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Determining Relationships among Executive Functioning, Empathy, and Autism Spectrum Disorder Traits in Neurotypical Adults

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DETERMINING RELATIONSHIPS AMONG EXECUTIVE FUNCTIONING, EMPATHY, AND AUTISM SPECTRUM DISORDER TRAITS IN NEUROTYPICAL ADULTS

by

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Under the direction of Committee Chair Sharee Light, PhD

ABSTRACT

Previous research has established that individuals with autism spectrum disorder (ASD) often have impairments in both cognitive empathy and executive functioning (EF), although little attention has been devoted to the relationships among these domains and ASD traits. Furthermore, the presence of an emotional empathy deficit in individuals with ASD has only begun to be explored, and studies have yielded discrepant findings likely attributable to differences in methodology and limited consideration of positive versus negative content. There is some evidence to suggest that EF may be important for emotional empathy and ASD traits. The current study aimed to clarify the relationships among these variables by examining the possibility that EF mediates the relationship between empathy and ASD traits in neurotypical adults. Although hypotheses regarding mediation were not supported, the study revealed a novel finding that positive emotional empathy was negatively associated with ASD traits, whereas cognitive empathy was not associated with ASD traits. Furthermore, planning ability was positively associated with cognitive empathy. Implications for future research based on these findings are discussed.

INDEX WORDS: Autism Spectrum Disorder; Emotional Empathy; Cognitive Empathy; Executive Functions; Positive Empathy; Mediation

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DEDICATION

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1 INTRODUCTION

Limited empathy, or the ability to understand and share others' feelings (Decety & Jackson, 2004), is often thought to be a core contributor to symptoms in individuals with autism spectrum disorder (ASD; de Waal, 2008; Decety & Meyer, 2008). Indeed, some studies have found impairments in cognitive empathy (eg., Dziobek et al., 2008; Golan, Baron-Cohen, Hill, & Rutherford, 2007), or the ability to take others' perspectives and infer their thoughts and feelings, and emotional empathy (e.g., Bacon, Fein, Morris, Waterhouse, & Allen, 1998), or the ability to feel other's emotions, in individuals with ASD. However, executive functions (EF), or a set of cognitive abilities that guide goal-oriented behaviors, have been shown to be related to both ASD traits (e.g., Gökçen, Frederickson, & Petrides, 2016; Lopez, Lincoln, Ozonoff, & Lai, 2005) and empathic abilities (e.g., Iacono, Ellenbogen, Wilson, Desormeau, & Nijjar, 2015; Lin, Keysar, & Epley, 2010) in individuals with ASD. For example, reduced inhibitory control may impair one's ability to inhibit one's own feeling, and impaired cognitive control may limit the ability to switch between one's own emotion and the feeling of another person. Therefore, it is possible that EF explains the relationship between empathy and ASD traits, and that previous studies that have not considered the role of EF in this relationship have neglected an important pathway through which these abilities interact.

Findings regarding the relationships between ASD traits and cognitive and emotional empathy are reviewed below, to elucidate the inconsistencies in findings across studies and to suggest that both differences across study methods and lack of consideration of EF may play a role in explaining these inconsistencies. Particular attention is paid to literature regarding emotional empathy for positive and for negative emotions, as a lack of consideration of valence may also account for variability in findings. Associations between EF and empathy, and between EF and ASD traits, are also reviewed to establish that

these relationships have been found and to support the assertion that EF may explain the relationships between empathy and ASD traits.

The current study builds on previous research by investigating emotional empathy using a reliable and naturalistic video task that successfully elicits positive empathy. The study also goes beyond prior research of individual relationships by investigating EF as a mediator of the relationships between cognitive empathy and ASD traits and between emotional empathy and ASD traits in neurotypical (NT) adults. It further seeks to answer the question regarding how positive empathy specifically relates to these abilities, as this has not been explored in previous literature. See Figure 1 for a visual representation of the proposed overall model. Findings contribute to a better understanding of the relationships among empathic abilities, EF, and ASD traits in neuroptypical (NT) adults.

1.1 Autism Spectrum Disorder

ASD is a neurodevelopmental disorder characterized by impairments in social interaction and communication skills, as well as the presence of restricted, repetitive, and stereotyped interests and behaviors (American Psychiatric Association, 2013). Previous diagnostic criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Test Revision (DSM-IV-TR; American Psychiatric Association, 2000) defined several subtypes within the ASD category. They include Autistic Disorder, Asperger's Disorder, and Pervasive Developmental Disorder- Not Otherwise Specified (PDD-NOS; thought to be a milder ASD). Although new diagnostic conventions do not distinguish among these subtypes, as the DSM-5 has eliminated them in favor of an overall "ASD" diagnosis (American Psychiatric Association, 2013), participants in the reviewed studies typically have one of these subtype diagnoses. Nevertheless, research evidence supports the idea that traits associated with ASD lie on a continuum and are present in the general population to varying degrees (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Constantino, 2011). Therefore, studying ASD traits in NT individuals can help to provide insight

into the relationships between ASD traits and other constructs (Gökçen et al., 2016; Gökçen, Petrides, Hudry, Frederickson, & Smillie, 2014).

1.2 Empathy

The term empathy generally refers to the ability to understand and share others' feelings (Decety & Jackson, 2004). It is a skill that allows individuals to understand others' intentions, share their emotions, and better predict their behavior (Simon Baron-Cohen & Wheelwright, 2004). As such, empathy is important to social learning and decision-making, and thus to having effective social interactions and relationships (Krahn & Fenton, 2009).

Empathy comprises two main components, emotional (or affective) empathy and cognitive empathy. "Emotional empathy" refers to the ability to experience the emotions of other people, and starts to develop as early as infancy (Hillis, 2014; Krahn & Fenton, 2009; Roth-Hanania, Davidov, & Zahn-Waxler, 2011). Two related processes that are often used to measure emotional empathy include emotional contagion, or adoption of another person's affective state (Hillis, 2014), and empathic concern, which incorporates sympathy and is associated with prosocial behaviors (Decety & Jackson, 2004). "Cognitive empathy" refers to the ability to recognize others' perspectives and make inferences about what someone thinks or feels, or to identify their point of view (Hillis, 2014; Krahn & Fenton, 2009; Shamay-Tsoory, 2016). This concept is often referred to as Theory of Mind (ToM) or mentalizing (Fan, Chen, Chen, Decety, & Cheng, 2014), and is a skill that comes about later in development. In particular, research suggests that ToM emerges in stages throughout early development and is fairly developed by the age of 5 years in NT children (Wellman & Liu, 2004).

Empathic skills are important for success in social situations, as an understanding of others' emotions is necessary to guide appropriate social responses (Decety & Lamm, 2006; Gable, Gonzaga, & Strachman, 2006; Morelli, Lieberman, & Zaki, 2015). Because empathy supports effective social interactions and the development and maintenance of relationships (Decety & Lamm, 2006; Morelli et al.,

2015), it is likely that impaired empathy is associated with relationship difficulties. For example, an individual with impaired emotional empathy may not respond to another's distress with concern and helping behaviors, leaving the distressed individual feeling as though the other does not care about him and thus damaging their relationship. Impaired cognitive empathy may lead to similarly inappropriate behavior, due to the lack of understanding of the other's perspective (Kerem, Fishman, & Josselson, 2001).

Individuals with ASD have impaired social interactions and atypical peer relationships (APA, 2013); as such, impaired empathy may be associated with these deficits. Therefore, findings regarding emotional and cognitive empathic deficits in individuals with ASD and in relation to ASD traits are reviewed below. The relationships of these domains with EF are also considered to establish support for investigation of EF as a mediator of these relationships. The review focuses on findings in adults, but when limited is supplemented with findings in children.

1.3 Empathy and ASD

Due to the importance of intact empathic understanding to effective social interactions and relationship development as discussed above, empathic impairment is a candidate contributor to the social deficits observed in individuals with ASD. Some evidence has been provided for a general empathy impairment in individuals with ASD. For example, some have found that on the Empathy Quotient (Baron-Cohen & Wheelwright, 2004), a self-report measure of both cognitive and emotional empathy, adults with ASD reported impaired empathy (Spek, Scholte, & Berckelaer-Onnes, 2010). However, findings are less consistent when considering cognitive and emotional empathy separately, as discussed below.

1.3.1 Cognitive Empathy

The relationship between cognitive empathy and ASD traits is of particular interest in the current study, as findings related to this relationship may suggest important methodological considerations. Baron-Cohen (1997) suggested that the social-communication impairments that characterize ASD result

from an impairment in ToM. A large number of studies have examined cognitive empathy impairments in individuals with ASD using a variety of different measures. Some use self-report measures such as the Interpersonal Reactivity Index (IRI; Davis, 1980). Others use behavioral tasks, which may involve emotional or cognitive perspective-taking. Emotional perspective-taking, or affect naming, tasks include emotion recognition paradigms such as the Reading the Mind in the Eyes task (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001), the Reading the Mind in the Voice task (Rutherford, Baron-Cohen, & Wheelwright, 2002), and the Multifaceted Empathy Test (Dziobek et al., 2008), in which one must identify feelings based on pictures of eyes, audio recordings, or photographs of individuals in emotional situations, respectively.

There are various ToM tasks involving cognitive perspective-taking. These include false belief tasks, which take a variety of forms but typically involve inferring what others will assume in unexpected situations. A simple but well-known example is the Smarties task (Perner, Leekam, & Wimmer, 1987), which involves children looking into a Smarties container and finding unexpected contents, such as pencils. They then indicate what others would expect to find in the container, which requires considering others' perspectives in lieu of their own knowledge. More advanced ToM tasks include the Strange Stories test, in which individuals read stories and answer questions involving inference about a character's thoughts, feelings, or intentions (Happé, 1994), and the Faux Pas test (Simon Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999), in which one must answer questions about characters, speech, or behaviors in a story involving awkward situations. A few studies have used moral judgments to identify whether or not individuals consider the actor's intentionality as a measure of perceptive-taking (Moran et al., 2011). Studies comparing performances on these measures between individuals with and without ASD are reviewed below, followed by the few studies that have looked continuously at a relationship between cognitive empathy and ASD traits.

Comparison of individuals with ASD to individuals without ASD. Adults with ASD have been shown to consistently self-report impairments in cognitive empathy on the IRI (Bellebaum, Brodmann, & Thoma, 2014; Bird et al., 2010; Dziobek et al., 2008; Mathersul, McDonald, & Rushby, 2013; Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2007; Shamay-Tsoory, Tomer, Yaniv, & Aharon-Peretz, 2002). This finding indicates that individuals with ASD tend to be aware of their difficulties with cognitive empathy. However, performances on behavioral tasks have been somewhat less consistent and are reviewed next.

Adults with ASD tend to have difficulty with cognitive empathy tasks that involve inferring others' emotional states. For example, various studies have found that adults and adolescents with ASD were impaired in accurately identifying emotional states based on the Reading the Mind in the Voice task (Golan et al., 2007; Kleinman et al., 2001; Rutherford et al., 2002), the Reading the Mind in the Eyes task (Gleichgerrcht et al., 2013; Golan et al., 2007; Kleinman et al., 2001; Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007), and the Multifaceted Empathy Test (Dziobek et al., 2008; Mazza et al., 2014). In general, findings support a deficit in individuals with ASD regarding inference of emotional state.

Adults with ASD tend to pass simpler false belief tasks (i.e., identifying false belief) that children with ASD fail (Kleinman et al., 2001; Moran et al., 2011), with a few exceptions (White, Coniston, Rogers, & Frith, 2011) that may be driven by impairments in a small subset of individuals (Ozonoff, Pennington, & Rogers, 1991). Senju and colleagues (2009) used eye tracking to show that although a NT group's eye movements anticipated a person's behavior based on inference into their mental states during a false belief task, the ASD group did not show this anticipation of the actor's behavior providing further evidence of false belief impairment in adults with ASD. In contrast, tasks reflecting higher level ability to attribute mental states to others more consistently suggest impairment in adults with ASD. For example, impairments have been demonstrated during the Strange Stories task (Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2007; Spek et al., 2010; White et al., 2011), during faux-pas tests (Gleichgerrcht et al.,

2013; Shamay-Tsoory et al., 2002; Spek et al., 2010; White et al., 2011), and when attributing mental states to interactions between animated shapes (Castelli, Frith, Happe, & Frith, 2002; White et al., 2011). Furthermore, when asked to make moral judgments about accidental and intentional harm, a group of individuals with ASD seemed not to consider intentionality in the person's actions, in contrast with the NT group (Moran et al., 2011), reflecting impaired perspective-taking ability. These findings together support the existence of a cognitive empathy impairment in individuals with ASD.

However, findings have not been entirely consistent across studies, as some have not found cognitive empathy impairments in adults with ASD. Most notably, some studies have found that individuals with ASD were not impaired on the Reading the Mind in the Eyes Test, although they were impaired on more naturalistic ToM tasks (Roeyers, Buysse, Ponnet, & Pichal, 2001) and more situational perspective-taking tasks including the Strange Stories Test and Faux Pas Test (Spek et al., 2010). Baron-Cohen (1997) and Roeyers (2001) suggest that these more advanced and naturalistic ToM tasks rely on EF, indicating that variability in EF ability may also explain inconsistent findings (see Section *1.4.1*). Taken together, adults with ASD may be more likely to be impaired on more advanced ToM tasks than those involving inferring emotion from photographs.

Continuous relationship between cognitive empathy and ASD traits. A handful of studies have explored relationships between cognitive empathy and ASD symptoms and traits continuously, rather than comparing groups with and without ASD. In children and adolescents, reduced ToM ability has been found to be associated with greater social-communication and repetitive behavior symptom severity (Joseph & Tager–Flusberg, 2004; Pasalich, Dadds, & Hawes, 2014; Peterson, Garnett, Kelly, & Attwood, 2009; Tager-Flusberg, 2003; Wallace et al., 2011). Fewer studies have explored this relationship in adults, although there is some evidence that higher levels of ASD traits are associated with reduced ToM in adulthood as well, in terms of self-reported cognitive empathy (Gökçen et al., 2014), performance on the Reading the Mind in the Eyes Test (Gökçen et al., 2016; Golan et al., 2007), and perspective-taking

for characters in a movie (Rot & Hogenelst, 2014). The current study expands on these findings by examining a continuous relationship between ASD traits and a well-validated cognitive empathy variable that incorporates inference of mental state based on face, voice, and body language.

Possible foundations of cognitive empathy impairment. Several explanations for a cognitive empathy impairment in individuals with ASD have been hypothesized. Leslie and colleagues (2004) proposed the existence of an impaired ToM module that is both a cognitive construct and brain network devoted to understanding mental states, and suggested that individuals with impairments in this network depend upon compensatory strategies for success on ToM tasks. Studies of impaired neurological connectivity in relation to ToM deficits support this theory (Castelli et al., 2002). However, this theory does not account for the negative association between cognitive empathy and ASD traits in individuals without an ASD diagnosis (Gökçen et al., 2016, 2014). In contrast, it is possible that variability in cognitive empathy in individuals with ASD is due to an association with other domain-general skills, namely EF (Marcovitch et al., 2015). Evidence in support of this proposition is presented below (Section *1.4.1*). Therefore, it is possible that variability in EF ability mediates the relationship between cognitive empathy and ASD traits.

The current study builds on previous findings by considering a continuous relationship between ASD traits and performance on a measure of cognitive empathy that involves inference of mental state based on face, voice, and body language. This investigation is consistent with the theory that ASD traits are continuous in the general population (Constantino, 2011), and will improve on previous studies that largely use a categorical comparison between groups with and without ASD. Studies examining another aspect of empathy, emotional empathy, in relation to ASD traits are also explored below.

1.3.2 Emotional Empathy

Baron-Cohen (2003) suggested that empathy must encompass a more complex range of skills than just recognition of mental states, as people may recognize emotions and predict behavior without

demonstrating that they care about or experience the other person's feelings. This addition of responding to and experiencing the person's emotions differentiates emotional empathy from cognitive empathy. Few studies have examined emotional empathy in adults in relation to ASD traits.

To this author's knowledge, the continuous relationship between emotional empathy and ASD traits in adults has not been examined. However, examination of emotional empathy in adults with ASD compared to those without ASD has received some limited attention, and findings have been mixed. Deficits have been identified based on self-report questionnaires (IRI; Mathersul et al., 2013) and ratings of emotional responses to pictures that corresponded to different neural activation (Schulte-Rüther et al., 2011). In contrast, studies have also found no emotional empathy impairment in individuals with ASD based on self-report questionnaires (Bellebaum et al., 2014; Rogers et al., 2007), ratings of emotional reactions to pictures (Dziobek et al., 2008), and activation in neuroimaging (Bird et al., 2010).

Differences in findings across these studies may be explained by methodological differences. In particular, some use self-report measures of daily life (Rogers et al., 2007), whereas others use self-report during behavioral tasks (Dziobek et al., 2008) or observed responses to stimuli (Scambler, Hepburn, Rutherford, Wehner, & Rogers, 2007). Self-report measures are limited in that they rely on one's ability to reflect on and make generalized statements based on one's own behavior, rather than identifying real-time responses to emotional content. In contrast, some studies only consider observational information, such as viewing an individual's response to an emotional situation (e.g., Bacon et al., 1998). However, emotions expressed are not always identical to emotions experienced (Ekman, 1993). Taken together, studies would be improved by considering both self-reported and observed emotional empathy.

Furthermore, the tasks used in these studies involved viewing static pictures of people's faces (Schulte-Rüther et al., 2011) or of individuals in emotional situations (Dziobek et al., 2008). Participants were then asked to rate their level of empathic concern for the individual. Therefore, these tasks rely on

use of visual cues only and require a level of insight into one's own experience to report empathic concern. Therefore, use of a more naturalistic emotional empathy measure would provide additional insight into the relationship between emotional empathy and ASD traits. Finally, variable findings may be explained by the valence of stimuli in the different tasks, as discussed below.

Positive and negative empathy. Different valences of stimuli across studies may help to explain variable findings. Studies of NT individuals suggest that positive empathy may be processed differently from negative empathy (Mirabito, Taiwo, Bezdek, & Light, 2019; Morelli, Rameson, & Lieberman, 2014), and findings from behavioral studies suggest that empathic engagement may differ by valence of the content (Dziobek et al., 2008; Schulte-Rüther et al., 2011). With regard to the studies mentioned above, Schulte-Rüther and colleagues' (2011) empathy-evoking stimuli included positive elements (i.e., happy faces), negative elements, and neutral expressions, and their results revealed empathy impairments. In contrast, Dziobek and colleagues (2008) analyzed only negative stimuli in their study, and findings demonstrated intact empathy. Furthermore, some research suggests that recognition of negative emotions may be harder than recognition of happiness (Adolphs, Sears, & Piven, 2001; Wallace et al., 2011). Thus, happy faces may be easier to recognize and label, but may evoke less emotional empathy in the viewer with ASD.

These studies highlight the need to further investigate patterns of impairments in positive and negative emotional empathy in relation to ASD traits using naturalistic empathy measures. Better understanding of empathic responses would help to clarify our knowledge of forces driving impairments, and may lead to the development of targeted interventions. Findings across studies have been variable which is likely due to the valence of stimuli used in different studies, differences in the level of realism of the tasks, and differential use of self-reported and observed empathy. Therefore, the current study examines emotional empathy in adults using a naturalistic task that considers positive and negative emotional empathy separately in relation to ASD traits. It also considers different responses when using self-

reported versus observed emotional empathy. Patterns in emotional empathy findings will be further explored below in consideration of studies that examined both cognitive and emotional empathy.

1.3.3 Emotional and cognitive empathy measured within single studies

Several studies have examined both cognitive and emotional empathy within single studies, allowing for comparison between tasks and identification of response patterns. Many of these studies have found a dissociation between impaired cognitive empathy and intact emotional empathy in participants with ASD.

This pattern of impaired cognitive empathy and intact emotional empathy has been found both with use of self-report questionnaires (Bellebaum et al., 2014) and with behavioral tasks. For example, Rogers and colleagues (2007) found that adults with ASD were impaired in cognitive empathy during both a behavioral task and self-report questionnaire; however, they were not impaired in emotional empathy when using a self-report measure (Interpersonal Reactivity Index; Davis, 1980) and an emotional empathy behavioral task was not used. In a follow-up study using the Multifaceted Empathy Test (MET), a measure involving viewing static images of distressing situations which was designed to be more ecologically valid than a questionnaire, Dziobek and colleagues (2008) confirmed that adults with ASD were impaired in cognitive, but not emotional, empathy. Interestingly, when using a similar paradigm involving viewing pictures of people expressing emotions, Schulte-Rüther and colleagues (2011, 2014) found the opposite pattern. Specifically, the ASD group's labels of others' emotions (cognitive empathy) were accurate, but ratings of their own emotional responses (emotional empathy) were less accurate. However, the task instructions ask how the participant feels when looking at the face in the stimuli, which may result in a different reaction from empathy. For example, the participant may feel afraid when looking at an angry face, rather than feeling empathically angry. Therefore, the tasks used in these studies may not have accurately elicited emotional empathy.

An additional explanation for discrepant findings is the difference between the cognitive empathy tasks. Schulte-Rüther's task is primarily an emotion recognition task involving judgment of isolated facial expressions. In contrast, Dziobek's task involves pictures of individuals in a context in which they are experiencing emotions (e.g., in a hospital), and ASD participants had difficulty labeling the emotions. This difference would suggest that perhaps basic emotion recognition is intact in some individuals with ASD, consistent with some findings discussed above in Section *1.3.1*, whereas context and background details may detract attention from the pictured person's emotional expression. Taken together, the patterns across studies may suggest that having more context, such as seeing a sad person in a hospital, may support emotional empathy by providing a context for one's emotion, whereas faces in isolation may not evoke strong empathic responses.

Further support for the dichotomy between cognitive and emotional empathy is found in literature comparing deficits of individuals with ASD and those with psychopathy or conduct disorder with callous-unemotional traits. This body of findings generally suggests that individuals with ASD are impaired on measures of cognitive but not emotional empathy, whereas individuals with psychopathy or conduct disorder with callous-unemotional traits are impaired on measures of emotional but not cognitive empathy (Blair, 2008; Jones, Happé, Gilbert, Burnett, & Viding, 2010; Lockwood, Bird, Bridge, & Viding, 2013; Schwenck et al., 2012). However, these theories emphasize that emotional empathy may still be impaired in individuals with ASD (Blair, 2005).

In contrast, some have identified impairments in both cognitive and emotional empathy in adults with ASD. However, these findings have primarily been based on self-reported cognitive and emotional empathy ratings on the IRI (Mathersul et al., 2013) and EQ (Hadjikhani et al., 2014; Mathersul et al., 2013). Therefore, individuals with ASD may notice difficulties in both domains within their everyday lives, whereas performances on behavioral tasks do not consistently suggest impairments in both domains. Both the IRI and EQ demonstrate good psychometric poperties and allow for separate examina-

tion of cognitive and emotional empathy. However, both self-report measures are subject to bias and limited insight, suggesting that behaveioral examination of these domains would provide additional information.

The only studies to this author's knowledge that examined continuous relationships between ASD traits and both cognitive and emotional empathy involved NT adults presenting with a range of ASD traits. Gökçen and colleagues' (2016) findings indicated that ASD traits were related to performance on a naturalistic ToM task but not on an emotional empathy task involving rating emotional responses to pictures of faces. As noted above (see Section *1.3.2*), this type of task may not accurately measure emotional empathy. In contrast, another study examining NT individuals with subclinical ASD traits found that lower cognitive empathy was associated with higher ASD traits, but only in those reporting lower trait emotional empathy (Rot & Hogenelst, 2014). Additional research is warranted to explore the relationships between ASD traits and both cognitive and emotional empathy within adults with a range of ASD traits.

As noted in previous sections, variable findings are likely attributable to differences in methodology for both cognitive and emotional empathy. In particular, studies vary in their examination of self-reported versus observed empathy, naturalistic versus static stimuli, and positive versus negative stimuli. Surprisingly, in single studies examining both cognitive and emotional empathy, none have used naturalistic emotional empathy paradigms. Instead, they have used static images or self-report questionnaires. However, use of ecologically valid tasks would add confidence to findings. The current study aims to investigate the differential relationships between cognitive empathy and ASD traits, and emotional empathy and ASD traits, by addressing these limitations of previous studies. It also builds on previous findings by exploring whether or not EF mediates these relationships; as such, relationships between EF and ASD traits, as well as between EF and empathy, are discussed next.

1.4 Executive Functions and ASD

Executive functions (EF) are cognitive abilities necessary for guiding flexible, goal-oriented behaviors (Pellicano, 2013). These abilities include cognitive flexibility or set-shifting, inhibition, planning, working memory, and problem-solving. It has been proposed that EF may be associated with empathy, and thus may explain variability in empathic abilities (Iacono et al., 2015; Ze, Thoma, & Suchan, 2014). In particular, the relationship between EF and ASD traits is reviewed below, as this relationship provides the first indication that EF may explain the association between empathy and ASD traits. The relationships between EF and empathy are subsequently reviewed.

Individuals with ASD often experience impairments in EF (Hill, 2004). Impairments in EF have even been proposed as a core component of the social, communication, and repetitive symptoms common in ASD (Kenworthy, Yerys, Anthony, & Wallace, 2008). Although the majority of the literature tends to examine EF impairments in children with ASD, some have examined deficits in adults with ASD. In particular, cognitive inflexibility (Ambery, Russell, Perry, Morris, & Murphy, 2006; Bramham et al., 2009; Lopez et al., 2005; Ozonoff et al., 2004, 1991) and poor planning (Ambery et al., 2006; Barnard, Muldoon, Hasan, O'Brien, & Stewart, 2008; Bramham et al., 2009; Lopez et al., 2005; Ozonoff et al., 2004, 1991) have been identified in individuals with ASD, even more so than in other developmental disorders such as ADHD (Hill, 2004; Pennington & Ozonoff, 1996). However, there is also evidence of impaired initiation (Bramham et al., 2009), working memory (Barnard et al., 2008), generativity (Ambery et al., 2006), and increased perseveration (Lopez et al., 2005; Ozonoff et al., 1991) in individuals with ASD.

In contrast, a small number of studies have not found evidence of these EF impairments in adults with ASD (Gilbert, Bird, Brindley, Frith, & Burgess, 2008; Miller & Ozonoff, 2000; Sachse et al., 2013). Some explanations for these different findings include age differences across samples, such as inclusion of adults only or addition of adolescents (Sachse et al., 2013), and differences in tasks, such as between traditional neuropsychological measures (Barnard et al., 2008; Lopez et al., 2005) and comput-

erized measures developed for particular studies such as use in an MRI scanner (Gilbert et al., 2008). In general, studies of individuals with ASD find EF impairments, although the particular domains affected vary between studies.

ASD symptoms are thought to be driven by impairments in EF skills, such as shifting, inhibiting, and being flexible (Turner, 1997), and thus these domains are likely associated. For example, in the social-communication domain, it is possible that individuals with ASD find it difficult to inhibit their own points of view and automatic responses, and may have difficulty flexibly shifting to consider others' perspectives and respond appropriately. Similarly, these abilities seem to relate to the restricted and repetitive behaviors domain, including adoption of restricted interests and adherence to routines. Specifically, it may be difficult to inhibit the urge to discuss topics of one's own interest, and to be flexible when one prefers routine.

EF abilities have been found to be associated with continuous ASD symptoms and traits. In adults, impairments in inhibition (Gökçen et al., 2016; Lopez et al., 2005), planning (Bramham et al., 2009; Gökçen et al., 2016), and in cognitive flexibility (Gökçen et al., 2016; Lopez et al., 2005) have garnered the most support. However, other facets of EF have also been found to be associated with ASD symptoms, including working memory (Lopez et al., 2005); semantic fluency, divided auditory attention, behavioral regulation (Kenworthy, Black, Harrison, Rosa, & Wallace, 2009); and initiation and strategy formation (Bramham et al., 2009). Furthermore, EF composite scores from report of daily executive dysfunction on the Behavior Rating Inventory for Executive Functions (BRIEF; Gioia & Isquith, 2011) have also been associated with ASD symptoms (Kenworthy et al., 2009; Leung, Vogan, Powell, Anagnostou, & Taylor, 2016).

Overall, findings of previous studies support an inverse relationship between EF and ASD traits. Literature considering the relationships between EF and empathy will be explored next, as existence of

this relationship also lend support to the suggestion that EF may explain the relationship between empathy and ASD traits.

1.4.1 EF and Cognitive Empathy

Theorists have suggested that EF skills and cognitive empathy are interrelated. Russell (1998) argued that EF development is necessary for ToM development, as ToM tasks require remembering sequences and inhibiting automatic responses (Senju, 2012), and they require cognitive flexibility in order to alternate effectively between one's own perspective and the character's perspective (Carlson & Moses, 2001). On the other hand, executive skills have been thought to rely on metarepresentational capacity related to ToM (Perner, 1998), as managing both internal experiences and internal representations of the outer world facilitates EF. Both of these theories suggest an important relationship between cognitive empathy and EF, and the literature supporting this relationship is summarized.

Some studies have found impairments in cognitive empathy and in EF in individuals with ASD. One study found that in a group with ASD, ToM and auditory working memory were both impaired, although authors did not examine direct associations between these measures (Holdnack, Goldstein, & Drozdick, 2011). In a landmark study, Ozonoff, Pennington, and Rogers (1991) compared a group of NT adults to those with high-functioning ASD on tasks of EF and ToM. They found that the group with ASD was impaired on EF tasks of cognitive flexibility, planning, and inhibition, as well as on ToM tasks. However, it is notable that the study included several measures in their ToM composites that do not directly measure ToM and are no longer widely used to study ToM, such as answering questions about mental and behavioral functions of the brain. Nonetheless, these studies begin to suggest that both cognitive empathy and EF are impaired in individuals with ASD.

Other studies have gone further to identify relationships between specific EF domains and ToM. Lin, Keysar, and Epley (2010) found that in a NT group, lower working memory and divided attention contributed to reduced ToM ability, suggesting that ToM requires significant attentional capacity and

ability to hold and manipulate mental information. Furthermore, Ahmed and Miller (2011) found that verbal fluency and deductive reasoning predicted performance on the Strange Stories task, and that verbal fluency, problem solving, and gender predicted performance on the Faux Pas Test. Overall, support has been provided for the assertion that EF and ToM are related. However, the particular EF domains found to be related to ToM have differed significantly among studies of adults with ASD.

Only three studies to this author's knowledge have considered the relationships among EF, cognitive empathy, and ASD symptoms in individuals with ASD, and all have focused on children or adolescents. One found that ToM and EF together are associated with ASD symptoms (Joseph & Tager–Flusberg, 2004), whereas EF alone was not associated with symptoms. The other two studies found no relationships among ToM, EF, and symptoms (Pellicano, Maybery, Durkin, & Maley, 2006) or found only EF to be related to symptoms (Pellicano, 2013). Findings appear to differ primarily due to methodology; Pellicano's (2013) study examined longitudinal relationships among domains over a 3 year span, whereas the other studies were cross-sectional. It is possible that the longitudinal associations among these domains are different from cross-sectional associations as these skills may change throughout development. Furthermore, the two cross-sectional studies differed in their measures of ASD traits; Pellicano and colleagues (2006) used a parent-report measure of ASD symptoms, whereas Joseph and Tager-Flusberg (2004) used an observational and interactive measure. Due to these very inconsistent findings, the relationships among these domains and symptoms warrant further examination, particularly in adults in whom these relationships have not yet been explored.

When NT adults with varying levels of ASD traits have completed cognitive empathy and EF tasks, findings have demonstrated that greater levels of ASD traits were associated with poorer cognitive empathy and cognitive flexibility compared to those with lower traits (Gökçen et al., 2016, 2014). Also, static ToM performance (i.e., the Reading the Mind In the Eyes Test) was related to cognitive flexibility and planning, and more naturalistic ToM tasks (15-minute movies showing social situations) were

related to these domains as well as inhibition (Gökçen et al., 2016). Furthermore, although ASD traits were related to a naturalistic ToM task, ASD traits were not uniquely associated with the static ToM test, further supporting the assertion that naturalistic tasks may provide a more sensitive measure of empathy than static images. In general, this study provides evidence of the relationships among ASD traits, cognitive empathy, and EF.

Overall, despite variability in the specific domains indicated, EF is generally found to be associated with various cognitive empathy tasks. This conclusion, in conjunction with the relationship established above between cognitive empathy and ASD traits, supports the hypothesis that EF may explain the relationship between cognitive empathy and ASD traits. However, these complex relationships have not yet been examined and are addressed in the current study.

1.4.2 EF and Emotional Empathy

Considering the variability in emotional empathy skills in individuals with ASD, it is surprising that so few studies have examined a relationship between EF and emotional empathy in this population. This relationship has been more thoroughly investigated in NT adults. Support for overlapping brain regions has been provided (Menon & Uddin, 2010), as well as relationships on behavioral tasks between emotional empathy and inhibitory control (Ze et al., 2014). Iacono and colleagues (2015) also found that inhibitory control moderated the relationship between empathy on the EQ- short form and social functioning, such that those with higher empathy had worse social outcomes in the context of worse inhibitory control.

In a sample of NT individuals varying in levels of ASD traits, EF was not related to performance on an affective empathy task (Gökçen et al., 2016). Interestingly, although they found that naturalistic videos were more sensitive measures of ToM than static pictures, the authors only used emotional responses to static images of faces to measure emotional empathy. Therefore, it remains possible that dynamic videos may provide a more sensitive measure of emotional empathy than pictures, and that

empathy for more realistic stimuli would be associated with EF ability. Therefore, additional research should examine the relationships between emotional empathy and ASD traits.

Overall, research on the relationship between emotional empathy and EF in relation to ASD traits is clearly lacking. Preliminary evidence suggests that there could be associations between EF and emotional empathy, but this evidence is quite limited. However, this relationship should be further explored because it could contribute to the understanding of variability in emotional empathy in individuals with ASD. In particular, it is possible that those who are impaired in emotional empathy are also impaired in their ability to switch flexibly between cognitive sets or inhibit automatic responses, whereas those with stronger emotional empathy may also experience stronger EF. This relationship has interesting theoretical implications regarding the role of EF in emotional empathy and ASD symptoms, and would begin to provide information toward future research on intervention targets for adults with ASD. The current study will explore this relationship, as well as the possibility that EF explains the relationship between emotional empathy and ASD traits.

1.5 Current Study

Based on the findings reviewed above, there is evidence of relationships between cognitive empathy and ASD traits, between cognitive empathy and EF, and between EF and ASD traits. The current study builds on previous research by examining the role of EF as a possible mediator of the relationship between cognitive empathy and ASD traits. Furthermore, some support has been provided for a relationship between emotional empathy and ASD traits, and few studies have explored relationships between emotional empathy and EF. The current study examines these relationships and explores whether EF mediates the relationship between emotional empathy and ASD traits in NT adults, while considering positive and negative emotional empathy separately.

In the current study, cognitive empathy is measured with a task that involves inferring mental state based on face and voice, and emotional empathy is measured using self-reported and observed

responses to realistic videos of positive and negative emotional scenarios that have been found to evoke empathy in NT individuals (Light et al., 2015). ASD traits are measured using a widely used reliable and valid self-report measure. Individuals also completed a neuropsychological battery, including reliable, valid, and widely used cognitive and EF tasks. These measures provide the ability to test the proposed relationships among empathy, EF, and ASD traits.

Furthermore, the current study examines these relationships in the general population with varying levels of ASD traits that do not reach clinical significance, consistent with the dimensional view that suggests that ASD symptoms should be considered on a continuum in the general population rather than based on categorical distinctions (Constantino, 2011).

This study is important for theoretical reasons. Of the domains considered in this study, cognitive empathy has received the most attention for its relationship to ASD traits, followed next by EF. However, few studies have explored the relationships between these two domains while considering their relationships with ASD traits, despite evidence that these skills are interrelated. It is important theoretically to advance our understanding of the relationships among these skills in order to better identify explanations for impairments. Compared to cognitive empathy and EF, emotional empathy has received little consideration in its relationship with ASD traits, particularly in adults. Therefore, it is unclear the extent to which emotional empathy is impaired in relation to ASD traits, and whether EF skills are important to empathic functioning or whether these are entirely separate domains. As a result, it is possible that overlooking emotional empathy has limited our current understanding of ASD. Greater understanding of the relationships among emotional empathy, EF, and ASD traits will build on our theoretical understanding of factors likely influencing ASD traits.

1.5.1 Hypothesis 1: The relationships among cognitive empathy, EF, and ASD traits

Evidence has been provided that cognitive empathy is associated with ASD traits (Gökçen et al., 2016, 2014; Golan et al., 2007; Wallace et al., 2011), suggesting that cognitive empathy impairments

may relate to ASD symptomatology. See Figure 2 for visual representation of Hypothesis 1. It was expected that executive functioning, particularly working memory and cognitive flexibility, would partially mediate the relationship between cognitive empathy and ASD traits. Specifically, it was expected that cognitive empathy would be positively associated with EF and negatively associated with ASD traits, and that EF would be negatively associated with ASD traits. However, when accounting for EF, the relationship between cognitive empathy and ASD traits was anticipated to be reduced. Therefore, it was considered likely that EF deficits would help to explain the relationship between cognitive empathy and ASD traits.

Specifically, strong cognitive empathy should be related to strong working memory (Holdnack et al., 2011; Lin et al., 2010) and cognitive flexibility (Gökçen et al., 2016; Ozonoff et al., 1991) due to the need to hold information in mind about the other person's perspective and switch flexibly between one's own and the other's perspective. Lower EF was predicted to relate to higher ASD traits, as reduced flexibility and working memory was expected to relate to social deficits and engagement in repetitive behaviors. Finally, lower cognitive empathy was expected to be associated with higher ASD traits as limited perspective-taking would likely be associated with difficulty having successful social interactions. However, lower EF was predicted to partially account for this relationship as reduced flexibility and working memory were expected to explain how perspective taking impairment relates to ASD traits.

1.5.2 Hypothesis 2: The relationships among emotional empathy, EF, and ASD traits

The second hypothesis sought to examine the relationships among emotional empathy, EF, and ASD traits, with positive and negative emotional empathy examined separately. Some evidence has been provided for relationships between emotional empathy and EF (Menon & Uddin, 2010; Shamay-Tsoory et al., 2002; Ze et al., 2014), between emotional empathy and ASD traits (Helt & Fein, 2016; Scambler et al., 2007), and as previously stated, between EF and ASD traits. However, studies have failed

to consider the relationships among all three domains. It was expected that EF would partially mediate the relationship between emotional empathy and ASD traits.

Hypothesis 2A. In the case of positive emotional empathy, it was expected that attention would partially mediate the relationship between positive empathy and ASD traits. Attention was selected due to prior research regarding positive affect strengthening attentional skills (Fredrickson & Branigan, 2005; Goschke & Bolte, 2014). Although information regarding positive empathy specifically and EF was not available in this study, it was expected that one with intact positive empathy would experience positive affect. Positive empathy was expected to inversely relate to ASD traits, and attention was expected to inversely relate to ASD traits.

Hypothesis 2B. Regarding negative emotional empathy, it was hypothesized that inhibition would partially mediate the relationship between negative empathy and ASD traits (Iacono et al., 2015; Ze et al., 2014). In particular, lower levels of negative empathy were expected to be associated with reduced inhibition of one's own experience. Lower inhibition was then expected to be associated with higher ASD traits, as difficulty inhibiting automatic responses can contribute to both social-communication and repetitive behavior symptoms. Lower negative empathy was expected to relate to higher ASD traits, as reduced empathy was expected to be associated with difficulties in relationships. However, reduced inhibition was expected to partially explain this relationship. This is because disinhibition of one's own experience would be the pathway through which impaired negative empathy would contribute to ASD traits.

Table 1. Findings from studies examining cognitive and/or emotional empathy impairment in adults and adolescents with ASD

Paper	**Adult or Child Study**	**N**	**Self-Report (or parent report) questionnaire**	**Behavioral Task**	**Includes positive empathy component?**	**Cognitive Empathy Impairment**	**Emotional Empathy Impairment**
Baron-Cohen & Wheelwright, 2004	Adult	ASD=90 NT=90	Empathy Quotient (EQ)	-	No	Yes (on EQ that measures both, but not in separate scales)	Yes (on EQ that measures both, but not in separate scales)
Bellebaum et al., 2013	Adult (*M*=27-30 years, *SD*=5-5.7)	ASD=10 NT=12	German abbreviated version of Interpersonal Reactivity Index (IRI)	Observational and active learning tasks with EEG	No	Yes: cognitive empathy impaired per self-report; higher cognitive empathy associated with impaired active learning	No: emotional empathy not impaired per self-report
Bird et al., 2010	Adult	ASD=18 NT=18	Toronto Alexithymia Scale (TAS-20); Bermond-Vorst Alexithymia Scale (BVAQ); IRI	While in MRI scanner, participant is given pain stimulation of various degrees, and partner (friend, romantic) sitting next to them with hand visible is put in pain in other conditions. Participant rates how unpleasant they found partner's pain	No	No: alexithymia rather than ASD associated with reduced activation in insular cortex (for self and other)	No: no difference in empathic brain responses (insular cortex) between groups when controlling for alexithymia
Castelli et al., 2002	Adult	ASD=10 NT=10	-	Describe mental states of moving shapes during PET task	Not reported	Yes: ASD group used fewer and less appropriate mental	-

						state words	
Dziobek et al., 2008	Adult	ASD=17 NT=18	IRI	Multifaceted Empathy Test (MET): infer the emotional state of person in pictures of emotionally charged situations (cognitive) and rate their own emotional reactions to the pictures (emotional)	No	Yes: lower on cognitive scales of IRI and on the MET	No: *p*=.05 on Affective Empathy scale; higher score on Personal Distress scale; no difference on MET
Gleichgerrcht et al., 2013	Adult	ASD=36 NT=36	IRI	Reading the Mind in the Eyes Test; Faux-pas test; Responses to trolley problem and footbridge dilemma with personal and impersonal scenarios	No	Yes: increased utilitarian judgments of personal scenarios associated with ToM impairment on Faux Pas test	Yes: increased utilitarian moral judgments of personal scenarios (high emotional saliency)
Golan et al., 2006	Adult	ASD=50 NT=22	-	Reading the Mind in the Eyes Task; Reading the Mind in the Voice Task	Yes, but not examined separately	Yes, and correlated with ASD symptoms	-
Kleinman, Marciano, & Ault, 2001	Adult	ASD=16 NT=24	-	First order false belief task; Identifying intonation of speakers; Mental State Eyes Task (identifying feelings based on pictures of eyes)	Yes, but not examined separately	Yes: passed first-order task, but impaired on visual and auditory tasks	-
Mathersul et al., 2013	Adult	ASD=40 NT=37	IRI; EQ	The Awareness of Social Inference Test (TASIT): video vignettes of conversations involving basic and subtle emotions and conversational inferences about use of sarcasm or lies, based on words, tone,	No	Yes: simple ToM intact in ASD group but advanced ToM (sarcasm and deception) were impaired on TASIT; ToM	Yes: emotional empathy scales of IRI and EQ impaired in ASD group (but did not explain TASIT performance)

				facial expression, and gesture		scales on IRI and EQ associated with performance	
Mazza et al., 2014	Adolescent (*M*=15 years)	ASD=15 NT=15	Basic Empathy Scale—Cognitive and Affective Subscales	First-order false belief task; advanced ToM requiring interpretation of lies, jokes, misunderstanding, etc.; Reading the Mind in the Eyes Task; Emotion Attribution Task; MET	Yes, analyzed separately for MET	Yes: ASD group lower on false belief and ToM tasks and self-report	Yes: negative empathy impaired but positive empathy not impaired; ASD not lower for self-report
Moran et al., 2011	Adult	Not reported	-	False belief task; making moral judgments regarding accidental and intentional harm	No	Yes: same judgments regardless of intentionality	-
Roeyers et al., 2001	Adults	ASD=24 NT=24	-	Strange Stories Test: read stories and answer questions involving inference about a character's thoughts, feelings, or intentions (ToM task); Reading the Mind in the Eyes Task; Labeling feelings of interacting individuals in a video	No	Yes/No: Impaired on Strange Stories Task and video task but not on Eyes Test	-
Rogers et al., 2007	Adult	ASD=21 NT=21	IRI	Strange Stories Test	Not reported	Yes: lower on cognitive scales of IRI and on Strange stories task	No: Same as NT group on Affective Empathy scale (but nearly significant, *p*=.08) of IRI and higher on Personal Distress scale

Rot & Hogenelst, 2014	Adult	NT=100 No ASD (ASD traits)	Balanced Emotional Empathy Scale (BEES), Berkeley Expressivity Questionnaire	Self-report of empathic accuracy (cognitive) after watching clips of emotional people discussing events	No	Yes: cognitive empathy impaired on behavioral task	Emotional empathy contributed to cognitive empathy performance
Rutherford, Baron-Cohen, & Wheelwright, 2002	Adult	ASD=19 NT=20	-	Identifying emotional states of spoken sentences	Yes, but not examined separately	Yes: impaired on Voice Test	-
Schulte-Rüther et al., 2011	Adult	ASD=18 NT=18	-	Infer the emotional state of a person in pictures (other task) and report emotions they themselves feel when viewing the pictures (self task)	Yes, but not examined separately (expressions were happy, sad, neutral)	No: labels of others' emotions were accurate	Yes: ratings of their own emotional responses were not congruent with emotions in pictures; brain regions recruited also differed
Senju et al., 2009	Adult	ASD=19 NT=17	-	Eye tracking during false-belief task	No	Yes: group did not anticipate actor's behavior	-
Senland & Higgins-D'Alessandro, 2013	Adolescent (range 12-18 years)	ASD=16 NT=16	IRI; Sociomoral Reflection Measure-Short Form	Participants were asked to describe a recent difficult situation and discuss what they did and why, describe their strengths, indicate if they were good at prosocial moral behaviors, and discuss how they realized they were not good at these behaviors	No	No: qualitative differences in perspective taking were not significant	No: did not differ on empathy scales, though ASD had lower moral reasoning and situations were more about social isolation and nonacceptance and relied less

							on implicit feedback as information
Shamay-Tsoory et al., 2002	Adolescent (case study age 17-18 years)	ASD=2 NT=6	IRI; Questionnaire Measure of Emotional Empathy	Faux-pas test; recognition of irony in stories describing interactions; recognition of facial expressions; recognition of affective prosody	Not reported	Yes: impaired on cognitive scale; detected faux-pas but did not cite hurt feelings as reasons and recognition of irony intact; emotion recognition impaired (one prosody, one faces)	Yes: impaired on emotional empathy scale
Spek et al., 2010	Adult	HFASD=32 AS=29 NT=32	EQ	Strange Stories Test: read stories and answer questions involving inference about a character's thoughts, feelings, or intentions (ToM task); Faux-pas test: answer questions about characters, speech, or behaviors in a story being awkward; Reading the Mind in the Eyes test	Not reported	Yes, all tasks impaired except Eyes task	-
White et al., 2011	Adult	ASD=16 NT=15	-	Identifying interactions between shapes and selecting emotions to reflect their mental states; false belief task; Strange Stories task	Not reported	Yes: all tasks impaired	-

Note. ADOS=Autism Diagnostic Observation Schedule; AS= Asperger Syndrome; DLD= developmental language delay; HFASD= high functioning ASD; ID= intellectual disability; LD= learning disability; LFASD= low functioning ASD.

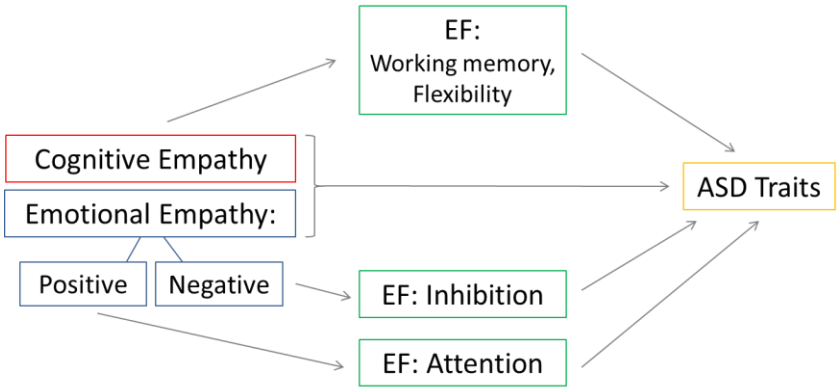

Figure 1. Proposed overall model of the relationships among empathy, EF, and ASD traits

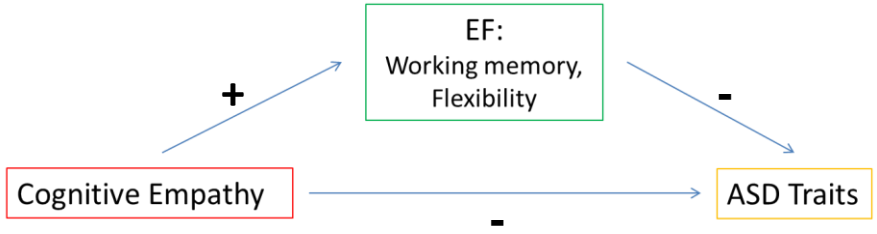

Figure 2. Visual representation of Hypothesis 1

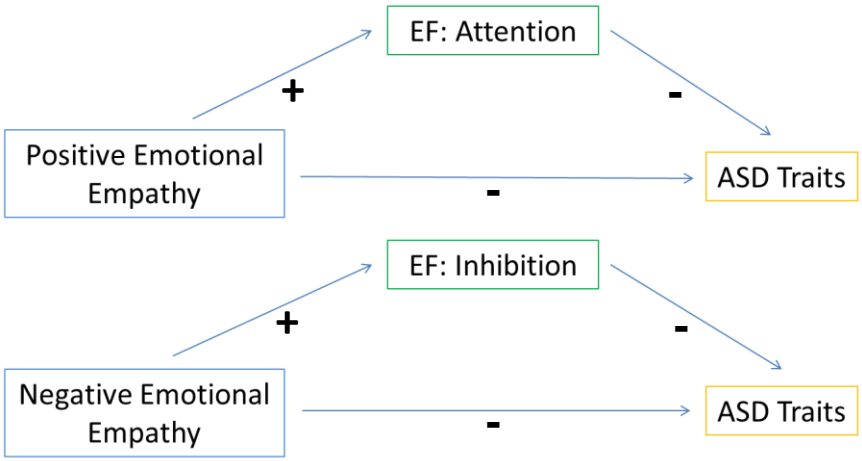

Figure 3. Visual representation of Hypotheses 2A (top) and 2B (bottom)

2 METHOD

2.1 Participants

Participants were adults aged 18 years and older. They were recruited from the metropolitan Atlanta region using flyers, emails and listservs, social media, other websites, announcements, and phone calls. Neurotypical participants were recruited, although individuals were not excluded for prior ASD diagnosis. Exclusion criteria included being a first-degree relative of another study participant, estimated full scale IQ below 70, history of neurological condition or brain injury, diagnosis of a psychotic disorder, visual or hearing impairment which would impede task completion, or inability to complete testing in English. Participants were compensated $50 for completion of all tasks.

Power analysis for mediation was conducted as described by Schoemann and colleagues (2017). This method used Monte Carlo bootstrapped confidence intervals, which allows the experimenter to specify multiple parameters as needed and has been shown to perform well compared to other power analysis methods (Schoemann et al., 2017). Using a target power of .80, 5,000 bootstrap replications, and weak to moderate correlations found in the literature ranging from -.30 to -.54, (Gökçen et al., 2014; Joseph & Tager–Flusberg, 2004; Lopez et al., 2005; Pellicano, 2013), a sample size of 57 participants was recommended for mediation models. In particular, effect sizes for power analysis were selected based on results of similar studies examining relationships between empathy and EF (Gökçen et al., 2016, 2014), between empathy and ASD traits (Gökçen et al., 2016, 2014; Pellicano, 2013), and between EF and ASD traits (Joseph & Tager–Flusberg, 2004; Lopez et al., 2005).

A total of 60 adults participated in the study. One participant was excluded from analyses due to performance in the impaired range on a qualifying task (i.e., CWIT Conditions 1 and 2). Therefore, a total of 59 participants were included in analyses. See Table 2 for sample characteristics. Participants were 75% female, racially diverse (12% White, 54% Black, 34% Other races), and were primarily undergradu-

ate students (64% undergraduate students, 24% completed undergraduate education, 10% graduate school). Two participants reported having a previous ASD diagnosis, specifically Asperger's syndrome, although all participants reported levels of ASD traits that did not reach clinical significance (see Figure 4 for distribution of ASD traits in the sample). Of the two participants who reported prior ASD diagnosis, one of them reported having had speech, physical, occupational, and ASD-specific therapies as a toddler. The other participant did not report participation in early intervention services.

2.2 Measures

2.2.1 The Autism-Spectrum Quotient

The Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001) is a 50-item self-report measure intended to assess ASD traits in adults with intelligence in the normal range. Participants respond with "yes" or "no" to each item, and all "yes" responses are summed to get a total score. Scores can range from 0, suggesting no ASD traits, to 50, suggesting a high number of ASD traits. Domains of ASD traits measured include social skill, attention switching, attention to detail, communication, and imagination. Items are based on the cognitive triad of symptoms (social, communication, and restricted and repetitive behaviors) from the DSM-IV (American Psychiatric Association, 1994), thought to characterize individuals with ASD (Wing & Gould, 1979). Although DSM criteria have since been updated to combine social and communication symptoms into a single domain (American Psychiatric Association, 2013), basic symptoms remain similar. Therefore, the AQ was considered to sufficiently measure ASD traits.

A score of 32 has been identified as a useful clinical cutoff, as 79.3% of the ASD group were found to obtain this score or higher, whereas only 2% of controls obtained this score (Baron-Cohen, Wheelwright, Skinner, et al., 2001). In a normative sample of 58 adults with prior ASD diagnosis, 174 adults without ASD, 840 students, and 16 winners of a prestigious math competition, the AQ was able to differentiate between ASD and non-ASD participants on overall score and sub-scores. The normative

sample was diverse in terms of sex, socioeconomic status, and areas of academic study, and scores in the high-functioning group did not differ significantly based on sex. The AQ has demonstrated strong psychometric properties, including test-retest reliability (*r*=0.7), internal consistency (Cronbach's alpha= 0.63 to 0.77), and convergent validity with parent-reported ASD traits (*M*=2.8 point difference, *SD*=-0.6). It has been used as a measure of ASD traits in a number of studies since its validation (e.g., Gökçen et al., 2014), including use for confirming ASD diagnosis in research participants (Bellebaum et al., 2014; Lombardo et al., 2007). In the current study, the AQ was used as a continuous measure of ASD traits.

2.2.2 Screening Measure

The Wechsler Abbreviated Scales of Intelligence, Second Edition. The Wechsler Abbreviated Scales of Intelligence, Second Edition (WASI-II; Wechsler, & Hsiao-pin, 2011) is a brief measure of estimated intellectual ability for individuals aged 6 to 90. Two versions of the test are available: a two subtest version which takes about 15 minutes to administer, and a four subtest version which takes about 30 minutes to administer (McCrimmon & Smith, 2013). The current study used the two subtest version. This version includes the Vocabulary subtest, a measure of verbal reasoning requiring individuals to verbalize word definitions, and the Matrix Reasoning Subtest, a measure of nonverbal reasoning requiring individuals to select from choices a response that completes a visual pattern. Raw scores are converted to T-scores for subtests, and subtest scores are combined to identify Full Scale IQ (FSIQ) Standard Scores (SS). Higher scores represent stronger abilities.

In a normative sample of 2,300 examinees divided into 23 age groups with 100 participants each, the WASI-II demonstrated strong psychometric properties in adults. This included test-retest reliability for subtests (r=0.90 to 0.92) and domain scores (r=0.94 to 0.97) as well as concurrent validity with other measures of intelligence and achievement (e.g., WAIS-IV; Wechsler, 2014). In the current study, WASI-II FSIQ of 70 or greater was used as inclusion criteria as executive functioning tasks may be diffi-

cult for those with well below average IQ, and the AQ was normed on a sample with IQ in the normal range. No participants were excluded due to low IQ.

2.2.3 Cognitive Empathy Measure

Advanced Clinical Solutions. The Advanced Clinical Solutions (ACS; Pearson, 2009) Social Cognition is a test battery measuring aspects of social cognition for individuals aged 16 to 90. The current study used three subtests from the Social Cognition test to form the "Total Social Perception" score: Affect Naming, Prosody-Face Matching, and Prosody-Pair Matching. The Affect Naming subtest requires participants to choose an emotion word from a list to describe the emotional state expressed by a person's pictured face. Prosody-Face Matching involves choosing a picture of a face from six choices to match the prosody of a sentence heard from a CD. Finally, the Prosody-Pair Matching subtest involves listening to a recorded sentence and choosing the appropriate interaction (including faces and body postures) from four pictures based on the prosody of the sentence. They must then indicate the emotion that was expressed by the sentence and determine whether the tone changed the meaning of the sentence. Raw scores are converted to scaled scores, with higher scores reflecting better performance. A "Total Social Perception" score integrating all three subtests was calculated and used as a continuous measure of cognitive empathy in the current study.

The ACS used the same normative sample as was used for the WAIS-IV, which matched demographic make-up with results of the US Bureau of the Census in 2005 (Chu, Lai, Xu, & Zhou, 2012). The Social Cognition test has demonstrated strong psychometric properties, including moderate to high internal consistency (0.69 to 0.96), high test-retest reliability (0.83), and high interrater reliability (98%; Chu, Lai, Xu, & Zhou, 2012; Kandalaft et al., 2012). Convergent validity with several other tasks measuring social cognition has been established, including the Reading the Mind in the Eyes task (Chu et al., 2012; Kandalaft et al., 2012). It has also been shown to discriminate between individuals with ASD and others (Holdnack et al., 2011; Kandalaft et al., 2012).

2.2.4 Emotional Empathy Measures

Empathic Response to Video Clips. An entire episode of the television show *Extreme Makeover: Home Edition* was divided into 18 clips and presented to participants as described by Light and colleagues (2015). Clips showing a family in need of a remodeled home evoke negative emotions, such as sadness, whereas other clips showing a family viewing the newly remodeled home evoke positive emotions, such as happiness. Two of the clips were considered to have neutral valence, four clips had negative valence, and 12 clips had positive valence. Therefore, more opportunity was provided to empathize with positive than with negative emotion. Immediately after viewing each video clip, participants completed a self-report scale rating their own experience of various positive and negative feelings, including joy, alarm, and worry on a scale from 1 (not at all) to 4 (extremely). In the current study, average self-report scores were calculated for positive empathy and negative empathy.

The video task and self-report questions were validated in a sample of 68 adult participants (Light et al., 2015). Facial electromyographic (EMG) signs of empathic concern and empathic happiness (i.e., measure of change in facial expression) during these video clips were found to be associated with prosocial behavior and self-reported empathy in response to the clips. Furthermore, fronto-striatal circuitry activation on fMRI during this task was associated with trait empathy (Mirabito et al., 2019).

Participants' faces were also recorded during this task and later coded for spontaneous facial expressions. Facial expressions in response to emotional stimuli have previously been used as a measure of emotional empathy (e.g., Scambler et al., 2007). Facial, vocal, or bodily reactions to stimuli were coded on a scale from 1 (absence of concern/happiness) to 4 (substantial concern/happiness demonstrated) as described in Light and colleagues' (2009) study. The codes were validated in the mentioned study, and coders demonstrated high interrater reliability (κ =.72). Furthermore, electroencephalogram (EEG) showed that codes of facial expressions were associated with frontal activation during empathy tasks. In

the current study, these codes were used as an observational measure of empathic concern and happiness, with higher scores reflecting greater empathy.

In the current study, video clips were assigned empathy ratings by two trained independent coders who reviewed recordings of the participants' faces while watching the videos. Interrater reliability was determined between the coders using weighted kappas, which were selected given the number of coders and ability to account for magnitude of disagreement between the raters (Hallgren, 2012). Initial reliability was very high (Weighted κ=.95) following five commonly scored participants. Overall reliability remained high (Weighted κ=.90), with 50% overlap between participants coded by the two raters. Codes were averaged to create observed positive and negative empathy scores. Self-reported and observed empathy were examined separately so as not to dilute information, as measures were not strongly correlated (see Table 4) and because previous research suggests that these sources of information may yield different findings (e.g., Dziobek et al., 2008; Mathersul et al., 2013).

The Positive Empathy Scale. The Positive Empathy Scale (Light et al., 2015) is a 15-item self-report measure intended to assess emotional empathy for positive emotions (e.g., *I also feel good when someone I know feels good*). Participants read each statement and indicate on a Likert scale the extent to which the item is true or untrue, with 1 being "extremely untrue," 4 being "neither true nor false," and 7 being "extremely true." Item responses were summed to obtain a total score, with higher scores reflecting high empathic happiness. The measure was modeled after the Interpersonal Reactivity Index (IRI; Davis, 1980), but adapted to measure only empathic happiness rather than sadness. Inter-item reliability was high (Cronbach's alpha=0.92) and convergent validity with the EQ and IRI was confirmed by Light and colleagues (2015). This scale was used as a self-report measure of daily positive empathy to compare to self-reported empathy during the video task, and was selected due to its ability to measure only positive emotional empathy rather than total emotional empathy.

2.2.5 Executive Functioning Measures

WAIS-IV Digit Span. The Digit Span subtest of the Wechsler Adult Intelligence Scales, Fourth Edition (Wechsler, 2014) is a measure of simple attention and verbal working memory. It can be administered in about 5 minutes. It is divided into three tasks: digit span forward (simple attention), backward (working memory), and sequencing (working memory; not administered in the current study). The forward condition requires listening to a string of two to ten digits and repeating them in the same order in which they were heard. The backward condition is similar, except that participants are asked to repeat the digits in reverse order. In all tasks, items begin with two digits and increase in difficulty. Psychometric properties are sufficient, with test-retest reliability of at least 0.70, inter-rater reliability of at least 0.90, and high concurrent validity (r=0.88) of the entire WAIS-IV measure with the Stanford-Binet IV (Delaney & Hopkins, 1987) intelligence test. In the current study, digit span forward (DSF) was used as a measure of attention, and digit span backward (DSB) was used as a measure of working memory.

The Delis-Kaplan Executive Functioning System. The Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001) is a battery of neuropsychological tests measuring executive functions. The current study used three tasks from this battery (described below), including Verbal Fluency, the Color-Word Interference Test, and the Tower Test. The normative sample was based on 1,750 individuals ranging from age 8 to 89, and was racially and socioeconomically diverse. Psychometric properties are sufficient; test-retest reliability for these subtests ranged from 0.62 to 0.80 and internal consistency ranged from 0.32 to 0.90. The D-KEFS has been used in both clinical and research settings, and has been shown to be sensitive to frontal lobe dysfunction (Homack, Lee, & Riccio, 2005).

The Verbal Fluency test is a measure of semantic and phonemic fluency, as well as a measure of cognitive flexibility. It has three conditions and takes less than 10 minutes to administer. In the phonemic fluency condition, participants are asked three times to name as many words as possible beginning with a target letter in one minute. The semantic fluency condition is similar, except that they must name

words that fall within two separate target categories. The switching condition requires one to name words from alternating categories, and is thus a measure of cognitive flexibility. In the current study, only the switching condition was used for analyses; however, data were collected for the semantic fluency condition to ensure that any impairment during the switching condition was due to difficulty with cognitive flexibility and not due to difficulty with semantic fluency. Raw scores were converted to scaled scores, with higher scores representing stronger abilities. In the current study, the score for total number of switches was used as a measure of cognitive flexibility. No participants were excluded due to scores in the impaired range on both the semantic fluency and switching conditions.

The Color-Word Interference Test is a Stroop task with four conditions. It takes roughly 15 minutes to administer. It asks participants to, as quickly as possible, name the colors of squares (Condition 1), read color words (Condition 2), inhibit reading color words and instead read ink color (Condition 3), and to alternate between reading color words and naming ink color (Condition 4). Raw scores were converted to scaled scores, with higher scores reflecting stronger performance. In the current study, Condition 3 was used as a measure of inhibitory control. Conditions 1 and 2 were only administered to ensure that any impairment on Condition 3 reflected difficulty with inhibitory control and not difficulty with processing speed. One participant was excluded due to performance in the impaired range on Condition 1 and Condition 3, indicating that poor performance may have been due simply to poor speeded naming ability.

The Tower Test is a measure of planning, which also involves components of working memory, inhibitory control, and cognitive flexibility. It takes about 15 to 20 minutes to administer. A participant is presented with an apparatus with three pegs on it and with up to 5 discs of varying sizes. The participant is then presented with the discs in a starting position, and an image of a final target position. They are instructed to move the discs one at a time to the target position without putting a large disc on top of a small disc, and using as few moves as possible. In the current study, the accuracy score, which assigns a

score based on the number of moves required to complete items, was used as a measure of planning and high level executive functioning. Raw scores were converted to scaled scores, with higher scores reflecting stronger performance. Although this measure was not included in hypotheses, data were collected for exploratory analyses given previous findings that it may relate to variables of interest (e.g., Ambery et al., 2006; Bramham et al., 2009).

2.2.6 Background and History Questionnaire

A questionnaire was administered to each participant asking them to report basic demographic information, diagnostic history, and information regarding exclusion criteria.

2.3 Procedure

Following recruitment, participants completed a brief screening process over the phone, to check for exclusionary criteria. If participants were eligible for the study, they scheduled an appointment at Georgia State University, which took 2 to 2.5 hours. When they arrived, they gave informed consent and were given a brief overview about what to expect during testing. They first completed a background questionnaire to obtain basic demographic information and again verify inclusion criteria. Next, they completed the WASI-II, as this measure was important for study eligibility. Participants then continued to complete the other tasks. First, participants completed behavioral assessments, including the cognitive empathy task and executive functioning tasks. The order of these was counterbalanced to control for fatigue. After completing these tasks, participants completed the video task, followed by the AQ. They completed the behavioral tasks first so that the questionnaire did not prime or impact their performance on behavioral empathy tasks. After completing all tasks, participants were thanked for their time and were given $50. No participants were excluded during the testing session. One participant discontinued participation midway through the task due to technical difficulties; the participant was compensated at a rate of $15 per hour as described in the consent form.

2.4 Statistical Plan

All analyses were completed using IBM SPSS Statistics, Version 25.

2.4.1 Assumptions

Assumptions of mediation were examined, which include the assumptions of general linear models. These assumptions include linearity, normality, homogeneity of error variance, and independence of errors (Hayes, 2009). Normality was examined using the Kolmogorov-Smirnov test. Homogeneity of variance was examined using visual inspection of P-P plots. Durbin-Watson test was used to assess independence of residuals, and the Deviation from Linearity test in SPSS was used to determine if data were linear. Multicollinearity was evaluated by examining the correlation matrix for very strong correlations. There are also several theoretical assumptions of mediation models, although these assumptions are not testable and are mainly aimed at establishing causality (MacKinnon, Fairchild, & Fritz, 2007). They include no reverse causality, minimization of measurement error, and no omitted variable that causes the mediator and the outcome. None of these assumptions are considered to be violated in the current study.

2.4.2 Preliminary Analyses

Descriptive statistics, including mean, standard deviation, and range for each variable of interest were reported. Sex differences were examined using independent samples t-test. One-way ANOVA was used to determine whether scores differed by administration order of tasks. A matrix of Spearman correlations is presented; Spearman correlations were selected as they are valid in the context of data that violate assumptions of general linear models (de Winter, Gosling, & Potter, 2016). Correlations with multiple variables within a mediation model were considered as covariates. IQ correlated with positive self-reported empathy and attention, so it was examined as a covariate in the model for Hypothesis 2A. However, it did not meaningfully change findings when it was included in the model.

2.4.3 Hypothesis 1: Relationships among cognitive empathy, EF, and ASD traits

Hypothesis 1 (see Figure 2) considered whether EF partially mediates the relationship between cognitive empathy and ASD traits. The mediation analyses were performed using Hayes' PROCESS macro for SPSS (2007), which evaluates each step of the mediation in accordance with Baron and Kenny's (1986) guidelines but using bootstrapped confidence intervals with 5,000 bootstraps to correct for bias in estimates (Hayes, 2012). The model involves testing each leg of the mediation model as a linear regression. The indirect effect of M (mediator) on X and Y measures the amount of mediation present. If the indirect effect is significant and the presence of the mediator reduces the relationship between X (predictor) and Y (outcome; paths *c-c'*), then partial mediation is present. Each mediation model includes an empathy variable as X, ASD traits as Y, and an EF variable as M.

In this model, the ACS Social Perception score was used as a behavioral measure of cognitive empathy, or the independent variable (X). The AQ total score provided the measure of ASD traits, or the dependent variable (Y). The WAIS-IV Digit Span Backward score (working memory) and D-KEFS Verbal Fluency Condition 3 number of switches (cognitive flexibility) were used as the EF measures, or mediating variables (M).

2.4.4 Hypothesis 2: Relationships among emotional empathy, EF, and ASD traits

Hypothesis 2 (see Figure 3) considered whether EF partially mediates the relationship between emotional empathy and ASD traits. This hypothesis used separate models for positive (Hypothesis 2A) and negative (Hypothesis 2B) emotional empathy. Self-reported and observed emotional empathy were also examined separately as they were not highly correlated and due to the possibility of different findings using the two methods.

Each model was examined using the PROCESS macro as described above. For Hypothesis 2A, AQ scores were the outcome, Digit Span Forward (attention) scores were the mediator, and the predictor was observed positive emotional empathy in one model and self-reported positive emotional empathy

in the other model. For Hypothesis 2B, AQ scores were the outcome, Color-Word Interference Test Condition 3 (inhibition) scores were the mediator, and the predictor was observed negative emotional empathy in one model and self-reported negative emotional empathy in the other model. Hypothesis 2B failed the assumption of heteroscedasticity, so the Davidson-MacKinnon option was implemented during analyses. This method estimates standard error such that it is consistent with heteroscedasticity and therefore does not require transformation of variables (Hayes, 2012).

Table 2. Sample characteristics

Characteristic	N
Total N	59
Age M(SD)	22.31 (6.30)
Sex	
Male	15 (25%)
Female	44 (75%)
Race	
White	7 (12%)
Black	32 (54%)
Hispanic	6 (10%)
Asian/Pacific Islander	9 (15%)
Multi-Racial	5 (9%)
Education Level	
Number of years M(SD)	14.62 (1.90)
In college	38 (64%)
College graduate	14 (24%)
Graduate school	6 (10%)
Unreported	1 (2%)

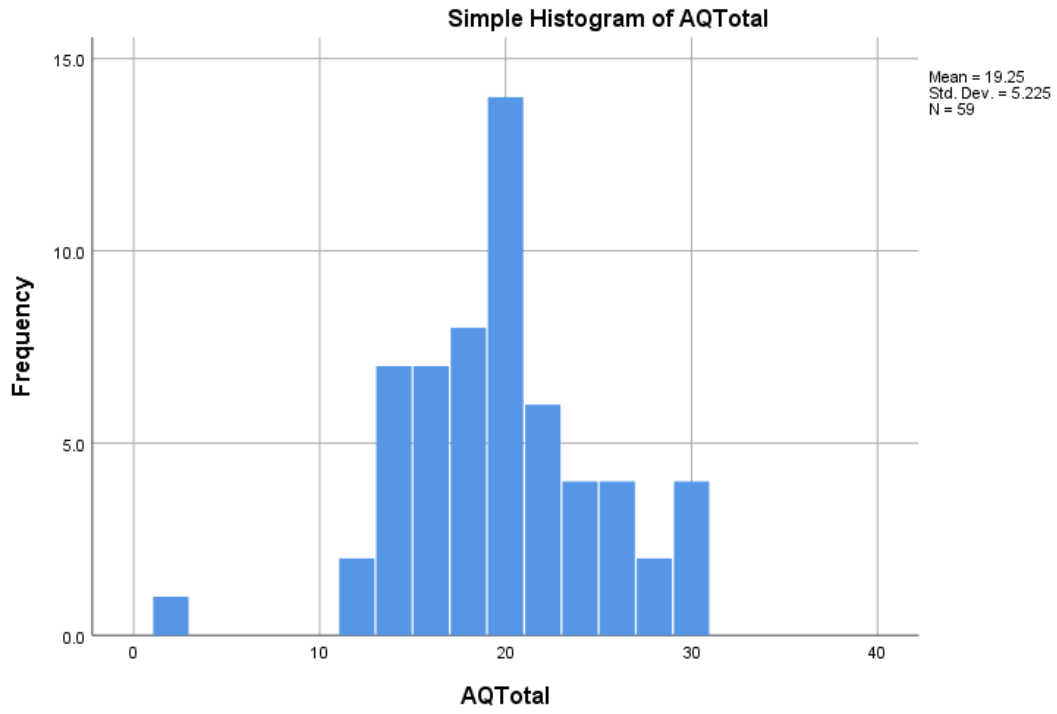

Figure 4. Distribution of ASD traits in total sample

3 RESULTS

3.1 Preliminary analyses

Descriptive statistics are presented in Table 3. There were no sex differences for any executive functioning or empathy variables, *ps*>.05. A one-way ANOVA was completed to determine whether or not administration order resulted in significantly different scores. Scores did not differ by administration order for any variable, with the exception of cognitive empathy, F(3, 55)=3.38, *p*=.02. Therefore, administration order was controlled for in the analyses involving cognitive empathy. Correlation matrix (see Table 4) indicated that IQ was significantly correlated with the majority of EF variables, but not with most empathy variables or ASD traits. Specifically, full Scale IQ was positively correlated with attention (Spearman's ρ=.36, *p*=.005), working memory (Spearman's ρ =.49, *p*<.001), inhibition (Spearman's ρ

=.53, *p*<.001), and planning (Spearman's ρ =.42, *p*=.001). However, IQ was not correlated with empathy variables, with the exception of a negative correlation with self-reported positive emotional empathy (Spearman's ρ =-.28, *p*=.03). IQ was generally not included as a covariate, as inclusion of an additional variable would reduce power for analyses, except for Hypothesis 2A.

3.2 Correlations among variables of interest

Spearman correlations among demographic, cognitive, and empathic variables were examined, to be valid in the context of data that violate assumptions of homoscedasticity and normality (de Winter et al., 2016; see Table 4 for correlation matrix). Multiple executive functioning measures demonstrated weak to moderate (Akoglu, 2018) positive correlations with each other, including inhibitory control with attention (Spearman's ρ =.32, *p*=.01), with working memory (Spearman's ρ =.32, *p*=.01), and with planning (Spearman's ρ =.40, *p*=.002). Also, working memory was correlated with attention (Spearman's ρ =.54, *p*<.001) and with planning (Spearman's ρ =.27, *p*=.04). Finally, cognitive flexibility was positively correlated with planning (Spearman's ρ =.40, *p*=.002).

Regarding empathy variables, positive and negative emotional empathy were moderately positively correlated with each other for both observed (Spearman's ρ =.58, *p*<.001) and self-reported empathy (Spearman's ρ =.44, *p*<.001). Within positive emotional empathy, self-reported and observed emotion were weakly to moderately positively correlated (Spearman's ρ =.35, *p*=.007). Similarly, self-reported and observed negative emotional empathy were moderately positively correlated (Spearman's ρ =.41, *p*=.001). However, cognitive empathy did not significantly correlate with any emotional empathy variables, *p*s>.05. The relationships between positive emotional empathy during the video task and the self-report measure of daily positive emotional empathy were examined; weak to moderate positive correlations were identified for self-reported (Spearman's ρ=.34, *p*=.008) and observed (Spearman's ρ=.33, *p*=.01) positive emotional empathy. Furthermore, a moderate negative correlation was identified between daily positive emotional empathy and ASD traits (Spearman's ρ=-.43, *p*=.001).

Inhibitory control was negatively correlated with self-reported positive (Spearman's ρ =-.44, *p*=.001), but not negative (Spearman's ρ =-.11, *p*=.43), emotional empathy. Furthermore, planning weakly to moderately negatively correlated with both self-reported empathy variables, including positive (Spearman's ρ =-.31, *p*=.02) and negative (Spearman's ρ =-.29, *p*=.03) empathy. In contrast, planning weakly to moderately positively correlated with cognitive empathy (Spearman's ρ =.34, *p*=.009). Additionally, self-reported positive empathy weakly negatively correlated with working memory (Spearman's ρ =-.29, *p*=.03).

3.3 Assumptions

Assumptions of mediation including linearity, normality, homogeneity of error variance, and independence of errors (Hayes, 2009) were examined. Kolmogorov-Smirnov tests showed that the majority of EF and empathy variables were not normally distributed, *p*s<.05, with the exception of cognitive flexibility, *D*(59)=.11, *p*=.09, ASD traits, *D*(59) =.11, *p*=.06, and observed positive emotional empathy *D*(59)=.08, *p*=.20. However, the mediation models in the current study use bootstrapping methods, which eliminate the necessity of normality and thus do not require data transformation (Hayes, 2012). Correlation matrix reveals that multicollinearity is not present among the variables (see Table 4). Durbin-Watson test indicated that residuals are independent, and all analyses had nonsignificant deviations from linearity. Two models violated the assumption of homoscedasticity; the models with self-reported and observed negative emotional empathy as X demonstrated homoscedasticity. Hayes' PROCESS macro used in the current study provides the Davidson-MacKinnon option for including a standard error estimator that is consistent with heteroscedasticity and therefore does not require transformation of variables (Hayes, 2012). This option was implemented for these two mediation models. Overall, assumptions were not violated, with the exception of homoscedasticity in two models, which was addressed statistically.

3.4 Hypothesis 1: Relationships among cognitive empathy, executive functions, and ASD traits

In this proposed mediation model, none of the paths are statistically significant (see Table 5 and Figure 5). Cognitive empathy does not predict ASD traits, b=.07, t(57)=.25, p=.80, indicating that path *c* is not significant, F(1, 57)=.06, p=.80, R^2=.001. The *a* path is not significant, as cognitive empathy is not associated with working memory, F(1, 57)=.41, p=.52, R^2=.007, or with cognitive flexibility, F(1, 57)=.07, p=.79, R^2=.001. Path b is not significant, F(1, 57)=.46, p=.71, R^2=.02, as working memory, b=-.03, t(57)=-.10, p=.92, and cognitive flexibility, b=.29, t(57)=1.14, p=.26, are not associated with ASD traits when controlling for cognitive empathy. The direct effect of cognitive empathy on ASD traits (path *c'*) is not significant, b=.08, t(57)=.29, p=.77. Finally, the indirect effects of working memory, b=-.002, 95% CI [-.09, .06] and cognitive flexibility, b=-.01, 95% CI [-.14, .16] on the relationship between cognitive empathy and ASD traits are not significant. Therefore, no significant associations are present and no partial mediation is present in the model. Controlling for administration order did not meaningfully change the model (see Table 6).

3.5 Hypothesis 2A: Relationships among positive emotional empathy, attention, and ASD traits

Two separate mediation models were examined to test Hypothesis 2A to allow for self-reported and observed emotional empathy to be explored independently. Therefore, one model included self-reported positive emotional empathy as X, whereas the other model included observed positive emotional empathy as X. See Figure 6 for visual representations of these models.

3.5.1 Self-Reported positive emotional empathy as X

Attention was examined as a partial mediator of the relationship between self-reported positive emotional empathy and ASD traits (see Table 7 and Figure 6). In this model, the *c* path was significant. In other words, high self-reported positive emotional empathy predicted low ASD traits, F(1, 57)=4.79, p=.03, R^2=.08. Specifically, for every one-unit increase in self-reported empathy, ASD traits decreased by

2.4 units, *b*=-2.40, *t*(57)=-2.19, *p*=.03. In contrast, the *a* and *b* paths were not significant. In particular, self-reported positive emotional empathy, *b*=-.45, *t*(57)=-.90, *p*=.37, was not significantly associated with attention, *F*(1, 57)=.82, *p*=.37, R^2=.01. Furthermore, attention, *b*=.05, *t*(57)=.15, *p*=.88, was not significantly associated with ASD traits when controlling for positive empathy, *F*(1, 57)=2.37, *p*=.10, R^2=.08. The direct effect of self-reported emotional empathy on ASD traits (path *c'*) is significant, *b*=-2.38, *t*(57)=-2.14, *p*=.04, consistent with findings for path *c*. However, the indirect effect of attention on this relationship is not significant, *b*=-.02, 95% CI [-.44, .32], indicating that partial mediation is not present. Therefore, high self-reported positive emotional empathy predicts low ASD traits, but this relationship is not mediated by attentional ability.

3.5.2 Observed positive emotional empathy as X

As above, attention was examined as a partial mediator of the relationship between positive emotional empathy and ASD traits, although in this model, directly observed rather than self-reported positive emotional empathy was examined as X (see Table 8 and Figure 6). None of the paths were significant in this model. Specifically, path *c* was not significant, as observed positive emotional empathy, *b*=-1.33, *t*(57)=-1.12, *p*=.27, was not associated with ASD traits, *F*(1, 57)=1.5, *p*=.27, R^2=.02. Path *a* was not significant as observed positive emotional empathy, *b*=-.07, *t*(57)=-.12, *p*=.90, was not significantly associated with attention, *F*(1, 57)=.02, *p*=.90, R^2=.0003. Path *b* was not significant as attention, *b*=.11, *t*(57)=.38, *p*=.70, was not significantly associated with ASD traits when controlling for observed positive emotional empathy, *F*(1, 57)=.69, *p*=.51, R^2=.02. The direct effect of observed positive emotional empathy on ASD traits (path *c'*) was not significant, *b*=-1.33, *t*(57)=-1.10, *p*=.27, consistent with findings of path *c*. The indirect effect of attention on the relationship between observed positive emotional empathy and ASD traits was not significant, *b*=-.008, 95% CI [-.39, .40]. Therefore, attention did not mediate the relationship between observed positive emotional empathy and ASD traits, and no significant associations were present within the model.

3.6 Hypothesis 2B: Relationships among negative emotional empathy, inhibitory control, and ASD traits

Two separate mediation models were examined to test this hypothesis. One model included self-reported negative emotional empathy as X, whereas the other model included observed negative emotional empathy as X. See Figure 7 for visual representations of these models. These models violated the assumption of homoscedasticity. As a result, the Davidson-MacKinnon option of the PROCESS macro was used, which renders analyses robust to heteroscedasticity (Hayes, 2012).

3.6.1 Self-reported negative emotional empathy as X

Inhibitory control was examined as a potential mediator of the relationship between self-reported negative emotional empathy and ASD traits (see Table 9 and Figure 7). The *c* path was not significant, although it approached significance; self-reported negative emotional empathy, b=-6.93, t(57)=-1.79, p=.08, was not significantly associated with ASD traits, F(1, 57)=3.19, p=.08, R^2=.04. Furthermore, the *a* path was not significant, as self-reported negative emotional empathy, b=-1.66, t(57)=-.76, p=.45, was not associated with inhibitory control, , F(1, 57)=.58, p=.45, R^2=.009. The *b* path also was not significant, as inhibition, b=-.28, t(57)=-.92, p=.36, was not associated with ASD traits when controlling for self-reported negative emotional empathy, F(1, 57)=1.74, p=.19, R^2=.05. The direct effect of self-reported negative emotional empathy on ASD traits (path *c'*) approached but did not achieve significance, b=-7.41, t(57)=-1.82, p=.07. Similarly, the indirect effect of inhibitory control was not significant, b=.47, 95% CI [-.93, 3.27]. Overall, inhibitory control did not mediate the relationship between self-reported negative emotional empathy and ASD traits, and no relationships within the model were significantly associated.

3.6.2 Observed negative emotional empathy as X

Inhibitory control was examined as a potential mediator of the relationship between directly observed negative emotional empathy and ASD traits (see Table 10 and Figure 7). The *c* path was not sig-

nificant, as observed negative emotional empathy, b=.90, t(57)=.78, p=.44, was not significantly associated with ASD traits, F(1, 57)=.60, p=.44, R^2=.009. However, the a path was significant, F(1, 57)=4.25, p=.04, R^2=.10. Specifically, for every one-unit increase in observed negative emotional empathy, inhibitory control decreased 1.45 units, b=-1.45, t(57)=-2.06, p=.04. In contrast, the b path was not significant, as inhibitory control, b=-.20, t(57)=-.61, p=.55, was not associated with ASD traits when controlling for observed negative emotional empathy, F(1, 57)=.49, p=.62, R^2=.02. The direct effect of observed negative emotional empathy on ASD traits (path c') was not significant, b=.61, t(57)=.47, p=.64. Similarly, the indirect effect of inhibitory control was not significant, b=.29, 95% CI [-.67, 1.24]. Overall, inhibitory control did not mediate the relationship between observed negative emotional empathy and ASD traits. However, observed negative emotional empathy was negatively associated with inhibitory control.

Table 3. Descriptive statistics for IQ, executive functioning, empathy, and ASD measures

Measure	M(SD)	Range
WASI-II FSIQ (2-subtest)	107.36 (11.27)	89-132
WAIS-IV Digit Span Forward (Attention)	9.20 (2.31)	4-14
WAIS-IV Digit Span Backward (Working Memory)	9.95 (2.47)	4-16
D-KEFS Verbal Fluency: Switching (Flexibility)	11.25 (2.70)	5-18
D-KEFS Color-Word Interference: Inhibition (Inhibition)	10.83 (2.51)	5-15
D-KEFS Tower: Achievement Score (Planning)	10.20 (2.49)	5-19
ACS Social Perception	10.92 (2.54)	6-17
Video Task Observation		
Positive Clips	1.95 (0.58)	1-3.33
Negative Clips	1.62 (0.55)	1-3.50
Video Task Self-Report		
Positive Items	2.72 (.61)	1.32-3.68
Negative Items	1.17 (.14)	1.01-1.62
AQ Total Score	19.25 (5.23)	2-30
Positive Empathy Scale	92.41 (11.77)	51-105

Note. FSIQ scores are presented as standard scores, EF and ACS scores are presented as scaled scores, and empathy and ASD trait scores are presented as raw scores. Possible scores on observational and self-reported emotional empathy measures range from 1 to 4. Possible scores for AQ range from 0 to 50, with 32 denoting clinically significant symptoms. Possible scores on the Positive Empathy Scale range from 15 to 105.

Table 4. Correlation matrix for variables of interest

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1- Age	1														
2- Education	.87**	1													
3- WASI-II FSIQ	-.07	.05	1												
4- DSF	-.11	-.04	.36**	1											
5- DSB	.04	.10	.49**	.54**	1										
6- VF Switching	-.27	-.25	.11	.06	.02	1									
7- CWIT Inhibition	.03	.07	.53**	.32*	.32*	.26	1								
8- Tower Achievement	-.07	-.07	.42**	.11	.27*	.30*	.40**	1							
9- Video Obs Positive Clips	-.28*	-.20	-.03	-.10	-.10	-.16	-.24	-.10	1						
10- Video Obs Negative Clips	-.15	-.09	-.11	-.09	-.06	-.01	-.22	-.08	.58**	1					
11- Video SR: Positive Items	.55	-.02	-.29*	-.13	-.29*	-.14	-.44**	-.31*	.35**	.13	1				
12- Video SR: Negative Items	.46	.11	.02	-.10	-.03	-.03	-.11	-.29*	.40**	.41**	.44**	1			
13- ACS	-.03	.07	.21	.12	.12	-.07	.01	.34**	.11	.13	-.05	-.10	1		
14- AQ	.15	.13	-.09	-.001	-.02	.14	-.07	-.07	-.17	.13	-.23	-.16	.01	1	
15- PES	-.09	-.07	.003	-.03	-.06	-.11	-.06	.06	.33*	.20	.34**	.20	.08	-.43**	1

Note. *p<.05, **p<.01. Spearman correlation coefficients are presented. DSF=Digit Span Backward; DSF=Digit Span Forward; VF=Verbal Fluency; CWIT=Color-Word Interference Test; Obs=Observed emotional empathy; SR=Self-reported emotional empathy; ACS=Advanced Clinical Solutions Social Perception Score; AQ=Autism Spectrum Quotient; PES=Positive Empathy Scale.

Table 5. Results of mediation model for Hypothesis 1: Relationships among cognitive empathy, working memory, flexibility, and ASD traits

Steps of Mediation Model	R^2	B (SE)	t	*p*	95% CI
Path c	.001				
Predictor: Cognitive Empathy		.07 (.27)	.25	.80	[-.48, .61]
Outcome: ASD Traits					
Path a	.01				
Predictor: Cognitive Empathy					
Outcome: Working Memory		.08 (.13)	.64	.52	[-.17, .34]
Outcome: Cognitive Flexibility		-.04 (.14)	-.26	.79	[-.32, .25]
Path b	.16				
Predictor: Working Memory		-.03 (.28)	-.10	.92	[-.47, .63]
Predictor: Cognitive Flexibility		.29 (.26)	1.14	.26	[-.22, .81]
Covariate: Cognitive Empathy		.08 (.28)	.29	.77	[-.47, .63]
Outcome: ASD Traits					
Path c’					
Predictor: Cognitive Empathy		.08 (.28)	.29	.77	[-.47, .63]
Mediator: Working Memory (Indirect Effect)		-.002 (.03)			[-.09, .06]
Mediator: Cognitive Flexibility (Indirect Effect)		-.01 (.07)			[-.14, .16]
Outcome: ASD Traits					

Table 6. Results of mediation model for Hypothesis 1: Relationships among cognitive empathy, working memory, flexibility, and ASD traits, controlling for administration order

Steps of Mediation Model	R^2	B (SE)	t	*p*	95% CI
Path c	.01				
Predictor: Cognitive Empathy		.06 (.27)	.21	.83	[-.49, .61]
Covariate: Administration Order		.42 (.62)	.21	.50	[-.82, 1.67]
Outcome: ASD Traits					
Path a	.01				
Predictor: Cognitive Empathy					
Covariate: Administration Order		-.10 (.29)	-.34	.73	[-.69, .49]
Outcome: Working Memory		.08 (.13)	.65	.52	[-.17, .34]
Covariate: Administration Order		-.56 (.31)	-1.78	.08	[-1.19, .07]
Outcome: Cognitive Flexibility		-.02 (.14)	-.18	.86	[-.30, .25]
Path b	.04				
Predictor: Working Memory		-.02 (.28)	-.06	.95	[-.49, .62]
Predictor: Cognitive Flexibility		.35 (.27)	1.33	.19	[-.18, .89]
Covariate: Cognitive Empathy		.07 (.28)	.25	.80	[-.49, .62]
Covariate: Administration Order		.62 (.64)	.96	.34	[-.67, 1.90]
Outcome: ASD Traits					
Path c’					
Predictor: Cognitive Empathy		.07 (.28)	.25	.80	[-.49, .62]
Mediator: Working Memory (Indirect Effect)		-.002 (.03)			[-.09, .06]
Mediator: Cognitive Flexibility (Indirect Effect)		-.01 (.07)			[-.15, .17]
Outcome: ASD Traits					

Table 7. Results of mediation model for Hypothesis 2A: Relationships among self-reported positive emotional empathy, attention, and ASD traits

Steps of Mediation Model	R^2	B (SE)	t	*p*	95% CI
Path c	.08				
Predictor: Positive Emotional Empathy		-2.40 (1.10)	-2.19*	.03	[-4.59, -.20]
Outcome: ASD Traits					
Path a	.01				
Predictor: Positive Emotional Empathy		-.45 (.50)	-.90	.37	[-1.45, .55]
Outcome: Attention					
Path b	.08				
Predictor: Attention		.05 (.29)	.15	.88	[-.54, .63]
Covariate: Positive Emotional Empathy		-2.38 (1.11)	-2.14*	.04	[-4.60, -.15]
Outcome: ASD Traits					
Path c’					
Predictor: Positive Emotional Empathy		-2.38 (1.11)	-2.14*	.04	[-4.60, -.15]
Mediator: Attention (Indirect Effect)		-.02 (.18)			[-.44, .32]
Outcome: ASD Traits					

Table 8. Results of mediation model for Hypothesis 2A: Relationships among observed positive emotional empathy, attention, and ASD traits

Steps of Mediation Model	R^2	B (SE)	t	*p*	95% CI
Path c	.02				
Predictor: Positive Emotional Empathy		-1.33 (1.19)	-1.12	.27	[-3.72, 1.05]
Outcome: ASD Traits					
Path a	.0003				
Predictor: Positive Emotional Empathy		-.07 (.53)	-.12	.90	[-1.13, 1.00]
Outcome: Attention					
Path b	.02				
Predictor: Attention		.11 (.30)	.38	.70	[-.48, .71]
Covariate: Positive Emotional Empathy		-1.33 (1.20)	-1.10	.27	[-3.73, 1.08]
Outcome: ASD Traits					
Path c’					
Predictor: Positive Emotional Empathy		-1.33 (1.20)	-1.10	.27	[-3.73, 1.08]
Mediator: Attention (Indirect Effect)		-.01 (.18)			[-.39, .40]
Outcome: ASD Traits					

Table 9. Results of mediation model for Hypothesis 2B: Relationships among self-reported negative emotional empathy, inhibitory control, and ASD traits

Steps of Mediation Model	R^2	B (SE)	t	*p*	95% CI
Path c	.04				
Predictor: Negative Emotional Empathy		-6.93 (3.88)	-1.79	.08	[-14.71, .84]]
Outcome: ASD Traits					
Path a	.009				
Predictor: Negative Emotional Empathy		-1.66 (2.18)	-.76	.45	[-6.04, 2.71]
Outcome: Inhibitory Control					
Path b	.05				
Predictor: Inhibitory Control		-.28 (.31)	-.92	.36	[-.90, .33]
Covariate: Negative Emotional Empathy		-7.41 (4.06)	-1.82	.07	[-15.54, .73]
Outcome: ASD Traits					
Path c’					
Predictor: Negative Emotional Empathy		-7.41 (4.06)	-1.82	.07	[-15.54, .73]
Mediator: Inhibitory Control (Indirect Effect)		.47 (1.04)			[-.93, 3.27]
Outcome: ASD Traits					

Note. Model uses Davidson-MacKinnon method to account for heteroscedasticity.

Table 10. Results of mediation model for Hypothesis 2B: Relationships among observed negative emotional empathy, inhibitory control, and ASD traits

Steps of Mediation Model	R^2	B (SE)	t	*p*	95% CI
Path c	.01				
Predictor: Negative Emotional Empathy		.90 (1.16)	.78	.44	[-1.43, 3.23]
Outcome: ASD Traits					
Path a	.10*				
Predictor: Negative Emotional Empathy		-1.45 (.70)	-2.06*	.04	[-2.87, -.04]
Outcome: Inhibitory Control					
Path b	.02				
Predictor: Inhibitory Control		-.20 (.33)	-.60	.55	[-.87, .47]
Covariate: Negative Emotional Empathy		.61 (1.30)	.47	.64	[-2.01, 3.22]
Outcome: ASD Traits					
Path c’					
Predictor: Negative Emotional Empathy (Direct Effect)		.61 (1.30)	.47	.64	[-2.01, 3.22]
Mediator: Inhibitory Control (Indirect Effect)		.29 (.46)			[-.67, 1.24]
Outcome: ASD Traits					

Note. Model uses Davidson-MacKinnon method to account for heteroscedasticity.

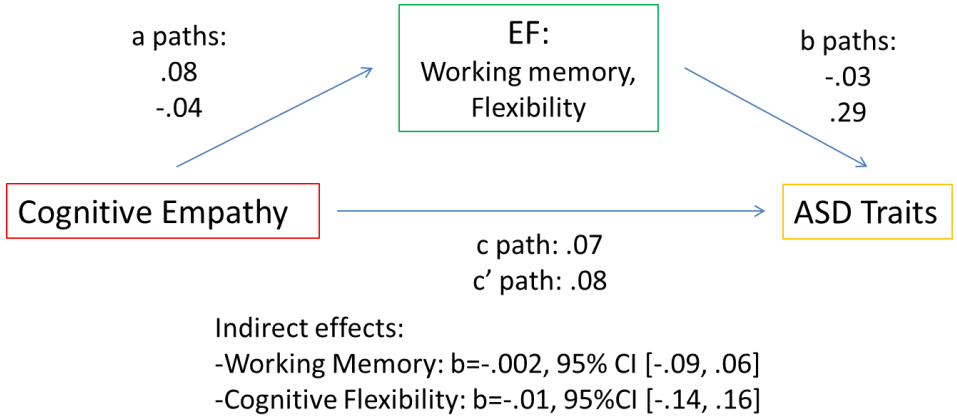

Figure 5. Results of Hypothesis 1

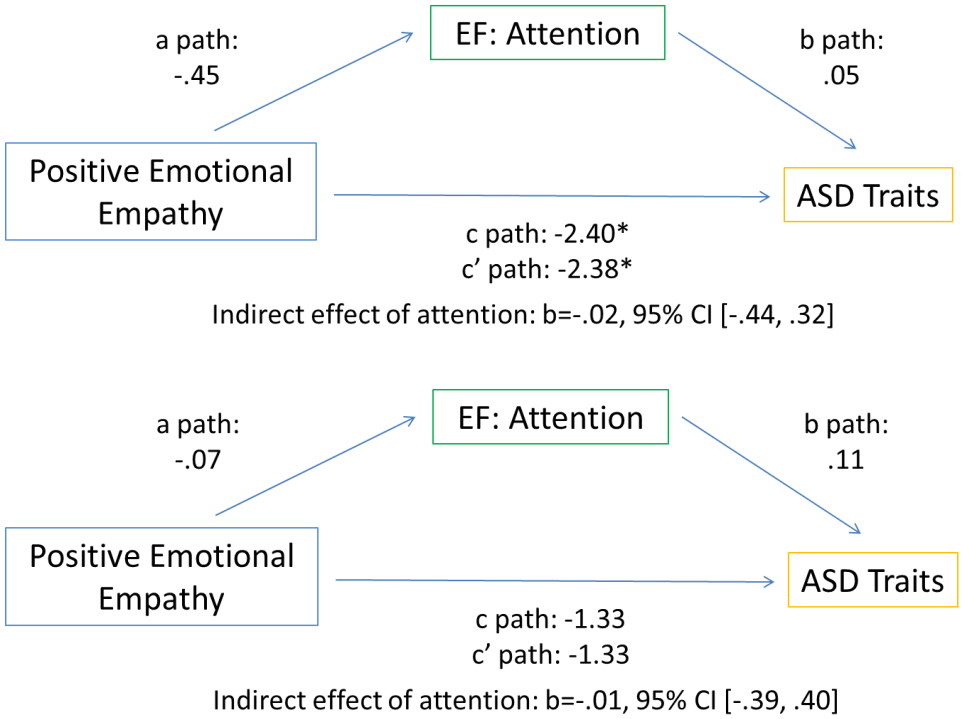

Figure 6. Results for Hypothesis 2A

Note. Top model shows results for self-reported empathy, and bottom model shows results for observed empathy.

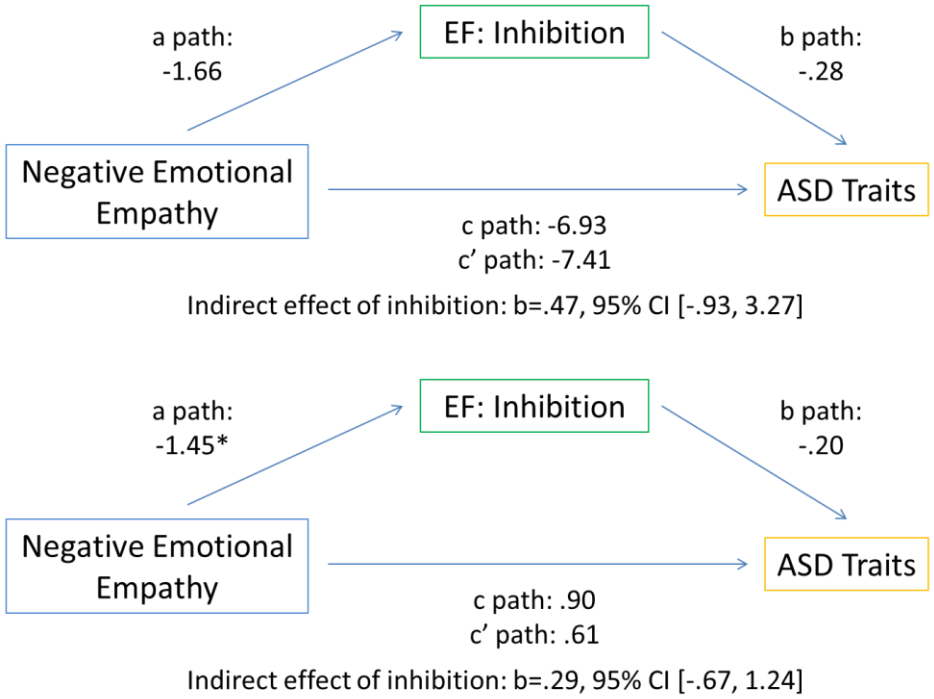

Figure 7. Results for Hypothesis 2B

Note. Top model shows results for self-reported empathy, and bottom model shows results for observed empathy.

4 DISCUSSION

The current study sought to clarify the relationships among empathy, EF, and ASD traits, and to test the assertion that EF explains the relationship between empathy and ASD traits in a NT sample of adults. Given the notion that ASD traits are present in the general population to varying degrees (Constantino, 2011), are normally distributed even in those without ASD (Baron-Cohen, Wheelwright, Skinner, et al., 2001), and may be continuously associated with other cognitive variables, it is helpful to consider the relationships among these various domains in individuals without ASD.

Mediation by EF was not supported across empathy domains; potential explanations for this lack of mediation are discussed below. However, some notable findings emerged in the relationships among individual domains, particularly between positive emotional empathy and ASD traits.

4.1 Eliciting positive emotional empathy

The method of this study successfully elicited both self-reported and observed positive empathy in individuals observing positive events, in contrast with previous studies (Morelli et al., 2015). In particular, studies that involve observation of adults' positive empathic responses tend to involve the participant in manipulations, such as having the participant self-disclose feelings to their partners (Gable et al., 2006; Maisel, Gable, & Strachman, 2008). However, the personal nature of this exercise is likely to impact an individual's personal affect regarding themselves, rather than mainly to elicit an empathic response to an outsider's experience. Also, it is difficult to administer this type of task reliably, as participants are driving the interactions and are likely to do so in variable ways. Other studies that measure positive empathy depend on self-report measures of empathy in individuals' daily lives, rather than on elicited empathy (Morelli et al., 2015). Therefore, it is meaningful that positive empathy was elicited successfully in the current study for individuals uninvolved in the situation.

Success in eliciting positive emotional empathy in the current study supports the use of this paradigm in additional studies of positive empathy. Not only did it successfully result in observed positive

empathy for uninvolved observers of the video clips, but the observed intensity of emotional empathy correlated with self-reported emotional empathy both during the task and on a measure of positive empathy in daily life. Therefore, the task provides a method of eliciting positive emotional empathy that is easy to reliably administer and that can simply be viewed by participants.

4.2 Hypothesis 1: Relationships among cognitive empathy, executive functioning, and ASD traits

The first hypothesis considered the role of working memory and cognitive flexibility as mediators of the relationship between cognitive empathy and ASD traits in NT adults. None of the paths of the proposed model were significant, and neither executive functioning variable mediated the relationship between cognitive empathy and ASD traits as hypothesized.

There are a few potential explanations for the lack of a relationship between cognitive empathy and ASD traits in the current study. The first possible explanation is that the majority of studies identifying impaired cognitive empathy in relation to ASD involve a comparison between an ASD group and a non-ASD group (Castelli et al., 2002; Dziobek et al., 2008; Kleinman et al., 2001; Rogers et al., 2007), although a few have found a relationship between cognitive empathy and ASD traits on a continuum (Golan et al., 2007; Rot & Hogenelst, 2014). Therefore, it is possible that comparison of those with high ASD traits (i.e., an ASD group) to those with low ASD traits (i.e., a non-ASD group) would yield a difference in cognitive empathy using the methods of the current study. However, current views on ASD suggest that symptoms lie on a continuous spectrum, and that a categorical cutoff is less appropriate (Constantino, 2011). This theory would imply that even in the current sample, in which participants have low levels of ASD traits, an association with cognitive empathy should be detectible. Consistent with this theory, one group (Gökçen et al., 2016, 2014) found an inverse relationship between ASD traits and ToM in a non-ASD adult sample. However, this finding has not been supported by additional studies. Therefore, additional explanations for the lack of this relationship in the current study are considered.

The majority of the literature establishing a relationship between cognitive empathy and ASD traits focuses on children. It is possible that cognitive empathy is more impaired in individuals with ASD in childhood than in adulthood. Specifically, individuals gain more experiences with social interactions as they age, which may contribute to reduced cognitive empathy deficits as they age. Therefore, it is possible that the relationship between cognitive empathy and ASD traits diminishes into adulthood. There is some evidence that empathic deficits decrease with age in individuals with ASD (McGovern & Sigman, 2005; Scheeren, Koot, Mundy, Mous, & Begeer, 2013), and that adolescents with ASD with intact IQ show intact cognitive empathy (Downs & Smith, 2004). Although longitudinal studies thus far have focused on progression through childhood, rather than from childhood into adulthood, it is possible that this pattern continues into adulthood.

In addition to the lack of a relationship between cognitive empathy and ASD traits, cognitive empathy was not associated with working memory or cognitive flexibility. This relationship had been hypothesized based on findings of similar associations in adults in previous studies (Lin et al., 2010), impairments in both these EF domains and cognitive empathy without direct comparison in previous studies (Holdnack et al., 2011; Ozonoff et al., 1991), and the theory that these executive skills are important to cognitive empathy (Carlson & Moses, 2001; Senju, 2012). However, due to limited research in this area, only a few studies have directly found cognitive empathy to be related to working memory (Lin et al., 2010) and to cognitive flexibility (Gökçen et al., 2016). Therefore, it is possible that these particular executive skills are individually less important to cognitive empathy in adults than previously believed.

However, performance on the Tower Test, a measure of planning that incorporates multiple executive skills including attention, working memory, inhibitory control, and cognitive flexibility, was positively correlated with cognitive empathy. This finding was reported in another study involving a sample of NT adults (Gökçen et al., 2016). Successful performance on this task may suggest that the sum of these executive parts is greater than each individual executive subdomain in isolation, and at least in

adults, this synergistic role of various executive subcomponents may be what is associated with cognitive empathy.

This finding could help to explain why literature on cognitive empathy in individuals with ASD does not always identify impairments. It is possible that recognition of another person's empathic state is not the core impairment, but ability to generate, organize, and plan an appropriate response to their emotional state is the core impairment. This finding is consistent with Frye's (Frye, Zelazo, & Palfai, 1995) theory that ToM depends on ability to reason based on rules *and* ability to plan deliberate action. However, this relationship should be explored in future studies as mediation was not supported in the current study.

4.3 Hypothesis 2A: Relationships among positive emotional empathy, attention, and ASD traits

Attentional ability was examined as a mediator of the relationship between positive emotional empathy and ASD traits. In this model, attention did not partially mediate the relationship when considering either self-reported or observed positive emotional empathy. Although research on the relationship between positive emotional empathy and EF has been very limited, prior studies have found that positive affect tends to enhance attentional skills, suggesting that these abilities may be interrelated (Fredrickson & Branigan, 2005; Goschke & Bolte, 2014). However, a measure of basic attention was used in the current study, in contrast to more complex attentional skills examined in the previous studies. For example, Fredrickson and Branigan (2005) considered the influence of positive affect on a measure of attention to global versus local details, with the suggestion that positive affect would broaden attention to focus on global details. It is possible that a task such as this, or one involving more complex aspects of attention such as divided attention, would have been associated with positive empathy in the current study. In particular, perhaps a minimal level of basic attention is required to be available to be affected by positive empathy, but once this minimal level of basic attention is achieved, it is no longer associated with empathy.

Although the relationship was not mediated by attention, self-reported positive emotional empathy predicted ASD traits, such that higher levels of empathy were associated with lower levels of ASD traits. In addition to these findings on a behavioral task, higher levels of self-reported positive emotional empathy in one's daily life was moderately correlated with lower levels of ASD traits. This is a novel finding, likely because the majority of previous studies did not examine positive and negative emotional empathy separately when considering a relationship with ASD traits, and only about half of them found emotional empathy to be impaired in an ASD group (see Table 1). It is possible that these studies did not find differences between the ASD and non-ASD groups because they combined positive and negative empathy, which are likely to be experienced differently (see Section *1.3.2*).

Those studies that did find a difference in emotional empathy between adults with and without ASD did not examine the continuous relationship between ASD traits and empathy (Mathersul et al., 2013; Schulte-Rüther et al., 2014), although group comparisons would suggest that higher ASD traits (i.e., an ASD group) may correspond to lower empathy scores. In contrast, Mazza and colleagues (2014) found that a small sample of adolescents with ASD did not demonstrate impaired positive empathy in response to static images of individuals looking happy. Results in the current study are thought to better reflect positive emotional empathy due to the more naturalistic and engaging nature of the video clips compared to static images.

This inverse association is consistent with the theoretical role for positive emotional empathy involvement in ASD symptomatology. The AQ is based on DSM-IV (APA, 1994) criteria for autistic disorder, involving the classic triad of social, communication, and restricted, repetitive, and stereotyped interests and behaviors (RRB; Baron-Cohen et al., 2001). Some symptoms seem as though they would be impacted by positive empathy in particular. For example, one of the social symptoms is "A lack of spontaneous seeking to share enjoyment, interests, or achievements with other people" (APA, 1994). This symptom speaks specifically to limited positive engagement with others, an impairment of which could

be driven by impaired positive empathy. Furthermore, impaired ability to sustain conversations and continuous engagement in RRB may be impacted by positive empathy. If individuals experience a reduced ability to feel another person's positive emotions, they are less likely to be reinforced by another person's positive emotions and thus less likely to engage in conversations that interest the other person or do activities related to another person's interests.

4.4 Hypothesis 2B: Relationships among negative emotional empathy, inhibitory control, and ASD traits

Inhibitory control was not a significant mediator of the relationship between negative emotional empathy and ASD traits. As discussed above, this negative finding may relate to the empathy stimuli, which provide more opportunities to elicit positive empathy than negative empathy. This could explain why previous findings indicating that inhibition mediates the relationship between empathy and interpersonal functioning (Iacono et al., 2015) are inconsistent with the current study. Furthermore, the empathy variable used in the mentioned study was a self-report measure of general empathy (EQ), rather than empathic responses to negative stimuli as in the current study. The outcome variable was also interpersonal functioning, which while related to ASD traits is not identical to ASD traits. Therefore, differences in methods between the current and the previous study may help to explain the difference in findings.

However, it is most likely that inhibitory control was not a mediator in the current study because negative emotional empathy was not associated with ASD traits to begin with. As discussed above (see *4.3.1*), negative emotional empathy was not associated with ASD traits, whereas positive empathy was associated with ASD traits. Two studies (Dziobek et al., 2008; Rogers et al., 2007) found (primarily negative) emotional empathy scores to be similar for adult groups with and without ASD. Authors indicated that this was consistent with anecdotal reports that individuals with ASD often do demonstrate caring for distressed individuals, and that perhaps individuals with ASD have been considered to have impaired

empathy because their responses to emotion are different than expected due to flattened affect and social anxiety. Therefore, it is possible that negative emotional empathy may not be associated with ASD traits, although this requires further investigation.

Nevertheless, higher observed negative emotional empathy was associated with lower levels of inhibitory control, which was in the opposite direction than hypothesized. It had been proposed that reduced negative empathy would be associated with reduced ability to inhibit one's *own* negative experience in response to another person's experience (i.e., resulting in greater personal distress). The current findings highlight a potential alternative relationship; such that reduced inhibitory control may relate to greater ease of comprehension and felt experience of someone else's emotional state (i.e., more akin to emotional contagion). In other words, one with reduced inhibitory control may be more prone to being impacted by and producing automatic responses to negative stimuli than one who is better able to inhibit these automatic responses. This finding is consistent with Iacono and colleagues' (2015) suggestion that reduced inhibitory control may relate to reduced ability to suppress responses to emotional stimuli in one's environment.

4.5 Self-reported versus directly observed emotional empathy

It is notable that self-reported and observed emotional empathy were not strongly correlated. In the current study, participants were made aware that their faces were being recorded while they watched videos and that these recordings were going to later be coded by an examiner. It is possible that knowledge of their being observed influenced their emotional expression. A well-established theory of social psychology, the evaluation apprehension theory (Cottrell, 1972), suggests that individuals may perform differently on tasks when they feel that another person is evaluating them. Similarly, one may behave in a way that they believe to be socially desirable (Koritzky & Yechiam, 2010), which in this case would be to emote either more or less than one typically would in response to emotional content. As discussed above, individuals with high levels of inhibitory control may be better able to inhibit responses

to emotional stimuli. Indeed, Ekman (1993) has suggested that individuals' facial expressions do not always reflect their emotions. Taken together, it is possible that self-reported emotion provided a more accurate reflection of how the individual was feeling in the current study.

4.6 Executive functions and ASD traits

Relationships between executive functions and ASD traits are discussed separately, as they apply to multiple models discussed above. In the current study, ASD traits were not significantly associated with any EF domain assessed. The lack of a relationship between EF and ASD traits in this study has a few possible explanations.

The current study used a sample that fell well below the ASD cutoff on the AQ. As mentioned above, most studies concerning this topic compare EF skills in an ASD group to a NT group to indicate impairments. It is possible that an association between these domains exists at impaired levels of EF. Furthermore, the current sample was primarily an undergraduate student sample, which selects for educated, often high achieving, and typically intelligent participants, rather than a more generalizable sample. Although there have been mixed findings regarding the relationship between intelligence and EF (Friedman et al., 2006; Jurado & Rosselli, 2007), successful engagement in higher education is likely to be supported by strong EF skills such as attention, working memory, planning, and organization. Therefore, it is possible that the lack of an association between EF and ASD traits is driven by the sample having the combination of both strong EF skills and low levels of ASD traits.

Additionally, it is possible that a variable integrating the important components of various EF domains, such as a latent class variable, would be associated with ASD traits, and that dividing EF up into different domains reduced power for identifying associations. Finally, the measure of ASD traits used in the current study was based on self-report. Although the AQ is well validated and widely used, it is possible that a behavioral measure of ASD would be more strongly associated with the behavioral EF measures used in the current study.

4.7 Summary

Although the mediations in the current study were not supported, positive emotional empathy was inversely associated with ASD traits, whereas cognitive empathy was not associated with ASD traits, in this sample of neurotypical adults with a restricted range of ASD traits that did not approach clinical significance. This is a novel finding that suggests future efforts should focus on the potential importance of positive emotional empathy in relation to ASD traits. Previous research has not examined the relationship between positive emotional empathy and ASD traits. However, findings from the current study indicate that reduced ability to demonstrate an empathic response to others' positive emotions is likely to be associated with relatively higher levels of ASD traits, even in a neurotypical sample. This finding is consistent with ASD symptoms that are likely to be associated with positive empathy specifically, such as a lack of seeking to share enjoyment with others. Furthermore, cognitive empathy was positively associated with planning ability on a complex EF task, which suggests that the integration of multiple executive skills is likely important to successful cognitive empathy.

4.8 Limitations

The current study has several limitations that should be considered when interpreting findings. Most notably, the sample used in the current study is an undergraduate population. As mentioned above, this sample reduces generalizability of findings to the general population (Gallander Wintre, North, & Sugar, 2001). Furthermore, the relatively small sample limited the opportunity for inclusion of covariates and multiple mediator models.

Another limitation of the study is that the sample was made of up mostly females. Although there were no significant differences between males and females on any tasks in the current study, the sex ratio does not reflect that found in individuals on the autism spectrum. In particular, males are four times more likely to be diagnosed with ASD than females (Baio et al., 2018). Furthermore, Baron-Cohen (2011) has even suggested that ASD reflects overrepresentation of traditional male characteristics due

to possible biological influences, and that this explains why ASD is more common in males. Although Mandy and colleagues (2018) found that males had higher levels of ASD traits in childhood but that this difference disappeared by adolescence, it is possible that the sample in the current study does not accurately reflect ASD traits found in the general population due to overrepresentation of females.

Furthermore, the stimuli used to elicit emotional empathy provided more numerous opportunities to evoke positive than negative empathy. This is because although the video clips used as the empathy measure include evidence of the devastating impact of a storm on a charitable woman's home and her life, they focus primarily on the positive impact of the remodeling of her home on her life and on those she helps in the community. Although this is a strength of the study in terms of eliciting a robust positive response in participants, this weakened the interpretability of negative empathy findings.

4.9 Future Directions

The current findings would benefit from replication with a larger sample that is not majority undergraduate, and with use of a task that better measures negative emotional empathy. This replication would lend support for greater research and clinical emphasis on positive than negative emotional empathy in relation to ASD traits. Additionally, it would be interesting to investigate the hypotheses from the current study using a cognitive empathy measure that is less dependent on emotion recognition and instead involves more strictly cognitive mental state attribution, such as the Faux Pas Test. Furthermore, the finding that planning is associated with cognitive empathy warrants further exploration. For example, causal relationships between these variables should be examined in order to identify additional intervention targets for improving cognitive skills across ASD.

Overall, these findings highlight the importance of examining positive and negative emotional empathy separately in future research of empathy in various populations, an occurrence which has been very rare in previous studies. Findings also indicate that although the focus of ASD research has been

primarily on cognitive empathy impairments, emotional empathy and particularly positive emotional empathy is an important area for focus in future research of ASD.

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