Parent Report Form (CBCL; Achenbach & Edelbrock, 1983) at .58; moderate correlations ranging between .37 and .51 were found between the domain scores the CBCL Social Competence total. However, test-retest reliability and validity data were not reported for the Secondary form.

Because teachers observe children and adolescents in different social contexts than do parents, teacher report of social skills was also obtained. The SSRS-T is the teacher version of the SSRS-P. Elementary ($\underline{n} = 9$) or Secondary ($\underline{n} = 4$) forms were administered depending upon the grade level of the participant. Both forms yield a total standard score as well as descriptive behavior levels for three domains of prosocial behavior including cooperation, assertion, and self-control.

The SSRS-T also demonstrates good psychometric properties (Gresham & Elliott, 1990). Internal consistency is strong with alpha coefficients of .94 and .93 for the total

score on the Elementary and Secondary forms, respectively, and domain score alpha coefficients are greater than .85. The test-retest reliability coefficients for the total and domain scores on the Elementary form range from .75 to .88. In addition, validity studies indicate that the total score from the Elementary form correlates with the total score of the Social Behavior Assessment (SBA; Stephens, 1981) at -.68 (higher scores on the SBA indicate greater social behavior problems); strong correlations ranging between -.48 and -.72 were found between the domain scores the SBA total. However, test-retest reliability and validity data were not reported for the Secondary form.

The SSQ-P is a parent report questionnaire designed for this study to assess participants' Active and Interactive social skills. Separate examination of these types of social skills was necessary in order to explore the hypothesis that ToM and executive function would demonstrate differential associations with Interactive and Active social skills. On the SSQ-P parents rate the frequency with which their child demonstrates certain behaviors on a 6-point likert-type scale ranging from 0 (Never) to 5 (Almost Always). The items included on the SSQ-P were chosen from a larger sample of items developed by the examiner and modeled after the Vineland-based measure used by Frith and colleagues (Fombonne et al., 1994; Frith et al., 1994; Sparrow et al., 1984). These items were reviewed by eight individuals with graduate and post-graduate training in autism spectrum disorders. Similar to previous research (Fombonne et al., 1994; Frith et al., 1994), these individuals were asked to classify items into two categories, those social skills that would "require" understanding of others mental states (Interactive social skills) and those social skills that are more routinized (Active social skills). Items for which there was over 85% classification agreement among raters were included on the scales,

resulting in a 28-item Interactive scale and an 35-item Active scale. The SSQ-P was administered in its original form (i.e., 63 items) to all participants and was refined on the basis of item analysis using techniques described by DeVellis (1991). First, three significantly skewed items were dropped, one from the Interactive scale and two from the Active scale. Next, items with corrected item-scale correlation coefficients of < .40 were excluded, five from the Interactive scale and eight from the Active scale. The resulting Interactive scaled comprised 22 of the original 28 items; the resulting Active scale comprised 25 of the original 35 items. Items for the Interactive and Active subscales for the SSQ-P are listed in Appendix C. Raw scores for each scale were used in data analysis.

The SSQ-T is the teacher version of the SSQ-P. The SSQ-T was developed based on the SSQ-P; items were excluded or reworded as necessary to make the measure applicable to the school environment, resulting in a 26-item Interactive scale and a 27-item Active scale. Teachers for 13 participants completed the SSQ-T in its original form. The SSQ-T was then refined using techniques described by DeVellis (1991). First, two significantly skewed items were removed from the Active scale. Due to the small sample size, a more conservative approach was taken in refining the SSQ-T than the SSQ-P and thus items with corrected item-scale correlation coefficients of <.30 were excluded, 3 from the Interactive scale and 8 from the Active scale. The resulting Interactive scale comprised 23 of the original 26 items; the resulting Active scale comprised 17 of the original 27 items. Items for the Interactive and Active subscales for the SSQ-P are listed in Appendix C. Raw scores for each scale were used in data analysis.

Procedures

Children were tested at the Center for Child Development at Vanderbilt University. Informed consent was obtained from parents and assent obtained from child participants prior to the administration of any research measures. In most cases, children completed all measures in a single day during a 5 hour testing session which included frequent breaks.

During their child's testing, parents completed the SSRS-P, the SSQ-P, and the demographic information form. To obtain test-retest data on the SSQ-P, parents were mailed a second copy to complete approximately two weeks after their child's testing session.

Parents of children currently enrolled in school (i.e., children who were not home schooled or on summer break) were asked to give a packet containing a consent form, SSQ-T, and the SSRS-T to their child's teacher. Teachers agreeing to participate in this study returned the signed consent form and completed questionnaires by mail.

Children received one $5 gift certificate from a local discount or toy store for each hour of testing they completed. Following an interpretive session with the examiner, parents received a written report summarizing the results of their child's evaluation. Teachers received $20 for completing the questionnaires.

CHAPTER III

RESULTS

Preliminary Analyses

Evaluation of Psychometric Properties of the SSQ

Reliability. Internal consistency was evaluated using coefficient alpha. For the Interactive and Active scales of the SSQ-P, alpha levels were .85 and .94, respectively. For the Interactive and Active scales of the SSQ-T, alpha levels were .93 and .87, respectively. Thus, these scales appear to have strong levels of internal consistency.

Test-retest data for the SSQ-P were available for 14 participants. On average, the retest SSQ-P was completed approximately one month after the first administration (range = 2.1 to 11.0 weeks, mean = 4.1 weeks, SD = 2.2). Reliability was assessed using Pearson correlations; the coefficients for the Interactive and Active scales were .97 and .93, respectively. In addition, no significant differences were found between the Interactive and Active scale scores from the initial administration to retest (*ps* > .40). These results indicate strong test-retest reliability for these scales.

Interrater reliability assessed by examining correlation coefficients between SSQ-P and SSQ-T was very low; the Interactive parent and teacher scales correlated at .08 and the Active parent and teacher scales correlated at -.03. Observing social behaviors in different contexts, and differences in item content, may have contributed to the small and nonsignificant coefficients between parent and teacher report (Achenbach, McConaughy, & Howell, 1987; Szatmari, Archer, Fisman, & Streiner, 1994).

Validity. Construct validity was assessed by correlating the subscales of the SSQ-P with the SSRS-P standard score and subscale behavior levels (coded with "fewer" behaviors = 0, "average" behaviors = 1, and "more" behaviors = 2). Results are presented in Table 2. The same pattern of correlations was obtained for the Interactive and Active scales. Significant correlations were found between the scales and the SSRS-P total standard score as well as the Cooperation, Responsibility, and Self-control subscales. Correlations with the SSRS-P Assertion subscale were not significant.

Table 2. Correlations among parent SSQ and SSRS scores

	SSQ-P Interactive	SSQ-P Active
SSRS-P Cooperation	.66***	.66***
SSRS-P Responsibility	.60**	.57**
SSRS-P Assertion	.26	.23
SSRS-P Self-Control	.70***	.57**
SSRS-P Standard Score	.63***	.59**

**p < .01, ***p < .001; one-tailed

Correlations between the Interactive and Active scales of SSQ-T and the teacher SSRS total standard score were moderate but not statistically significant (see Table 3). Correlations between the Interactive and Active scales and the subscales of the SSRS-T

Table 3. Correlations among teacher SSQ and SSRS scores

	SSQ-T Interactive	SSQ-T Active
SSRS-T Cooperation	.26	.13
SSRS-T Assertion	.40	.21
SSRS-T Self-Control	.18	.33
SSRS-T Standard Score	.39	.44

were small and not significant for the Cooperation subscale and the Self-Control subscale. Correlations between the Interactive scale and the Assertion subscale were moderate but not significant and correlations between the Active scale and Assertion subscale were small.

Descriptive Statistics

Table 4 presents descriptive statistics for the study measures. Values of skewness and kurtosis were within acceptable limits for all measures (Field, 2000). Values given for SSRS-P and SSRS-T are standard scores. All other values are raw scores.

Relation of ToM, Executive Function, and Verbal Ability to Social Skills

Because the hypotheses in this study were based on specific assumptions about the relations between ToM, executive function, and verbal IQ to social skills, preliminary

Table 4. Ranges, means, and standard deviations for study measures.

Measure	Possible Range	Range	Mean	Standard Deviation
ToM False Belief	0 – 9	0 – 9	5.0	2.9
ToM Strange Stories	0 – 12	0 – 10	4.9	2.9
WCST Perseverative Responses*	0 - 126	6 – 54	24.3	17.2
Tower of Hanoi	0 - 54	4 – 54	30.0	10.9
Digit Span Backwards	0 - 14	2 – 11	5.8	2.2
Counting Span	0 - 15	2 – 14	6.9	3.5
SSQ-P Interactive	0 - 110	16 – 85	45.0	19.5
SSQ-P Active	0 - 125	34 – 113	73.2	22.2
SSRS-P	40 - >130	52 – 120	82.5	16.7
SSQ-T Interactive**	0 - 115	20 – 76	48.0	18.5
SSQ-T Active**	0 - 85	24 – 75	48.9	13.9
SSRS-T**	40 - >130	63 – 98	83.8	10.5

*$\underline{n}$ = 18
**$\underline{n}$ = 13

analyses were conducted examining the correlations between these variables (see Table 5). Nonverbal IQ and chronological age were also included to assess their role as potential significant covariates. Parent report data were examined first. No significant

Table 5. Correlations among parent report of social skills, theory of mind, and executive function measures.

	SSQ-P Interactive	SSQ-P Active	SSRS-P	ToM False Belief	ToM Strange Stories	WCST Perseverative Responses	Working Memory	Tower of Hanoi
ToM False Belief	.18	.10	-.19					
ToM Strange Stories	.16	.02	-.11	.63**				
WCST Perseverative Responses	-.18	-.25	-.46*	-.16	-.24			
Working Memory	.40*	.39*	.29	.18	.38*	-.59**		
Tower of Hanoi	.50**	.46*	.25	.32	.27	-.42*	.58**	
VIQ	.14	.10	-.03	.33	.69**	-.27	.60**	.24
PIQ	.51**	.65**	.41*	.00	.16	-.44*	.50*	.48*
FSIQ	.40*	.45*	.23	.21	.51*	-.43*	.67**	.44*
CA	-.03	.08	.02	.37*	.14	-.46*	.34	.33

*$\underline{p} < .05$; **$\underline{p} < .01$; one-tailed

correlations were found between ToM and overall social skills, Interactive social skills, or Active social skills. However, several significant correlations were found between measures of executive function and social skills indicating that parents reported better social skills for children who performed better on the executive function tasks. Specifically, the working memory composite and the Tower of Hanoi demonstrated a strong positive relation to Interactive and Active social skills and number of perseverative responses from the WCST demonstrated a strong negative relation to the SSRS standard score. No significant correlations were found between Verbal IQ or chronological age and overall social skills, Interactive social skills, or Active social skills; however, Nonverbal IQ was a significant correlate of all three measures of social skills indicating that parents reported better social skills for children with higher Nonverbal IQ scores.

Thus, results from correlation analyses examining parent report data indicated that Hypothesis 1 was only partially supported in that executive function, but not ToM, was a significant predictor of overall social skills. Hypothesis 2 was not supported as ToM and executive function failed to demonstrate the predicted differential relations to Interactive and Active social skills; contrary to predictions, ToM failed to predict Interactive social skills and executive function was a significant predictor of both Interactive and Active social skills. Finally, the lack of a relation between Verbal IQ and overall social skills, Interactive social skills, or Active social skills failed to support Hypothesis 4. However, the significant correlation between Nonverbal IQ and the social skills measures indicated the need for post hoc analyses evaluating the relation between executive function and social skills when controlling for Nonverbal IQ.

Correlation analyses were repeated using the teacher report measures of social skills (see Table 6). No significant correlations were found for ToM, executive function, and verbal ability to any of the teacher report social skill measures. Thus, results from correlation analyses examining teacher report data also failed to support Hypotheses 1, 2 and 4.

Table 6. Correlations among teacher report of social skills, theory of mind, and executive function measures.

	SSQ-T Interactive	SSQ-T Active	SSRS-T
ToM False Belief	-.02	-.46	-.38
ToM Strange Stories	.28	-.13	-.14
WCST perseverative responses	-.11	-.09	.09
Working Memory Composite	-.03	-.28	-.15
Tower of Hanoi	-.22	-.28	-.31
VIQ	.37	-.02	.19
PIQ	-.17	-.01	-.30
FSIQ	.14	-.01	-.01
CA	-.16	-.24	-.69**

Note: $\underline{n} = 13$
**$\underline{p} < .01$; one-tailed

Nonverbal IQ also failed to correlate with the teacher report measures of social skills. However, there was a significant negative correlation between the teacher SSRS standard score and chronological age, indicating that teachers rated older children as having poorer social skills on the SSRS-T.

Main Analyses

Parent report data were examined first. Based on results from correlational analyses discussed above, no additional analyses were needed to investigate Hypotheses 1, 2, and 4. Hierarchical regression analyses were employed to investigate Hypothesis 3, the prediction that executive function moderates the relation between ToM and Interactive social skills. To facilitate computation of the interaction term to be used in analyses, composite scores were calculated for the ToM and executive function predictor variables. A ToM composite was calculated by averaging the computed z-scores for the ToM false belief measure and the ToM Strange Stories measure. An executive function composite was calculated by averaging the computed z-scores for the working memory and Tower of Hanoi measures. These executive function measures were chosen for inclusion in the regression model due to their significant correlation with the SSQ Interactive scale. The ToM × executive function interaction term was calculated by multiplying the ToM composite and the executive function composite.

Hypothesis 3 proposed that the interaction term "ToM × executive function" would explain a significant proportion of variance in Interactive social skills beyond what is accounted for by the independent effects of ToM and executive function. Table 7 summarizes the results of the regression analysis testing Hypothesis 3. As expected from

Table 7. Hierarchical regression of ToM and executive function on parent report of Interactive social skills.

	Interactive	
Predictors	ΔR^2	β
Step 1		
Theory of Mind	.03	-.06
Step 2		
Executive Function	.23*	.54*
Step 3		
Theory of Mind x Executive Function	.02	-.15

* $p < .05$

the correlation analyses, ToM did not account for a significant proportion of variance in Interactive social skills when entered at Step 1. At Step 2, the executive function composite comprising the working memory and Tower of Hanoi scores was a significant predictor of Interactive social skills. Finally, the ToM × executive function interaction term entered at the third step did not account for a significant proportion of the variance in Interactive social skills beyond executive function. Thus, results did not support Hypothesis 3.

Teacher report data were examined next. Based on results from correlational analyses discussed above, no additional analyses were needed to investigate Hypotheses

1, 2, and 4. Though the sample was small for the number of predictors entered, exploratory hierarchical regression analyses were completed to investigate Hypothesis 3 which proposed that executive function moderates the relation between ToM and teacher report of Interactive social skills. The same composite variables computed for the regression analyses with the parent report measures of social skills were used in these analyses. Results indicated that the ToM × executive function interaction term did not account for a significant proportion of the variance in Interactive social skills, thus again failing to support Hypothesis 3.

Post hoc Analyses

Given the significant relation between Nonverbal (Performance) IQ and the parent report measures of social skills and executive function, additional hierarchical regression analyses were conducted to evaluate the relation between executive function and social skills when controlling for individual differences in Nonverbal IQ. Results are summarized in Table 8 and indicate that executive function fails to account for a significant proportion of the variance in social skills above that accounted for by Nonverbal IQ.

Table 8. Hierarchical regression of Nonverbal IQ and executive function on parent report of Interactive, Active, and General social skills.

	Interactive		Active		General	
Predictors	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1						
Nonverbal IQ	.26*	.33	.42**	.55*	.17	.26
Step 2						
Executive Function	.07	.33	.02	.17	.09	-.35

Note: For analyses predicting Interactive and Active social skills, the composite score comprised of the average of the computed z-scores for the working memory and Tower of Hanoi measures was entered for executive function. For the analysis predicting General social skills, number of perseverative responses from the WCST was the executive function variable.
* $p < .05$; ** $p < .01$

CHAPTER IV

DISCUSSION

Relation between ToM and Social Skills

The purpose of the current study was to examine the relation between ToM, executive function, and social skills in high-functioning individuals with ASD. Contrary to hypotheses, ToM was not a significant predictor of overall social skills or Interactive social skills. This was true for both measures of false belief and the Strange Stories task. Though these findings are consistent with the majority of research examining the relation between ToM and overall social skills (Fombonne et al., 1994; Frith et al., 1994; Ozonoff & Miller, 1995; Prior et al., 1990), the failure to find a relation between ToM and Interactive social skills is inconsistent with previous research (Fombonne et al., 1994; Frith et al., 1994). There are several possible reasons for the differences in findings. First, participants in previous studies were somewhat older and lower functioning than participants in the current study. For example, participants in the Frith et al. study had a mean chronological age of 15 years and a mean Verbal IQ of 52; participants in the Fombonne et al. study had a mean chronological age of 17 years and mean Verbal IQ below the borderline range. It may be that ToM is simply a better predictor of social skills in lower-functioning individuals than in higher-functioning individuals because higher-functioning individuals have additional cognitive skills, such as superior executive function or nonverbal cognitive skills, which "assist" them in social situations. Further

research including both lower- and higher-functioning individuals would be necessary to examine this possibility empirically.

Second, as ToM tasks designed to tap a wide range of ability levels were included in the current study, it seems unlikely that the failure to find a relation between ToM and social skills is due to a failure to measure "advanced" ToM capabilities. Other research using "advanced" tasks, i.e., the Strange Stories task, has also failed to find a relation between it and narrative ability in high-functioning children with ASD (Losh & Capps, 2003). Instead, it may be that tasks tapping another dimension of ToM skills are needed. Tager-Flusberg (2001) has proposed a model of ToM which distinguishes between "social-cognitive" abilities, the cognitive reasoning about mental states that traditional ToM tasks are designed to assess, and "social-perceptual" abilities, the more immediate judgments about mental states made by processing information in faces, voices, and gestures. Although both social-perceptual and social-cognitive abilities are theoretically important to every day social functioning, traditional ToM false belief tasks are likely not strong measures of social-perceptual abilities as they do not include "on-line" social information. Thus, a better way to examine the relation between ToM and social skills would be to use ToM tasks that potentially tap both ability areas.

One such task may be the Social Attribution Task (Klin, 2000), a measure designed to assess spontaneous attribution of social meaning to ambiguous visual stimuli. In this task, participants are asked to provide a narrative describing a brief animated sequence of moving shapes. Research with adolescents and adults indicates that typically developing participants tend to describe the events in the animated sequence in anthropomorphic terms more often than do high-functioning participants with ASD. For

example, typically developing individuals tend to use mental state terms to describe the shapes as well as attributing social meaning to the animated sequences (e.g., describing the shapes as "tricking" one another). Other studies using tasks very similar to the Social Attribution Task have reported comparable findings. For example, in one study children with ASD used mental state descriptions less often than typically developing children and less appropriately than children with cognitive impairment (Abell, Happé, & Frith, 2000). Another study found that adults with ASD used fewer and less appropriate mental state terms than typically developing participants to describe animated sequences specifically designed to depict interactive "intentionality", such as shapes "coaxing" one another (Castelli, Frith, Happé, & Frith, 2002).

Unfortunately, the ability of the Social Attribution Task and similar tasks to predict real life social competence has not yet been reported. In fact, relatively few studies have examined the relation between social-perceptual skills and social skills in individuals with autism. Nonetheless, some evidence exists that the social-perceptual deficits of individuals with autism is related to their social deficits. For example, Klin and colleagues (Klin, Jones, Schultz, Volkmar, & Cohen, 2002) used eye tracking technology to observe viewing patterns in high-functioning adolescents and adults with ASD during a video presentation of a complex social interaction (scenes from a movie). Results indicated that greater amounts of time spent viewing the mouths of individuals in the video was related to higher social adaptation as measured by the Vineland and lower social impairment as measured by the social scale of the ADOS. Conversely, greater amounts of time spent viewing objects in the video was related to lower social adaptation scores and greater social impairment.

Other researchers have sought to examine the relation between social deficits in autism and abnormal neural processing in brain regions believed to mediate social cognition, particularly the processing of faces. Face processing deficits, such as poor eye contact and poor responding to facial expressions of emotion, as well as abnormalities in associated neural systems, have been shown to be present in young children with autism and persist throughout the lifespan (Dawson, Webb, & McPartland, 2005). For example, Dawson and colleagues (Dawson, Webb, Carver, Panagiotides, & McPartland, 2004) examined the latency of the event related potential (ERP) response to an affective stimulus (a picture of a woman with a fearful expression) in preschool age children with ASD. They found that slower processing of the affective facial stimulus was associated with more severe impairments on laboratory tasks of social orienting, joint attention, and attention to other's distress. Pelphrey and colleagues (Pelphrey, Morris, & McCarthy, 2005) used fMRI to investigate neural responses in high-functioning adults with ASD to the presentation of a face stimulus showing eye gaze "congruent" with the presentation of a visual target (i.e., looking in the direction of the target) and "incongruent" with the presentation of a visual target (i.e., not looking in the direction of the target). Results indicated that, unlike in typically developing individuals, in individuals with autism a brain region associated with social perception (i.e., the superior temporal sulcus, or STS) did not show different activity in response to viewing congruent and incongruent eye gaze shifts. These findings were interpreted to indicate that, in individuals with autism, the STS is not sensitive to the intentions conveyed by different gaze shifts. Individual differences in the degree of abnormality in the STS processing significantly correlated with the ADI-R such that lower levels of incongruent/congruent differentiation (i.e., more

atypical processing) were associated with a greater degree of social and nonverbal communication symptoms as reported on the ADI-R.

Finally, in considering the relation between ToM and Interactive social skills in the current study, it is important to acknowledge that attempts to differentially measure Interactive and Active social skills may not have been successful. Although these scales demonstrated strong internal consistency and test-retest reliability, they were developed theoretically and the small sample size prohibited the use of empirical techniques, such as factor analysis, to determine whether distinct Interactive and Active factors could be derived. The parent report Interactive and Active scales were highly correlated with one another and demonstrated identical patterns of correlations with the other study measures. Their high correlation with the SSRS-P, an overall measure of social skills, may indicate that these scales served as more general measures of social skills than had been intended. The teacher report Interactive and Active scales demonstrated lower correlations to the SSRS-T, and examination of the size of the correlation coefficients indicates that the teacher Interactive and Active scales may exhibit some differential relations to other study measures (e.g., the negative correlation between the Active scale and false belief approached significance and the positive correlation between the Interactive scale and VIQ approached significance). However, given the small sample size of available teacher data and the number of correlations examined, the potential significance of this pattern should not be overstated. Future research could improve upon the measurement of Interactive and Active skills by developing the scales on larger samples and examining their structure through factor analysis. It may also be that conceptualizing social skills

categorically as either Interactive or Active is too simplistic and that skills weighted along an Interactive-Active continuum may show a clearer relation to ToM.

Although this study was not designed as a treatment study, the findings offer some insight into appropriate interventions for individuals with autism. The lack of a relation between social skills and the social-cognitive ToM tasks used in this study, in addition to previous research indicating that social-cognitive ToM interventions do not lead to gains in social skills (Hadwin et al., 1996, 1997; Ozonoff & Miller, 1995; Swettenham, 1996), call into question the efficacy of teaching social-cognitive ToM skills as a method of improving social skills in individuals with ASD. Instead, current results suggest that intervention and supports focusing on nonverbal cognitive deficits of individuals with ASD may be more fruitful. For example, interventions focused on teaching social-perceptual skills, such as attending to and understanding facial expressions, may be more effective in improving social skills than those focused on teaching social-cognitive skills.

Relation between Executive Function and Social Skills

In contrast to ToM which failed to predict social skills, executive function was a significant predictor of parent report of overall, Active, and Interactive social skills. However, these relations were no longer significant when controlling for Nonverbal IQ. Results from previous research examining the relation between executive function and social skills, though limited, have been mixed. One study failed to find a relation between measures of executive function and social skills (Ozonoff et al., 2004) while others have

(Joseph & Tager-Flusberg, 2004; Liss et al., 2001), though the relations were no longer significant when controlling for verbal ability.

One possible explanation for the different findings for the current study and the work by Ozonoff et al. may be the method of administration of the executive function tasks. Previous research suggests that individuals with autism may have more difficulty with executive function tasks administered by an examiner rather than by a computer, presumably because of the additional social demands required by an in-person administration (Ozonoff, 1995). A difference between the Ozonoff et al. study and the present investigation is that Ozonoff et al. utilized computer-administered tests of executive function while this study did not; it is possible that the relation between executive function and social skills in the current study reflects the confound of the executive tasks having a greater social component. However, other research has failed to replicate this finding of differential performance on computerized vs. person administered tests (Shu et al., 2001), and other measures administered in this study in a similar fashion, i.e., the measures of ToM, failed to show any relation at all to social skills. Further research empirically investigating differences between computer and person administered tests would be necessary to answer this question more definitively.

Contrary to prediction, Nonverbal IQ, and not Verbal IQ, was a significant covariate in the relation between executive function and social skills. This is inconsistent with previous research demonstrating that the relation between executive function and social skills diminishes when controlling for differences in verbal, but not nonverbal, ability (Joseph & Tager-Flusberg, 2004; Liss et al., 2001). Although participants in the current study exhibited a wide range of verbal ability (i.e., Verbal IQ scores ranging from

74 – 139), their average Verbal IQ score exceeded the average Verbal IQ scores in the other studies by approximately 15 points. It may be that excluding participants with deficits in Verbal IQ in the current study, a restriction not present in the other studies, reduced the potential relation between verbal ability and social skills. Conversely, Liss et al. (2001) excluded participants whose Nonverbal IQ was below 80, possibly decreasing the relation between nonverbal cognitive ability and social skills.

The ToM model proposed by Tager-Flusberg (2001) may also offer some insight into the significant relation between Nonverbal IQ and social skills in the current study. It may be that general nonverbal cognitive abilities are linked with social-perceptual skills, thus accounting for the relation between Nonverbal IQ and social skills. For example, previous research has demonstrated a relation between recognition of emotion and nonverbal cognitive skills in high-functioning individuals with ASD (Buitelaar, Van der Wees, Swabb-Barneveld, & Van der Gaag, 1999b). In addition, though further empirical investigation is needed before making strong conclusions about the relation between nonverbal cognitive skills and social skills, the concept of nonverbal learning disability (NVLD) may be of relevance. NVLD refers to neuropsychological profile of deficits in nonverbal reasoning and problem-solving and preserved rote verbal skills and memory, and both research and clinical accounts suggest that this profile is found in some higher functioning individuals with ASD (Rourke & Tsatsanis, 2000; Volkmar & Klin, 1998). Because much important social information is nonverbal (e.g., interpreting facial expressions and gestures), the deficits in nonverbal skills associated with NVLD are thought to affect social competence (Volkmar & Klin, 1998).

It is not clear why there was a differential relation between the measures of executive function and the parent report measures of social skills; measures of planning and working memory predicted parent report of Interactive and Active social skills while a measure of flexibility predicted the SSRS-P. These findings might suggest that the skills assessed by the Interactive and Active scales of the SSQ-P tend to be more complex and require more planning and working memory skills than the skills measured by the SSRS-P. In contrast, the SSRS-P may assess skills related to being more flexible and less rigid in social situations. However, review of individual items on these scales does not necessarily support this interpretation as all three scales appear to assess skills of varying complexity and relation to flexibility. In addition, most tests of executive function do not measure a single skill but rather tap a variety of executive processes (Ozonoff et al., 1994; Pennington & Ozonoff, 1996). Thus, it is difficult to make strong conclusions about the implications of the differential relations between the executive function and social skills measures in the current study. Again, future research with a larger sample would allow for a more in-depth examination of the scales' structure and their relation to other measures.

Finally, given the significant relation between social skills and executive functioning in the current study, as well as in research with other clinical populations, in future research it may be worthwhile to investigate the effects of improved executive functioning skills on social skills in individuals with ASD. For example, cognitive flexibility training has resulted in increased flexibility on tasks not specifically taught in individuals with autism, schizophrenia, and mental retardation (Bock, 1994; Delahunty, Morice, & Frost, 1993; McKinney & Corter, 1971; Ozonoff, 1998; Wykes, Reeder,

Corner, Williams, & Everitt, 1999), and intervention with individuals with schizophrenia found evidence that improvement in cognitive flexibility was associated with improvement in social functioning, but only when a threshold level of improvement in flexibility was reached (Wykes et al., 1999).

Findings from Teacher Report

The association between executive function and social skills found for the parent report measures of social skills was not replicated in the sample of teachers. The teacher report social skills measures did not correlate with measures of executive function or Nonverbal IQ. The small sample size limits conclusions that can be drawn from these data. One explanation, nonetheless, may be that teachers primarily observe students with ASD in more structured social contexts (e.g., games in gym class) than do parents, and thus social deficits associated with executive function impairments may not be as apparent. However, this interpretation implies that teachers would rate students with ASD as less impaired on the social measures than did parents. Comparison of the SSRS-T and SSRS-P standard scores indicate that this is not the case. In addition, the only significant correlation that emerged from the teacher data indicates that teachers tended to rate older participants as having poorer social skills on the SSRS; this pattern was not found with the parent report data. It may be that teachers, having more opportunity to compare children's behavior with same-age peers than parents, observe greater social skills deficits in older children as social demands from peers become more complex.

Study Limitations

This study has several limitations that need to be acknowledged. In addition to the measurement issues already discussed, there remains the question of the ecological validity of the social skills measures used in this study. This study relied on informant report of social skills, but other types of measures may have more ecological validity. Unfortunately, identifying appropriate, ecologically valid measures of social skills is a common challenge in much research involving children with ASD. More direct indicators of social competence commonly used with typically developing children, such as sociometric status or observations of in-vivo peer interactions, are difficult to use with children with ASD due to wide variation in school placements and availability of peers (Sigman & Ruskin, 1999). Ultimately, supplementing informant report measures of social skills with direct observation of skills in a laboratory setting may provide valuable information.

Another limitation of this study is its small sample size. Although the sample size in this study is similar to that of many other studies including high-functioning individuals with ASD (Liss et al., 2001; Ozonoff & McEvoy, 1994; Ozonoff, Pennington et al., 1991), the absolute number of individuals is somewhat small and consequently may limit generalizability of the current findings. The small sample is particularly problematic when considering the implication of the results from the teacher report.

Finally, as this study was designed to examine within group differences in individuals with ASD, it does not provide any information about the relation between ToM, nonverbal cognitive skills, and social skills in other clinical groups or typically developing individuals. Additional research would be necessary to determine if the

relation between Nonverbal IQ, executive function, and social skills found in this study is specific to individuals with autism or present in other populations. Furthermore, although theory supports the interpretation of the current results to indicate that deficits in nonverbal processing skills, whether related to executive function skills or more specific social-perceptual skills, may lead to social deficits in individuals with ASD (Tager-Flusberg, 2001), the correlational design of the current study does not allow for statistical examination of the possibility that nonverbal deficits produce social skill deficits. Longitudinal data examining and comparing the development of nonverbal processing skills and social skills over time would be necessary before making stronger statements about causal relations.

Summary and Conclusions

In sum, this study has examined the relation between ToM, executive function, and social skills in high-functioning individuals with ASD. Executive function and Nonverbal IQ, rather than social-cognitive ToM, were significant predictors of social skills. Future research examining the relation between nonverbal cognitive skills and social-perceptual abilities may provide more insight into the development and remediation of social skills deficits in high-functioning individuals with ASD.

APPENDIX A

FALSE BELIEF TASK SCRIPTS

First-order False Belief: Crayon Box Task (based on Perner et al., 1989)

Examiner holds up Crayon box.

See this?

What do you think is inside?
(Box recognition question*)

Examiner opens box, shows child contents (miniature car).

What's this?
(Contents Recognition Question)

Examiner closes box.

Before you looked inside, what did you think was in the box, (crayons or a car)?
(Own-belief Test Question)

What is in the box really, (crayons or a car)?
(Control Question 1)

If we showed this box to your mom/dad, what would she/he think is in it, (crayons or a car)?
(Other-belief Test Question)

What is in the box really, (crayons or a car)?
(Control Question 2)

*If participants fail to recognize what the contents of the box should be, administration with this particular item will be terminated and attempted again with a band-aid box.

First-order False Belief: Sally & Andy Story (based on Baron-Cohen et al., 1985)

Andy has a plane. He puts it in the toy box before he goes outside to play. While Andy is outside playing, Sally takes the plane out of the toy box and puts it in the closet. Andy comes back inside. He wants to get his plane and take it outside.

Where will Andy look for his plane, (in the toy box or in the closet)?
(Belief Test question)

Where is the plane really, (in the toy box or in the closet)?
(Reality Control Question)

Where was the plane first of all, (in the toy box or in the closet)?
(Memory Control Question)

First-order False Belief: Dad & Rachel Story (based on Baron-Cohen et al., 1985)

Rachel has a toy car. She puts it under her bed, then she goes to have lunch. While Rachel is having lunch, Dad comes in to clean her room. He takes the car out from under the bed, and puts it in the drawer. Rachel finishes lunch. She goes to her room to get her car.

Where will Rachel look for her car, (under the bed or in the closet)?
(Belief Test Question)

Where is the car really, (under the bed or in the closet)?
(Reality Control Question)

Where was the car first of all, (under the bed or in the closet)?
(Memory Control Question)

Second-Order Belief: Library Story (based on Baron-Cohen, 1989)

This is Mom, Dad, and John.

One day Dad said, "I'm going to the library. Do you want to come John?" John said "No, I don't feel like it right now." So Dad went off to the library, Mom stayed to work in the garden, and John went to play in the back yard.

Where did Dad say he was going?
(Prompt Question)

A little while later Mom saw Dad coming back from the library. "Where are you going?" she asked. Dad said, "The library was closed, so I'm going to visit the neighbors." "OK", said Mom, I'm going to stay and work in the garden some more."

Where did Dad tell Mom he was going?
(Prompt Question)

Did John hear that?
(Prompt Question)

Dad walked by the backyard on his way to the neighbors. John said "Hi Dad, where are you going?" Dad said "The library was closed, so I'm going to visit the neighbors." And off he went.

Where did Dad say he was going?
(Prompt Question)

Does Mom know that Dad talked to John?
(Prompt Question)

A little later, John was bored, and decided to go see his Dad. He ran to the front yard and yelled "Mom, I'm going to see Dad!"

Where does Mom think John will go, (to the library or to the neighbors)?
(Test Question)

Why does she think he will go there?
(Justification Question)

Where is Dad really, (at the library or at the neighbors)?
(Reality Question)

Where did Dad go first of all, (to the library or to the neighbors)?
(Memory Question)

Second-Order Belief: Computer Game Story (based on Bowler, 1992)

Tom and Jane are friends. Tom wants to buy a video game, so he and Jane go to Target. Tom sees a game he likes there, but before he buys it he wants to see how much it costs at Wal-Mart. Tom and Jane go to Wal-Mart. Tom sees the game, but it is more expensive than the one at Target. Tom decides to go back to Target after lunch to buy the game.

Where is Tom going to buy his game?
(Prompt Question)

When?
(Prompt Question)

Tom and Jane decide to go to their own houses to eat lunch. They decide that after lunch they will meet at Tom's house and go to Target to buy the game.

Where are Tom and Jane going to meet?
(Prompt Question)

Where are they going?
(Prompt Question)

Tom eats his lunch at his house. While he is waiting for Jane to come over, Tom calls Target to make sure they still have the game he likes. He finds out that Target just sold out of the game.

Does Tom know that Target doesn't have the game anymore?
(Prompt Question)

Does Jane know that Tom called Target?
(Prompt Question)

Jane is late, and Tom starts to get worried that Wal-Mart will sell out of the game, too. He decides he better not wait for Jane to come over before he goes to buy his game. He goes out to buy the game.

Jane arrives at Tom's house a few minutes later. She is late because she called Target and found out they were sold out of the game. She sees that Tom has left a note for her on his front door that says "I went to buy the game!"

Where does Jane think Tom went to buy the game, (to Target or Wal-Mart)?
(Belief Test Question)

Why? (Justification Question)

Where has Tom gone really to buy the game, (to Target or Wal-Mart)?
(Reality Control Question)

Where did Tom want to buy the game at first, (Target or Wal-Mart)?
(Memory Control Question)

Second-Order Belief: Birthday Puppy Story (based on Sullivan et al., 1994)

Tonight it's Peter's birthday and mom is surprising him with a puppy. She has hidden the puppy in the tool shed. Peter says, "Mom, I really hope you get me a puppy for my birthday." Remember, Mom wants to surprise Peter with a puppy. So, instead of telling Peter she got him a puppy, Mom says, "Sorry Peter, I did not get you a puppy for your birthday. I got you a really great toy instead."

What did mom really get Peter for his birthday?
(Prompt Question)

What did mom tell Peter she got him for his birthday?
(Prompt Question)

Now, Peter says to Mom, "I'm going outside." Outside, Peter goes down to the tool shed to get his skateboard. In the tool shed, Peter finds the birthday puppy! Peter says to himself "Wow, Mom didn't get me a toy, she really got me a puppy for my birthday." Mom does NOT see Peter go to the tool shed and find the birthday puppy.

Does Peter know that his Mom got him a puppy for his birthday?
(Prompt Question)

Does Mom know that Peter saw the birthday puppy in the tool shed?
(Prompt Question)

Ding-dong! Mom's friend Barbara comes over for a visit. While talking to Mom Barbara asks, "What does Peter think you got him for his birthday?"

What does Mom say to Barbara, (a toy or a puppy)?
(Belief Test Question)

Why does Mom say that?
(Justification Question)

What did mom get Peter for his birthday really, (a toy or a puppy)?
(Reality Control Question)

What did mom tell Peter she got him in the beginning of the story, (a toy or a puppy)?
(Memory Control Question)

Third-Order Belief: Prisoner Story (based on Happe, 1994)

During the war, the Orange Army captured a member of the Blue Army. The Orange Army wants the prisoner to tell where the Blue Army's tanks are; they know they are either by the sea or in the mountains. The Orange Army knows that the prisoner will not want to tell them; he will want to save his Blue Army, and so he will certainly lie to them. The prisoner is very brave and clever; he will not let the Orange Army find his Blue Army's tanks. The Blue Army's tanks are really in the mountains. When the Orange Army asks the prisoner where the Blue Army's tanks are, the prisoner says, "They are in the mountains."

Is it true what the prisoner said?
(Prompt Question)

Why did the prisoner say what he said?
(Justification Question)

Where does the prisoner think the Orange Army will look for his Blue Army's tanks, (by the sea or in the mountains)?
(Belief Test Question)

Third-Order Belief: School Bully Story (based on Happe, 1994)

Mike wins a prize in a contest at school. He puts the prize in his desk to keep it safe. During lunch, the school bully comes up to Mike. The bully is not very nice. He tells Mike to tell him where the prize is because he's going to take it. The bully knows that the prize is either in Mike's desk or in Mike's locker. The bully also knows that Mike doesn't want him to take the prize, so Mike will lie about where it is. Mike is smart and not scared of the bully. Mike will not let the bully take his prize.

Remember, Mike put the prize in his desk. When the bully asks, "Where is the prize, in your desk or in your locker?" Mike says, "It's in my desk."

Is what Mike said true?
(Prompt Question)

Why did Mike say what he said?
(Justification Question)

Where does the Mike think the bully will look for the prize, (in his desk or in his locker)?
(Belief Test Question)

Third-Order Belief: School Project Story (developed by the examiner)

Marsha, John, and Steven are having lunch together in the cafeteria. They decide to meet outside after school to work on a project together.

Where are Marsha, John, and Steven going to meet?
(Prompt Question)
When lunch ends, Marsha and John go to class together. Marsha says to John "You know, it's too cold to work on the project outside. Let's meet at the library instead." John says "Ok, after school I'll go outside and get Steven and tell him to come to the library."

Where do John and Marsha decide to meet instead?
(Prompt Question)

Does Steven hear them talking?
(Prompt Question)

Later that day Marsha sees Steven in the hallway. John is not nearby. Marsha says "Hey Steven, after school we are going to meet in the library instead of outside." Steven says "Ok, I'll see you in the library."

Where does Marsha tell John to meet?
(Prompt Question)

Does Steven hear them talking?
(Prompt Question)

Later, John sees Steven in the hallway. Marsha is not nearby. John says "Steven, we're going to meet at the library after school." Steven says, "I know, Marsha already told me."

Does Marsha hear John and Steven talking?
(Prompt Question)

After school Marsha rushes to John's class to tell him that she talked to Steven, but John is already gone. The teacher tells Marsha "John said he was going to meet Steven."

Where does Marsha think John went to meet Steven, (outside or at the library)?
(Belief Test Question)

Why? (Justification Question)

Where did John really go to meet Steven, (outside or at the library)?
(Reality Control Question)

Where did Marsha, John, and Steven decide to meet first of all, (outside or at the library)?
(Memory Control Question)

APPENDIX B

DESCRIPTIONS OF STRANGE STORIES AND SCORING CRITERIA

(Based on Happé, 1994a, 1994b; Happé et al., 1999; Happé et al., 1996; Happé et al., 1998)

Double Bluff

Story description: A brave and clever prisoner tells his captors exactly where his army is hiding its tanks.

Test question: Why did the prisoner say what he said?

2 point response: Because he knows that they think he will lie.

1 point response: Because he wants to trick them.

0 point response: Because he was scared.

Double Bluff

Story description: A smart and clever boy tells the school bully exactly where he hid a school prize.

Test question: Why did the boy say what he said?

2 point response: Because he knows that the bully thinks he will lie.

1 point response: To fool the bully.

0 point response: Because he couldn't tell a lie.

Sarcasm

Story description: A man and a woman go on a picnic and it starts to rain. The woman remarks that it is a nice day for a picnic.

Test question: Why does she say that?

2 point response: Because she is being sarcastic.

1 point response: Because she is angry.

0 point response: Because it is a nice day.

Persuasion

Story description: A boy who wants an extra serving of food in the cafeteria tells the lunch lady that his mother will not give him any dinner when he gets home even though he knows that is not true.

Test question: Why does he say that?

2 point response: Because he is trying to trick them to get more food.

1 point response: Because he wants more pizza.

0 point response: Because it's a long time before dinner.

White Lie

Story description: A girl receives a gift that she does not like but tells the giver that it is just what she wanted.

Test question: Why did she say this?

2 point response: Because she didn't want to hurt her parents' feelings.

1 point: To be polite.

0 point: Because she liked it.

Misunderstanding

Story description: A thief drops a glove as he is making his getaway. A policeman walking by shouts at him to stop so he can give him back his glove. The burglar turns himself in to the policeman.

Test question: Why did the burglar do this, when the policeman just wanted to give him back his glove?

2 point response: Because he thought the policeman knew that he had just robbed the shop.

1 point response: Because he thought he was caught.

0 point response: Because the policeman was going to arrest him.

APPENDIX C

INTERACTIVE AND ACTIVE SCALES OF THE SSQ-P

Interactive Scale

1. Understands what makes other people feel surprised or embarrassed
2. Chooses appropriate gifts for others
3. Understands when someone is being sarcastic[a]
4. Understands that others' feelings may be different from his/her own
5. Understands that others may not know something she/he knows[a]
6. Hides her/his disappointment when she/he receives a gift she/he does not like
7. Infers another person's perspective or point of view
8. Recognizes when his/her behavior is unintentionally irritating or aggravating others[b]
9. Understands that others may not share his/her interests
10. Offers to help someone without being asked
11. Accurately predicts how others will react to his/her behavior
12. Understands what makes other people feel happy, sad, angry, or afraid
13. When appropriate, tells "white" lies so as not to hurt others' feelings
14. Initiates conversation on topics of interest to others
15. Recognizes when someone is trying to intentionally provoke or upset him/her
16. Recognizes when she/he has hurt or offended someone without being told
17. Puts herself/himself "in someone else's shoes"

18. Responds to hints in conversation (e.g., if someone says "Those potato chips look good.", will offer some)
19. Refrains from saying things to others that might hurt or embarrass them
20. Understands that his/her behavior "makes an impression" on others
21. Responds to subtle social cues (e.g., will end a conversation with someone who keeps looking at his or her watch)
22. Shares information about others inappropriately (e.g., share personal information about parents with strangers) [a]
23. Provides enough information in conversation so a listener understands what he/she is talking about[a]
24. Recognizes that others' likes and dislikes may be different from his/her own[a]
25. Understands that his/her behavior affects the way other people think and feel about him/her
26. Does something just to be nice to someone else
27. Figures out why he/she has made someone upset or angry
28. Introduces a topic of conversation so that others can understand what he/she is talking about (e.g., begins by saying "In this movie I saw…", or "During my vacation I…")

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a = items with corrected item-scale correlation coefficients of < .40

b = significantly skewed items

Active Scale

1. Maintains a neat appearance (appropriate for his/her age)
2. Follows time limits set by adults (e.g., comes home at a certain time)
3. Uses appropriate table manners
4. Follows the rules in simple board, card, or video games when playing with others
5. Understands that different behavior is appropriate for different situations (e.g., understands it's OK to talk while watching TV at home, but not OK to talk while watching a movie in a theater)
6. Spontaneously greets familiar people (i.e., says hello before the other person says hello) [a]
7. Responds appropriately when introduced (e.g., says hello)
8. Remembers to return things he/she has borrowed
9. Initiates conversation on topics of interest to himself/herself[b]
10. Says "thank you" without being reminded
11. Respects others' physical space (e.g., does not stand too close or touch others inappropriately)
12. Initiates routine small talk (e.g., talk about the weather)[b]
13. Spontaneously responds when others greet him/her or say goodbye
14. Keeps secrets when told to do so (e.g. follows instructions to not discuss the contents of a gift until it is opened)
15. Makes requests politely
16. Shares his/her possessions when asked

17. Practices good hygiene with minimal reminding or assistance
18. Asks permission before taking or using something that belongs to someone else
19. Participates with others in activities he/she likes
20. Spontaneously says goodbye when leaving
21. Remembers to cover his/her mouth when sneezing or coughing
22. Engages in undesirable behaviors in public (e.g., spitting, nose picking)
23. Completes simple household chores with minimal reminding or assistance (e.g., making bed, putting away dishes, helping in the yard)
24. Independently plans for a visit or activity with peers (e.g., arrange a meeting place and time)[a]
25. Asks others for help or information politely
26. Follows household rules without reminding (e.g., obeys TV or computer time limits, goes to bed without reminding)
27. Introduces self to new people without prompting[a]
28. Apologizes when someone points out a mistake or poor behavior[a]
29. Actively pursues a hobby or interest (e.g., reads or learns about a topic on his/her own, requests or purchases items related to it) [a]
30. Follows school rules without reminding (e.g., stays in seat, does not leave class without permission, arrives on time)
31. Waits patiently for his/her turn during a game or activity
32. Makes a simple purchase without assistance (e.g., buy a candy bar or movie ticket) [a]

33. Complies with simple requests from others (e.g., will lend an item or help with a chore if asked)
34. Becomes destructive or physically aggressive when upset (reversed scored) [a]
35. Uses appropriate telephone manners (e.g., identifies self, takes and delivers messages) [a]

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a = items with corrected item-scale correlation coefficients of < .40

b = significantly skewed items

APPENDIX D

INTERACTIVE AND ACTIVE SCALES OF THE SSQ-T

Interactive Scale

1. Understands what makes other people feel surprised or embarrassed
2. Understands when someone is being sarcastic
3. Understands that others' feelings may be different from his/her own
4. Understands that others may not know something she/he knows
5. Infers another person's perspective or point of view
6. Recognizes when his/her behavior is unintentionally irritating or aggravating others
7. Understands that others may not share his/her interests
8. Offers to help someone without being asked
9. Accurately predicts how others will react to his/her behavior
10. Understands what makes other people feel happy, sad, angry, or afraid
11. When appropriate, tells "white" lies so as not to hurt others' feelings[a]
12. Initiates conversation on topics of interest to others[a]
13. Recognizes when someone is trying to intentionally provoke or upset him/her
14. Recognizes when she/he has hurt or offended someone without being told
15. Puts herself/himself "in someone else's shoes"
16. Responds to hints in conversation (e.g., if someone says, "Those potato chips look good," will offer some)
17. Refrains from saying things to others that might hurt or embarrass them
18. Understands that his/her behavior "makes an impression" on others

19. Responds to subtle social cues (e.g., will end a conversation with someone who keeps looking at his or her watch)
20. Shares information about others inappropriately (e.g., shares personal information about parents with strangers) [a]
21. Provides enough information in conversation so a listener understands what he/she is talking about
22. Recognizes that others' likes and dislikes may be different from his/her own
23. Understands that his/her behavior affects the way other people think and feel about him/her
24. Does something just to be nice to someone else
25. Figures out why he/she has made someone upset or angry
26. Introduces a topic of conversation so that others can understand what he/she is talking about (e.g., begins by saying, "In this movie I saw…," or "During my vacation I…")

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a = items with corrected item-scale correlation coefficients of < .30

b = significantly skewed items

Active Scale

1. Maintains a neat appearance (appropriate for his/her age)
2. Follows time limits set by adults (e.g., ends an activity by a certain time)[a]
3. Uses appropriate table manners
4. Follows the rules in simple board, card, or video games when playing with others [a]
5. Understands that different behavior is appropriate for different situations (e.g., understands it's OK to talk while watching TV at home, but not OK to talk while watching a movie in a theater)
6. Spontaneously greets familiar people (i.e., says hello before the other person says hello)
7. Responds appropriately when introduced (e.g., says hello) [a]
8. Remembers to return things he/she has borrowed
9. Initiates conversation on topics of interest to himself/herself[b]
10. Says "thank you" without being reminded
11. Respects others' physical space (e.g., does not stand to close or touch others inappropriately) [a]
12. Spontaneously responds when others greet him/her or say goodbye
13. Makes requests politely
14. Shares his/her possessions when asked [a]
15. Practices good hygiene with minimal reminding or assistance
16. Asks permission before taking or using something that belongs to someone else
17. Participates with others in activities he/she likes [a]
18. Spontaneously says goodbye when leaving
19. Remembers to cover his/her mouth when sneezing or coughing

20. Engages in undesirable behaviors in public (e.g., spitting, nose picking)
21. Asks others for help or information politely
22. Introduces self to new people without prompting[b]
23. Apologizes when someone points out a mistake or poor behavior
24. Follows school rules without reminding (e.g., stays in seat, does not leave class without permission, arrives on time)
25. Waits patiently for his/her turn during a game or activity [a]
26. Complies with simple requests from others (e.g., will lend an item or help with a chore if asked)
27. Becomes destructive or physically aggressive when upset [a]

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a = items with corrected item-scale correlation coefficients of < .30

b = significantly skewed items

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