ATTENTIONAL PROCESSES IN YOUTH WITH ASD AND CO-OCCURRING ANXIETY

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ABSTRACT

Prior research suggested that attentional control plays a role in the development and maintenance of anxiety disorders in youth. Research also suggests that youth on the autism spectrum suffer from difficulties in executive functioning, including attentional control. The current study investigated the relationship between attentional control and autism spectrum symptoms. The relationship between attentional control, anxiety, and emotion regulation skills was also explored. Participants were 76 treatment seeking youth between the ages of 7 and 17 (M_{age} = 11.05, SD = 2.99) who met diagnostic criteria for an anxiety disorder and had either minimal symptoms of autism spectrum disorder or severe levels of autism symptoms. Results failed to find evidence that those with severe autism symptoms had more attentional control difficulties than those with minimal autism symptoms. The results also failed to show a link between anxiety levels and attentional control variables, as well as a link between emotion regulation and attentional control. Consistent with previous research, poor emotion regulation skills were correlated with higher levels of anxiety. Potential reasons for lack of significant findings are discussed, as well as implications for the present data on current research.

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CHAPTER 1

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Attentional Processes in Youth with ASD and Co-Occurring Anxiety

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterized by impaired communication and social functioning, as well as the presence of restricted, repetitive behaviors, interests, or activities (American Psychiatric Association [APA], 2013). The autism spectrum is becoming recognized as a common neurodevelopmental condition; prevalence studies now estimate that 1 out of every 68 children, or 1 in 42 boys and 1 in 189 girls, are affected. Within this population, the rate of comorbidity is high. In an epidemiological, population-derived sample, Simonoff et al. (2008) found that 71% of children with ASDs had at least one comorbid disorder. Anxiety disorders are among the most common comorbid disorders. Indeed, the majority of studies find that among youth with a primary diagnosis of ASD, lifetime prevalence is between 42% to 79%, with variability due to methodological and sample differences (Kent & Simonoff, 2017). These rates are markedly higher than prevalence rates in the general population, which is estimated to have a lifetime prevalence of 8.3% – 27% (Costello, Egger, & Angold, 2005).

In typically developing children, anxiety is associated with numerous negative functional outcomes (Swan & Kendall, 2016). Using a tool designed to assess for functional impairment in youth with anxiety disorders, it has been demonstrated that anxiety interferes across familial, social, and school domains (Langley, Bergman, McCracken, & Piacentini, 2004). Studies of children whose anxiety goes untreated

found the anxiety to be related to negative outcomes later in life, such as continued anxiety, depression, drug dependence, and poor academic achievement (Benjamin, Harrison, Settipani, Brodman, & Kendall, 2013; Woodward & Fergusson, 2001).

There is emerging evidence to suggest that anxiety is also associated with negative symptoms in children with ASD, even above those typically associated with ASD. Socially, anxiety is associated with impairment in social abilities. In children with an average IQ (> 70), increased anxiety was related to greater impairments in social reciprocity (Sukhodolsky et al., 2008) and to poor social skills in general (Bellini, 2004). Anxiety is also related to the presence of gastrointestinal problems and sensory over-responsivity (Mazurek et al., 2013) as well as increased family discord (Kelly, Garnett, Attwood, & Peterson, 2008). Given the functional impairments due to anxiety in the ASD population, perhaps even above that of anxiety in the typically developing population, efforts to understand anxiety within the content of ASD are crucial.

Cognitive Models of Anxiety

Attentional biases. In seeking to understand the development and maintenance of anxiety in youth with ASD, models developed to understand anxiety in the general population provide a useful starting point. Multiple cognitive models of anxiety suggest that a biased processing of threat causes and/or maintains anxiety (e.g., Bradley et al., 1997; Eysenck, Derakshan, Santos, & Calvo, 2007), and it has been argued that the influence is moderated through facilitated attention to threat. Research with adults and children has found that anxious individuals (including both diagnosed cases and those with elevated anxiety) show an attention bias towards negative and threatening information, whereas non-anxious individuals do not. Attentional biases have been

demonstrated in the adult literature (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), but findings in the child literature have been mixed. Whereas some studies have failed to find evidence of these attention biases (for a review see Bar-Haim et al., 2007; Puliafico & Kendall, 2006), multiple studies with larger sample sizes and inclusion of wider age ranges provide evidence that youth also demonstrate these attentional biases towards threat (e.g., Abend et al., 2018; Waters, Henry, Mogg, Bradley, & Pine, 2010).

To date, however, only three studies have pursued this line of research in anxious, ASD populations. Using a traditional dot-probe task, Hollocks, Ozsivadjian, Matthews, Howlin, and Simonoff (2013) found that children with ASD and anxiety did not show an attentional bias toward threating stimuli, as is frequently observed in the general population. They examined attentional biases towards threat-related words and faces and were unable to find evidence that, across the sample, there was a threat bias. These results should be interpreted with caution, however. Although the children with ASD were found to have elevated levels of anxiety on parent-report measures of anxiety, this was not independently evaluated using a structured interview for anxiety. Another study also used a dot-probe task to measure attention biases in anxious, ASD youth (May, Cornish, & Rinehart, 2015). These authors also failed to find evidence of a bias toward threatening stimuli in the ASD youth; however, this study also carries with it the same limitations of the Hollocks et al. (2013) study.

More recently, the authors of the first study described above completed a similar study; however, they instead used a semi-structured interview to confirm the presence of an anxiety disorder (Hollocks, Pickles, Howlin, & Simonoff, 2016). In this sample of

ASD youth with and without an anxiety disorder, they found that youth with both showed an attentional bias toward threatening faces. This finding was not observed for happy faces. Additionally, the bias towards threatening information was not found in their control sample of typically developing youth. As part of their study, they also collected information about physiological measures previously found to be associated with anxiety in ASD youth (cortisol levels and heart rate response during a social stress paradigm; Hollocks, Howlin, Papadopoulos, Khondoker, & Simonoff, 2014). The authors demonstrated that attentional biases are independently related to anxiety severity, as were physiological measures. This study provides one of the first examinations to show that similar cognitive mechanisms that are hypothesized to be involved in the development and maintenance of anxiety disorders in typically developing youth also hold for youth with ASD.

Attentional control. Although there is considerable variation in proposed models of information processing in anxiety (Mogg & Bradley, 2016), attentional control is often implicated in various stages of cognitive processes. Attentional control is a multifaceted construct that includes the ability to inhibit dominant attentional responses, shift attention, and update working memory (Bardeen & Orcutt, 2011). There are multiple lines of evidence that support the hypothesis attentional control is both strongly related to anxiety.

In an early influential study, Derryberry and Reed (2002) found evidence to suggest that attentional control moderated the relationship between anxiety and bias for threat-related stimuli. Individuals with poor attentional control and high trait anxiety had difficulty disengaging from threat-related stimuli at longer delays, whereas those with

high trait anxiety, relative to the sample median, and good attentional control were better at shifting their attention away from the threat-related stimuli. These lines of research work have since been studied within populations of individuals who meet diagnostic criteria for anxiety disorders.

In a study with adults, those diagnosed with an anxiety disorder were found to have impaired attentional control, relative to a healthy control population (Pacheco-Unguetti, Acosta, Marquis, & Lupiánez, 2011). They were found to be impaired in their ability to ignore distracting information in a flanker task. This finding is likely related to the top-down process of voluntary control of attention, and it may underlie the cognitive difficulties reported by adults with anxiety (i.e., distractibility, rumination). Further supporting the aforementioned interpretation, the authors also found that those with a diagnosed anxiety disorder have increased difficulty in shifting their attention away from an object that captured their attention. Similar to the finding of Derryberry and Reed (2002), the results here provide further support to the hypothesis that attentional control is one of the specific mechanisms involved in anxiety disorders.

The attention bias modification literature is related to research into the relationship between attentional control and anxiety. Although these types of paradigms initially demonstrated favorable results (Amir, Beard, Burns, & Bomyea, 2009), later reviews of these paradigms found that they are not as effective as initially thought (MacLeod & Clarke, 2015). Despite the inconsistent results, emerging evidence suggests that cognitive control plays a role in these types of interventions. Using a shortened version of an attention bias modification procedure (e.g., training individuals to develop a bias toward negative stimuli or to develop a bias away from negative stimuli), Basanovic &

MacLeod (2017) explored the relationship between magnitude of change on these training paradigms and attentional control. Attentional control was measured using two behavioral paradigms that examined the cost to inhibit responding to visually salient stimuli and the time taken to shift attention from one stimulus to another. They found that individual differences across both measures of attentional control were associated with the change in attentional bias. Importantly, this was found across both training conditions. As the authors state, the results both suggest that training of attentional control is a component of attention bias modification training and provide further evidence that attentional control is an important construct to consider when examining anxiety.

The failure of attentional bias modification intervention has spurred research into other types of attention bias modification training procedures, some of which have focused on training top-down processes related to attentional control. For example, some of these interventions have instead focused on training individuals to search for positive stimuli while ignoring negative stimuli. Such an approach has some beneficial effects (Waters et al., 2015; Waters, Zimmer-Gembeck, Craske, Pine, & Mogg, 2016) and lends support to the importance of attentional control in anxiety disorders.

Attentional control abilities have also been examined outside of the context of attentional biases, such as in Attentional Control Theory. At its core, attentional control theory states that anxiety impairs multiple cognitive processes, including the efficiency of the central executive, inhibition functioning, and shifting functioning (Eysenck et al., 2007). Such an approach would suggest that difficulties in attentional control follow

from anxiety, rather than cause anxiety per se. However, such an account is not necessarily counter to the idea that deficits in attentional control precede anxiety causally.

Taking a different approach, some researchers have shown that anxiety is associated with domain general dysfunction in attentional control. Bishop (2009) performed an fMRI study that showed that individuals with high trait anxiety have reduced recruitment of the dorsolateral prefrontal cortex, an area of the brain that is believed to be important for attentional control. Importantly, they found this to be the case only when the task demands were low such that the primary task did not occupy full attentional resources. Bishop used her evidence to suggest that poor attentional control may be a type of processing style or deficit that could underlie anxiety, threat-related biases, and "more general, day-to-day problems in concentration and work-related cognitive function" (Bishop, 2009, p. 97).

Lastly, attentional control has been implicated in processes that are related to anxiety, such as emotion regulation. Emotion regulation is a broad concept that involves multiple components, including the ability of an individual to modulate one's emotional experiences and use various emotion regulations strategies (Gross, 1998). Multiple studies have shown that attentional control is an important component of this broad skill. For example, in a recent study examining self-report of attentional control, O'Bryan, Kraemer, Johnson, McLeish, and McLaughlin (2017) found that individuals with better emotional control were better able to engage in goal-directed behavior when experiencing negative emotions. Greater attentional control has also been found to be related to one's propensity to engage in rumination and, in turn, higher symptoms of internalizing disorders (Mills et al., 2016). Studies such as these show that there are multiple pathways

through which attentional control might exert an influence over the development and maintenance of anxiety.

Cognitive Control in ASD

Importantly, individuals with ASD have been found to have dysfunction in many areas of cognitive functioning that are associated with attentional control (Hill, 2004). For example, children on the spectrum have been found to have difficulty in shifting attention. Evidence for this comes from difficulties making conceptual shifts in tasks such as the Wisconsin Card Sorting Task and the Intra-dimensional / Extra-dimensional shift (ID/ED) of the CANTAB (Hill, 2004; Ozonoff et al., 2004). Individuals with ASD also have difficulty in resisting distractor influence, as measured by tasks such as the Flanker task (Geurts, van den Bergh, & Ruzzano, 2014; Hill, 2004).

Although individuals with ASD are understood to have impairments in various aspects of executive functioning, the literature has produced mixed findings when examining constructs that are core to attentional control. For example, researchers have looked closely at one aspect of attentional control: the ability to shift attention away from a stimulus that has captured attention. Whereas some research has found evidence to suggest this ability is impaired in ASD youth, some have not. These studies have typically used the Gap-Overlap paradigm, a measure of visual attention which provides an index of the latency to begin an eye movement from a centrally presented stimulus to a new stimulus presented in the periphery (e.g., a saccade). There are overlap trials, in which the centrally presented stimulus remains in view as the novel, peripheral stimulus is presented. There also are gap trials, in which there is a temporal gap between the centrally presented stimulus and the presentation of the novel, peripheral stimulus.

Although several studies using the Gap-Overlap paradigm have shown that youth with ASD show difficulties in disengaging attention (Landry & Bryson, 2004; Sabatos-DeVito, Schipul, Bulluck, Belger, & Baranek, 2016), many have not been able to replicate these findings. Across the studies that did demonstrate a specific deficit in attentional disengagement, the use of dynamic, colorful stimuli was common (e.g., Elsabbagh et al., 2009; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). In contrast, the stimuli across the other experiments uses static stimuli of either pictures (e.g., faces or objects; J. Fischer, Koldewyn, Jiang, & Kanwisher, 2013) or simple shapes (e.g., "x" or boxes; Goldberg et al., 2002; Todd et al., 2009). It may be that these simple shapes did not capture attention in the same way that dynamic, colorful stimuli do. Looking at the pattern of results across these studies also reveals an interesting pattern. There was evidence of widespread attentional impairment when simple stimuli were used. There was no evidence of attentional impairment when common stimuli were used, such as faces, cars, and other objects. But when dynamic stimuli were used, there was evidence for a deficit in attentional disengagement in ASD youth. Only one study to date has examined static versus dynamic stimuli within the same participants (Sabatos-DeVito et al., 2016), and they found that youth with ASD showed a greater deficit to disengage attention when presented with dynamic stimuli that also included an auditory sound, but they did not find any specific differences in the ASD group between static and dynamic stimuli attentional disengagement. However, it must be noted that there was an overall effect of group on analysis of reaction times of attentional disengagement, with the ASD group showing slower latencies compared to the other groups. It may be the case that those with ASD have more difficulty disengaging their attention from dynamic stimuli because they capture

the attention of ASD youth more than typically developing or other developmentally disabled youth. Attentional disengagement may not be a generalized deficit, but children with ASD may have difficulty disengaging attention under certain conditions, such as when presented with stimuli that have visual properties that more strongly capture attention.

Present Study

Across multiple domains, the literature supports the idea that attentional control is related to anxiety. Attentional control, along with other executive functioning domains, is believed to be impaired in youth with ASD. Taken together, these lines of research suggest a possible pathway through which we can understand why there are higher rates of anxiety in ASD. However, no research to date has examined the role of attentional control in anxious youth on the autism spectrum.

The present study examined the relationship between attentional control and anxiety in youth with elevated symptoms of ASD and without symptoms of ASD. Given that autism is a spectrum disorder, the study included typically developing children who have elevated autism symptoms and those with a formal diagnosis of ASD. It is hypothesized that anxious youth with high ASD symptoms will show greater deficits in attentional control than anxious youth with low ASD symptoms, specifically mechanisms that allow for flexible shifting of attention and mechanisms that allow for the suppression of irrelevant information. It is also hypothesized that dysfunction in these attentional control mechanisms will be related to the severity of anxiety symptoms such that greater attentional control impairment will be related to more severe anxiety. An exploratory aim of the current study is to explore whether attentional control mechanisms moderate the relationship between emotion regulation, specifically emotional lability and

demonstrations of negativity, and anxiety, given the relationship between attentional control and emotion regulation skills.

Method

Participants

Participants were drawn from a sample of 114 youth (M = 11.02 years, SD = 3.06). Data were collected from two sites, the Child and Adolescent Anxiety Disorders Clinic (CAADC) at Temple University and The University of South Florida (USF). Participants from the CAADC primarily came from those who were referred for outpatient treatment. Referrals came from multiple sources in the community, including school counselors, pediatricians, and other parents. A small subset of patients (n = 8) were drawn from a multisite RCT conducted at the CAADC and USF. These families were similarly referred for outpatient treatment through a study examining two different psychotherapies to treat anxiety in an ASD population. Youth and their parents participated in the current study during their initial assessment, prior to the initiation of treatment. Families were included in the study if youth (a) were been between 7 and 17 years of age at the time of the initial assessment, (b) met DSM-IV diagnostic criteria for an anxiety disorder (social anxiety disorder, generalized anxiety disorder, social phobia, specific phobia, obsessive compulsive disorder, posttraumatic stress disorder, or Anxiety Disorder- Not Otherwise Specified), and (c) read and spoke English and had at least one English-speaking parent. Youth were excluded from the present study if they (a) were diagnosed with a principal disorder other than an anxiety disorder, or (b) had vision problems (i.e., blindness in one or more eyes). Based on these criteria, 11 youth were excluded from data analyses because the structured diagnostic interviews completed in the initial intake. These

excluded youth were determined to have a non-anxiety principle disorder (e.g. major depressive disorder or oppositional defiant disorder. Youth were not excluded due to the presence of non-principal comorbidities to increase external validity of the study (i.e., anxiety disordered youth often have multiple comorbid disorders; Kendall et al., 2010). Youth were not excluded on the basis of sex, ethnicity, or SES.

The sample used in data analysis included 76 youth who were found to have high and low scores on measures of autism severity. Mean age for the entire sample was 11.05 years (*SD* = 2.99), and the majority was female (60.5%). The majority identified as Caucasian (81.6%), followed by Black (6.6%), Asian (5.3%), Hispanic (2.6%), and Other (3.9%). Parents reported their families' total household income as $0-19,999 (2.6%), $20,000-39,000 (6.5%), $40,000-59,000 (15.8%), $60,000-79,000 (9.5%), and over $80,000 (56.6%); 9.2% did not report an estimate of household income.

The most common disorder observed in the sample was Generalized Anxiety Disorder (68.4%), followed by Social Phobia (47.4%), Specific Phobia (44.7%), Separation Anxiety (26.3%), Anxiety NOS (1.3%), and OCD (1.3%). The majority of the sample (72.4%) met criteria for two or more anxiety disorders. Additionally, several participants met criteria for non-anxiety disorders. ADHD was the most common (17.1%), followed by ODD (6.6%), and MDD (1.3%). Diagnoses were made during the interviews based on Clinical Severity Ratings (CSR) as given by the assessing clinician. A minimum CSR of 4 on the 9-point scale (0-8) is required for a diagnosis; ratings below 4 denote subclinical difficulties.

Regarding ASD, participants were separated into two groups: Low ASD and Severe ASD. These groups were made using scores on the Social Responsiveness Scale, a

questionnaire to assess ASD symptoms (see below for more information). The Low ASD group (n = 50) had T-Scores that are indictive of a low level of ASD-related symptoms. The Severe ASD group (n = 26) had T-Scores that are indicative of a severe level of ASD-related symptoms. Of the 26 participants in this group, 8 had a diagnoses of ASD confirmed with a structured interview for ASD symptom (see below for more information).

Clinician Measures

Anxiety Disorders Interview Schedule for Children (ADIS-C/P). Children were evaluated for the presence of an anxiety disorder using the ADIS-C/P (Silverman & Albano, 1996), a semi-structured interview for diagnosing anxiety and other DSM-IV-TR disorders (APA). The ADIS-C/P has demonstrated high -interrater reliability (kappa = .80 - .92, Lyneham, Abbott, & Rapee, 2007), favorable psychometric properties (March & Albano, 1998), and convergent validity (Wood, Piacentini, Bergman, McCracken, & Barrios, 2002). Diagnoses used the Clinical Rating Scale (CSR), ranging from 0 (i.e., not at all) to 8 (i.e., a debilitating problem). A CSR of 4 or higher denotes a diagnosis. Diagnoses were made only using the parent interview, given previous evidence that youth with ASD are less reliable in reporting their anxiety symptoms. Parent interviews were conducted by graduate students and postdoctoral fellows. ADIS-IV-C/P training requires the attainment and maintenance of interrater reliability levels of $\geq$.85 (Cohen's K).

Autism Diagnostic Observation Schedule, Second Edition (ADOS-2). The ADOS-2 (Lord et al., 2012) is a semi-structured observational assessment administered directly to the participant to elicit social interaction, use of language, and observe potential restricted or repetitive behaviors. The ADOS-2, Module 3 was the primary tool used to establish a

diagnosis of ASD. The ADOS-2, Module 3 has appropriate sensitivity (.91) and specificity (.84; Gotham, Risi, Pickles, & Lord, 2007). The ADOS was administered to a subset of participants (n = 8) who were recruited in the current study though the multisite RCT. The ADOS-2 was administered by advanced graduate students and a licensed clinical psychologist with specialized training on the ADOS. Advanced graduate students were trained by the licensed clinical psychologist and reached research reliability on this instrument (i.e., 80% agreement in coding observed ADOS administrations and live administrations).

Parent Measures

Multidimensional Anxiety Scale for Children (MASC). The MASC (March, Parker, Sullivan, Stallings, & Conners, 1997) contains 39 items rated on a 4-point Likert scale, with 0 indicating that the statement is "never" true of the child and 3 indicating that the statement is "often" true of the child. The MASC measures a variety of domains, including somatic complains ("My child gets shaky or gittery."), worries ("My child worries about what others think of them."), fear avoidance ("My child stays away from things that upset them.") and other behaviors associated with anxiety ("My child tries to do everything exactly right"). The MASC has been found to have robust psychometric properties (March et al., 1999). In the current study, Cronbach's $\alpha = .90$. The scale assesses for the presence of four factors of anxiety: physical symptoms, social anxiety, harm avoidance, and separation anxiety. The overall MASC score was used.

Social Responsiveness Scale – Parent Version (SRS-P). The SRS-P (Constantino & Gruber, 2005) was used to assess level of ASD symptomatology. The SRS-P is a 65-item questionnaire that measures social deficits characteristic of ASDs. Parents rate their child

on a 4-point Likert scale, focusing on observed aspects of routine, reciprocal social behavior, and preoccupations. The SRS-P can be used to categorize children as demonstrating typical, moderate (T-Scores from 60 to 75), or severe levels of ASD symptomatology (T-Scores greater than 75). Scores in the moderate range are typical of youth with mild or high-functioning ASD and tend to be associated with difficulties in reciprocal social behavior (Constantino & Gruber, 2005). Scores in the severe range, however, are typically associated with a more pronounced presentation of ASD and are accompanied by a severe deficit in social interactions. The SRS-P has demonstrated sound psychometric properties, including higher internal reliability (current study $\alpha = .97$), inter-rater reliability, and test-retest reliability (Constantino et al., 2003). As well, the SRS-P has demonstrated convergent validity with the ASD Diagnostic Interview-Revised (Constantino et al., 2003).

Emotion Regulation Checklist (ERC). The ERC (Shields & Cicchetti, 1997) is a 24-item questionnaire that measures parental perceptions of emotion regulation skills and emotional lability designed to be completed by a caregiver that knows the child well. Respondents answer questions on a 4-point Likert scale, with a "4" indicating that the statement is almost always true of the child. The ERC is divided into two subscales: Emotion Lability / Negativity and Emotion Regulation. The Emotion Lability / Negativity subscale consists of 15 items (some of which are reverse scored), assessing the child's mood swings, anger, and intensity of emotions, and is understood to be a measure of emotion dysregulation. The Emotion Regulation subscale consists of 8 items (some of which are reverse scored), assessing the social appropriateness of the child's emotions, emotion understanding, adaptive regulation, and empathy**.** Both scales show high

construct validity and internal consistency (Shields & Cicchetti, 1997). In the current study, The Emotion Lability / Negativity subscale was used as an index of emotion regulation skills. Internal consistency was found to be high (α = .82).

Computer Tasks

Attention Network Task (ANT). The Attention Network Task (Fan, McCandiss, Sommer, Raz, & Posner, 2002) is a computerized task that measures multiple aspects of attention and has been adapted for use in child populations (Rueda et al., 2004). The child version was used in the current experiment. The ANT was chosen because it had been demonstrated to be a reliable measure of attentional control capabilities in children, even when taking developmental changes into account (Rueda et al, 2004). Each trial begins with a presentation of a centrally located fixation stimuli (i.e., a cross) followed by one of four potential warning cues: no stimuli, a centrally located stimulus (e.g., an asterisk over the cross), a spatial stimulus (e.g., an asterisk above or below the central cross which indicates where the correct position of the main target), or a double stimulus (e.g., asterisks both above and below the central cross). The initial, central stimulus is presented for between 400 and 1600 ms, followed by a 150ms presentation of one of the four aforementioned stimuli. Following the second stimulus, a central target is presented, and participants have to report whether the target is facing right or left via keyboard button press. The target stimulus was presented in one of three conditions: neutral, where the target was presented in isolation; congruent, where the target was flanked with distractor stimuli that were pointing in the same direction; and incongruent, where the target stimulus was flanked by distractor stimuli pointing in the opposite direction. The target stimuli are presented for 1700ms or until the participants makes a response. To

make the task more approachable for youth, the target stimuli are cartoon fish and the child is told they have to "feed" the fish by telling the computer which direction the central fish is facing. The youth get feedback in the form of small bubbles emanating from the fish is the response is correct. No direct feedback is given if the answer is incorrect.

The ANT measures three distinct attention networks (Fan et al., 2002): the alerting network, the orienting network, and the conflict network. The alerting network refers to a general state of being sensitive to incoming information, either in a general state of arousal (e.g. tonic alertness) or during a more transient alert state (i.e. phasic alertness). In the ANT, altering network scores are calculated through subtracting two conditions: reaction time (RT) for trials with no cue – RT for trials with double cues. Thus, this subtraction measures the difference in reaction time when the individual is given a cue that alters them to the trial (but without information about where the target will be) versus when they have no alerting cue at all.

The orienting network refers to the ability to disengage, shift, and reengage attention (Posner & Cohen, 1984). In the ANT, orienting network scores are calculated through subtracting two conditions: RT for central cues – RT for spatial cue trials. Therefore, the orienting network score measures the difference in RT when the participant has been cued to specific central target position (spatial cue) and when the participant does not know the central target position (central cue trials) and has to shift attention to the location of the central target.

The last attention network is the conflict network. Conflict network scores are a measurement of the ability to filter out distracting information. In the ANT, conflict

network scores are calculated through subtracting two conditions: RT for incongruent trials and RT for congruent trials. The conflict network score thus measures the difference in reaction time when distracting information is consistent with the central target stimulus (congruent trials) and when distracting information is inconsistent with the central target stimulus (incongruent trials).

Participants were initially given 24 practice trials, followed by and 144 trials that were used in the final calculation of the attention network variables. Youth were allowed to complete the practice trials again if they appeared to not understand the task instructions. The main task was divided into three blocks of 48 trials. Trials were evenly distributed across all flanker conditions (congruent, incongruent, neutral) and cue conditions (no cue, spatial cue, central cue, double cue). Only trials with correct responses were used in data analysis.

Procedure

Intake procedures varied slightly for those participating in the RCT and those who were not. The current study was approved by the Institutional Review Board at all sites. For those who sought treatment in the standard outpatient clinic in the CAADC, parents were consented, youth were assented, and the intake began. The ADIS-IV-C/P was completed by trained and reliable diagnosticians. Following the administration of the ADIS, parents were asked to complete questionnaires. Youth also completed the child version of the ADIS-IV-C/P. Following this, youth were invited to participate in the computer tasks. For the subset of youth who participated in the RCT, the parent portion proceeded similarly. However, youth in the RCT were not assessed using the ADIS-IV-

C/P. They instead went straight into completion of computer tasks administered as part of the RCT's initial assessment.

Presentation of all computer tasks was conducted in a quiet room on a PC laptop. Participants were seated approximately 50cm from the computer screen (15-inch screen size). The ANT task was programmed and presented using E-Prime® 2.0 (Psychology Software Tools, Pittsburgh, PA; www.pstnet.com). A trained research assistant remained with the youth while they completed the computer tasks. Some study personnel were not blind to study hypotheses; however, they were blind to anxiety severity and presenting concerns for youth. Instructions were read to the participating youth using a standard script. Participant response for both computer tasks required pressing the right and left arrow keys; youth were instructed to keep the pointer finger from each hand on the respective arrow keys. The ANT task took approximately 15 minutes for youth to complete.

Data Analysis Plan

Only youth with complete data on the main variables (i.e., ANT, SRS-P, and MASC) were included. Those with missing data on the ERC were not included in those analyses. This decision was made because data was not missing at random for the ERC, due to technical error during administration of this questionnaire to a specific group of subjects. Of the larger sample of youth, those with SRS-P T-scores in the moderate range were excluded from further analysis. Thus, the final sample included youth with low levels of ASD symptoms or severe levels of ASD symptoms, suggestive of an ASD diagnosis. Chi-Square tests and independent sample t-tests were used to determine if there were

differences between the two groups on demographic variables, comorbidities, or performance variables on the ANT (i.e., overall reaction time).

Each study aim was investigated using either a repeated measures ANOVA or hierarchical multiple regression analysis. To analyze group differences in the Conflict and Orienting Networks, each network was examined separately using a repeated measures ANOVA. Repeated measures included the individual component reaction times for each network (e.g. congruent and incongruent trials for the Conflict Network; spatial cue and center cue for the Orienting Network) along with group status (Low ASD and High ASD). Multiple Regression analysis included severity of ASD symptoms (SRS Scores), severity of parent-reported anxiety (MASC Score), and overall Conflict Network Score or Orienting Network scores.

Results

Preliminary Analysis

In keeping with the design of the ANT task, individual trials were excluded if response time was greater than three standard deviations above mean response time for that subject (e.g., Reinhold-Dunne et al., 2009). Data cleaning was completed because the task allows for indefinite response times and these extreme outliers may indicate trials in which the individual momentarily stopped engaging in the task. No subjects had to be removed due to potential misunderstanding of the task (e.g., 75% or more of trials were incorrect). Preliminary data analysis confirmed that the ANT task performed as expected. For the Orienting Network, there were significant differences between Center Cue trials (M = 708.12, SD = 157.94) and Spatial Cue trials (M = 681.18, SD = 153.71), $t(75) = -5.00$, $p = .00$, $d = -1.16$. For the Conflict Network, there were significant

differences between Congruent Trials (M = 689.79, SD = 152.87) = and Incongruent Trials (M = 771.27, SD = 167.71), $t(75) = -14.71$, p = .00, $d = 3.40$. Prelimary analysis also showed those participants in the high ASD group that came from the RCT (N = 5, in the final sample did not significantly differ on SRS score. Those from the RCT has a mean SRS T-Score of 81.60 (SD = 4.72) and those from the CAADC had a mean score of 84.28 (SD = 5.44), $t(24) = 1.05$ p = .31, $d = .52$).

Demographic factors were not found to be related to child anxiety. Study variables were examined for skewness and kurtosis. Most variables were found to be approximately normally distributed, with the exception of base measures of reaction time on the ANT. These data were log transformed in subsequent analyses, as is common practice with reaction time data. Difference scores calculated using the ANT (e.g., Conflict and Orienting Reaction Time) were found to be normally distributed and thus not transformed. No significant outliers (i.e., more than 3 standard deviations above or below the group mean) in the reaction time data were observed. Means and standard deviations of study variables are presented in Table 1.

Bivariate correlations between study variables are presented in Table 2. Across all participants, attentional control variables were not found to significantly correlated with parent report of child anxiety (Orienting: $r = -.13$, p = .28; Conflict: $r = .19$, p = .10), ASD symptoms severity (Orienting: $r = -.02$, p = .81; Conflict: $r = .21$, p = .07), or emotion regulation skills (Orienting: $r = -.07$, p = .55; Conflict: $r = .19$, p = .10). Child anxiety and severity of ASD symptoms were significantly correlated ($r = .35$, p = .00), as were regulation skills and anxiety ($r = .40$, p = .00).

Table 1

ANT Information by SRS-P Category

Variable	Low ASD (N = 50)	Severe ASD (N = 26)	Significance Test	*p*	Effect Size
Accuracy (% correct)					
Central Cue Trials	.92 (.13)	.93 (.10)	*t*(74) = -.23	.82	.08 (*d)*
Spatial Cue Trials	.94 (.14)	.92 (.08)	*t*(74) = .51	.58	.17 (*d)*
Congruent Trials	.93 (.14)	.94 (.06)	*t*(74) = .12	.91	.09 (*d)*
Incongruent Trials	.90 (.19)	.88 (.19)	*t*(74) = .90	.79	.11 (*d)*
Reaction Time (ms)					
Central Cue Trials	685.06 (141.12)	752.48 (180.00)	*t*(74) = -1.80	.08	.44 (*d)*
Spatial Cue Trials	656.20 (144.01)	729.21 (163.04)	*t*(74) = -2.03	.05*	.49 (*d)*
Congruent Trials	666.51 (139.26)	734.23 (170.19)	*t*(74) = -1.86	.07	.46 (*d)*
Incongruent Trials	741.70 (153.36)	828.14 (182.13)	*t*(74) = .-2.19	.03*	.54 (*d)*
Network Score (ms)					
Orienting	28.63 (35.44)	23.27 (64.48)	*t* (74) = .49	.63	.12 (*d)*
Conflict	75.19 (41.67)	93.91 (58.87)	*t* (74) = -1.62	.10	.40 (*d)*

Note: ASD = Autism Spectrum Disorder. SRS-P = Social Responsiveness Scale, parent report. *d* = Cohen's d. ms = milliseconds. RT = Reaction Time.
* $p < .05$.

Table 2

Correlations (r) between attention and clinical measures

Variable	1	2	3	4	5
1. ANT Conflict	--				
2. ANT Orienting	-.22	--			
3. MASC-P	.19	-.13	--		
4. SRS-P	.07	-.02	.35**	--	
5. ERC	.09	.07	.40**	.66**	--

Note: ANT = Attention Network Task; MASC – P = Multidimensional Anxiety Scale for Children – Parent Report; SRS-P = Social Responsiveness Scale – Parent Report; ERC = Emotion Regulation Checklist – Lability / Negativity Subscale.
* $p < .05$; ** $p < .01$.

Group Characteristics

As shown in Table 3, the Low ASD and Severe ASD groups did not differ on any demographic variables: age, sex, distribution of race, or household income. Table 3 also shows the distribution of anxiety and non-anxiety disorders. In the Severe ASD group, a diagnosis of social phobia was more common (χ^2 =17.69; df = 1, N = 76, p = .00, φ = .48). Additionally, ADHD was more common in the Severe ASD group (χ^2 =17.71; df = 1, N = 76, p = .00, φ = .41). No other significant differences were noted for DSM diagnoses. The Low ASD and Severe ASD groups did, however, differ on several study variables. As expected, the Severe ASD group has higher SRS-P scores than the Low ASD group ($t(57) = -24.13$, p = .00, $d = 7.17$). Additionally, the groups differed on parent report of anxiety ($t(57) = -2.14$, p = .03, $d = .53$) and emotion lability / negativity ($t(67) = -5.67$, p =.00, $d = 2.62$).

Table 3

Demographic and Descriptive Information by SRS-P Category

Variable	Low ASD (N = 50)	Severe ASD (N = 26)	Significance Test	*p*	Effect Size
Age	11.42 (3.21)	10.34 (2.49)	t (74) = 1.49	.14	.37 (*d*)
Sex (# Male)	31	15	χ^2 (1, N = 76) = .13	.13	.04 (Phi)
Ethnicity (# White)	42	20	χ^2 (4, N = 76) = 4.92	.30	.25 (Phi)
Household Income					
$10,000 –$19,999	0	2			
$20,000 - $29,999	1	2			
$30,000 - $39,999	0	2			
$40,000 - $49,999	2	3			
$50,000 - $59,999	5	2			
$60,000 - $69,999	2	1			
$70,000 - $80,000	3	1			
$80,000 +	33	10	χ^2 (7, N = 69) = 13.26	.07	.44 (Phi)
Diagnoses					
GAD	32	20	χ^2 (1, N=76) = 1.32	.25	.13 (Phi)
SAD	3	3	χ^2 (1, N=76) = 1.	.31	.12 (Phi)
SOC	15	21	χ^2 (1, N=76) = 17.69	.00*	.48 (Phi)
SP	25	9	χ^2 (1, N=76) = 1.64	.20	.15 (Phi)
OCD	1	0	χ^2 (1, N=76) = .53	.21	.14 (Phi)
ANX-NOS	1	0	χ^2 (1, N=76) = .53	.47	.08 (Phi)
Total Anxiety DXs	2.00 (.81)	2.30 (1.12)	t (74) = -1.37	.17	.33 (*d*)
ODD	2	3	χ^2 (1, N=76) = .21	.21	.14 (Phi)
MDD	0	1	χ^2 (1, N=76) = .16	.16	.16 (Phi)
ADHD	3	10	χ^2 (1, N=76) = 12.71	.00*	.41 (Phi)
MASC – P	54.65 (19.15)	63.78 (14.20)	t (74) = -2.14	.04*	.53 (*d*)
SRS-P (T-Score)	51.18 (5.72)	83.85 (5.31)	t (74) = -24.14	.00*	7.17 (*d*)
ERC	27.94 (4.55)	35.50 (6.34)	t (74) = -5.66	.00*	2.62 (*d*)

Note: GAD = generalized anxiety disorder; SAD = separation anxiety disorder; SOC = social phobia; SP = specific phobia; ANX-NOS = Anxiety Not Otherwise Specified; ODD = Oppositional Defiant Disorder; MDD = Major Depressive Disorder; ADHD = Attention Deficit Hyperactivity Disorder; MASC-P = Multidimensional Anxiety Scale for Children – Parent Report; SRS-P = Social Responsiveness Scale – Parent Report; ERC = Emotion Regulation Checklist – Lability / Negativity Scale; *d* = Cohen's d. Phi = Φ.
* $p < .05$.

As shown in Table 1, the Severe ASD group was overall slower on Incongruent Trials and trials with a Spatial Cue. On Incongruent Trials, those with Severe ASD had a mean reaction time of 828.14 milliseconds (SD = 182.13), whereas those with Low ASD had a mean reaction time of 741.70 milliseconds (SD = 153.36), $t(74) = -2.19$, p = .049, d = .54). On trials with a Spatial Cue, those with Severe ASD had a mean reaction time of 729.21 milliseconds (SD = 163.04) and those with Low ASD had a mean reaction time of 656.20 (SD = 144.01), $t(74) = -2.19$, p = .03, d = .49).

Correlations among study variables was different between the two groups. In the Low ASD group, attentional control variables were not found to significantly correlated with parent report of child anxiety (Orienting: $r = -.05$, p = .76; Conflict: $r = .02$, p = .87), ASD symptoms severity (Orienting: $r = -.10$, p = .51; Conflict: $r = .15$, p = .29, or emotion lability / negativity (Orienting: $r = .07$, p = .63; Conflict: $r = -.02$, p = .91). Child anxiety and severity of ASD symptoms were significantly correlated ($r = .35$, p = .01), as were regulation skills and anxiety ($r = .37$, p = .01).

Among the Severe ASD Group, Conflict scores were significantly correlated with child anxiety ($r = .42$, p = .03). They were not significantly correlated with ASD symptom severity ($r = .05$, p = .82) or emotion lability / negativity ($r = .16$ p = .49). Orienting scores were not significantly correlated with child anxiety ($r = -.25$, p = .23), ASD symptom severity ($r = .09$, p = .67) or emotion lability / negativity ($r = .11$ p = .62). Child anxiety was also not significantly correlated with ASD symptom severity ($r = .13$ p = .53) or emotion lability / negativity ($r = .30$ p = .18).

Aim 1: Differences in Attentional Control Variables between Low ASD and Severe ASD groups.

The differences between variables indexing attentional control were examined using repeated measures ANOVAs. To examine the differences between the Low and Severe ASD groups in the orienting network, a 2 (Orienting Cue Trials, Center Cue Trials) by 2 (Low ASD, Severe ASD) repeated measures ANOVA was used. Parent report of anxiety, presence of an ADHD diagnosis, and presence of a Social Anxiety diagnosis were included as covariates, given that the Low ASD and Severe ASD groups differed on these variables. Trial types were the repeated measure and ASD group was the between subjects factor. There was a significant effect of Trial Type ($F(1, 71) = 4.89$, $p = .03$). However, there was not a significant Trial Type by ASD Group interaction ($F(1, 71) = 2.56$, $p = .11$). Thus, reaction times for Orienting Cue Trials and Center Cue Trials were significantly different, which indicates the main manipulation for the Orienting Network in the ANT task was valid. However, the effect did not vary significantly between the two groups.

To examine the differences between the Low and Severe ASD groups in the conflict network, a 2 (Congruent Trials, Incongruent Trials) by 2 (Low ASD, Severe ASD) repeated measures ANOVA was used. Parent report of anxiety, presence of an ADHD diagnosis, and presence of a Social Anxiety diagnosis were included as covariates, given that the Low ASD and Severe ASD groups differed on these variables. Trial types were the repeated measure and ASD group was the between subjects factor. There was a significant effect of trial type ($F(1, 71) = 12.97$, $p = .001$). However, there was not a significant Trial Type by ASD Group interaction ($F(1, 71) = .16$, $p = .59$). Thus, reaction times for Congruent Trials and Incongruent Trials were significantly different,

which indicates the main manipulation for the Conflict Network in the ANT task was valid. However, this effect did not differ significantly between the two groups.

Because the main focus of this aim is to examine differences in attentional abilities between the Low and Severe groups, having ADHD as a covariate may potentially remove some variance that is of interest (i.e. attentional processes). Therefore, the data was also examined without using ADHD as a covariate. This resulted in a similar pattern of data. For the orienting network, there was a similar significant effect of trial type ($F(1, 71) = 8.35$, $p = .005$), and no significant Trial Type by ASD Group interaction ($F(1, 71) = 2.78$, $p = .10$). For the conflict network, there was a similar significant effect of Trial Type ($F(1, 71) = 7.29$, $p = .009$), and no significant Trial Type by ASD Group interaction ($F(1, 71) = 0.00$, $p = 1.00$).

Aim 2: Deficits in Attentional Control Mechanisms and Their Relationship to Anxiety Severity.

The ability of attention variables to predict anxiety severity individually was examined using hierarchical multiple regression. Variables were mean-centered to reduce multicollinearity. These analyses were done separately for Low ASD and the Severe ASD group. Correlations across the whole sample suggest that neither Conflict scores ($r = .19$, $p = .10$) nor Orienting scores ($r = -.13$, $p = .28$) are significantly associated with parent report of child anxiety. Hierarchical regression analyses were conducted to determine the relationship between attention variables and parent report of anxiety. These were conducted in separate models for Conflict Network and Orienting Network. The results of these regressions are reported in Tables 4 and 5.

Table 4

Multiple Regression Examining the Relationship Between Attention Control Variables and Child Anxiety – Low ASD Group

Outcome	Variable	B	SE B	β	R^2	*F*
MASC-P	ANT-C	.01	.07	.02	.00	.03

	ANT-C	-.01	.06	-.03	.12	3.21*
	SRS-P	1.17	.46	.35*		

	ANT-C	0.12	.17	.17	.12	2.15
	SRS-P	1.19	.48	.49*		
	SRS-P * ANT-C	.00	.01	.01		
MASC-P	ANT-O	-.02	.07	-.05	.00	.03

	ANT-O	-.04	.07	-.08	.13	3.37*
	SRS-P	1.18	.46	.35*		

	ANT-O	.19	.14	.22	.16	2.91*
	SRS-P	1.14	.46	.34		
	SRS-P * ANT-O	.02	.01	.35		

Note: ANT-C= Attention Network Task Conflict Score; ANT-O= Attention Network Task Orienting Score; MASC – P = Multidimensional Anxiety Scale for Children – Parent Report; SRS-P = Social Responsiveness Scale – Parent Report
* $p < .05$.

For the Low ASD group, a multiple regression model using Conflict scores, SRS-P scores, and their interaction to predict MASC-P scores did not explain a significant amount of the overall variance ($R^2 = .06$, $F(3, 46) = 2.10$, $p = .11$). None of the individual predictors were significant predictors in the final model. In contrast, using Orienting scores, SRS-P scores, and their interaction to predict MASC-P score, the model did explain a significant amount of the overall variance ($R^2 = .11$, $F(3, 46) = 2.91$, $p = .04$). However, no individual variable was significant in the final model.

Table 5

Multiple Regression Examining the Relationship Between Attention Control Variable and Child Anxiety – Severe ASD Group

Outcome	Variable	B	SE B	β	R^2	*F*
MASC-P	ANT-C	.10	.05	.42*	.17	5.05*

	ANT-C	.10	.05	.42*	.19	2.27
	SRS-P	.30	.50	.11		

	ANT-C	.24	.23	.97	.20	1.83
	SRS-P	.32	.51	.12		
	SRS-P x ANT-C	.00	.01	-.58		
MASC-P	ANT-O	-.05	.04	-.25	.06	1.15

	ANT-O	-.06	.04	-.26	.08	1.05
	SRS-P	.41	.53	.15		

	ANT-O	-.07	.36	-.33	.08	.67
	SRS-P	.42	.57	.16		
	SRS-P x ANT-O	.00	.02	.07		

Note: ANT-C= Attention Network Task Conflict Score; ANT-O= Attention Network Task Orienting Score; MASC – P = Multidimensional Anxiety Scale for Children – Parent Report; SRS-P = Social Responsiveness Scale – Parent Report
* $p < .05$

For the Severe ASD group, a multiple regression model using Conflict scores, SRS-P scores, and their interaction to predict MASC-P scores did not explain a significant amount of the overall variance ($R^2 = .20$, $F(3, 22) = 1.83$, $p = .17$). None of the individual predictors were significant predictors in the final model. Similarly, using Orienting scores, SRS-P scores, and their interaction to predict MASC-P score, the model did not explain a significant amount of the overall variance ($R^2 = .08$, $F(3, 22) = .67$, $p = .58$) and no individual variable was significant in the final model.

Aim 3: Moderation of the Relationship between Emotion Regulation Skills and Anxiety Severity by Attentional Control Variables.

Multiple regression analysis explored if the attentional control variables moderate the relationship between emotion lability / negativity and anxiety, as shown in Table 6. As predicted, there was a significant correlation between emotion lability / negativity and MASC-P scores (r = .40, p < .00), such that increased emotion lability / negativity was correlated with increased anxiety. Preliminary analysis also revealed that emotion lability / negativity scores were higher for those with a diagnosis of ADHD (F(1, 67) = 9.28, p < .00) and females (F(1, 67) = 4.60), p = .04). ERC scores were also significantly correlated with age. Therefore, these variables were included as covariates in these analyses, along with those variables associated with MASC-P scores (i.e., SRS-P scores).

The first model examined the relationship between Conflict scores, emotion lability / negativity, and parent-report of anxiety. Emotion lability / negativity scores significantly predicted child anxiety (b_{ERC} = 1.30, t = 2.87, p = .01). Conflict scores did not significantly predict child anxiety (b_{CON} = .02, t = .51, p = .61). Conflict scores were not found to moderate the relationship between emotion lability / negativity scores and child anxiety ($b_{CON\ X\ ERC}$ = .01, t = 1.74, p = .09).

The second model examined the relationship between Orienting scores, emotion lability / negativity, and parent-report of anxiety. Emotion lability / negativity scores significantly predicted child anxiety (b_{ERC} = 1.18, t = 2.58, p = .01). Orienting scores did not significantly predict child anxiety (b_{CON} = -.05, t =-.96, p = .34). Orienting scores were not found to moderate the relationship between emotion lability / negativity scores and child anxiety ($b_{CON\ X\ ERC}$ = .00, t = .25, p = .80).

Table 6

Multiple Regression Examining If Attention Control Variables Moderates the Relationship Between Emotion Regulation and Anxiety

Outcome	Variable	B	SE B	R^2	*F*
MASC-P	ERC	1.30*	13.21	.23	2.60*
	ANT-C	.02	.05		
	ANT-C x ERC	.01	.01		
MASC-P	ERC	1.18*	.46	.20	2.19*
	ANT-O	-.05	.06		
	ANT-O x ERC	-.00	.01		

Note: ANT-C = Attention Network Task Conflict Score; ANT-O = Attention Network Task Orienting Score; MASC – P = Multidimensional Anxiety Scale for Children – Parent Report; ERC = Emotion Regulation Checklist – Lability / Negativity Scale.
* $p < .05$

Discussion

The current study explored the relationship between attentional control and anxiety severity within anxious youth with minimal ASD symptoms and those at levels suggestive of an ASD diagnosis. Although evidence suggested that attention control is associated with anxiety, results from the current study indicated little support for the hypothesis that variables measuring attentional control would be associated with anxiety severity. Prior literature suggested that youth with ASD have difficulties in attention control above those of youth in the general population (e.g. Kheen, Muller, & Townsend, 2013). However, this hypothesis was also not supported by the current findings. Lastly, an exploration into whether the relationship between poor emotion regulation and increased anxiety was moderated by attentional control abilities failed to support a moderating effect of attentional control abilities on this relationship.

The lack of significant findings runs counter to the study hypothesis and those suggested by a review of the literature. The current findings suggest that attentional control abilities may not be directly related to the presence or severity of anxiety in youth and, instead, may exert an influence over other processes that are related to anxiety. Indeed, cognitive and information processing theories of anxiety suggest that there are multiple pathways through which anxiety could be influenced by attentional control abilities (e.g. Mogg & Bradley, 2016). Most prominently, the link between attentional control and anxiety has been explored through examination of attentional biases towards threatening information. The influence of attentional control on anxiety symptoms may be best examined through these types of paradigms; however, attention biases were not explored in the current study. Although attention biases have received the most research, others have looked at how attentional control plays a role in other domains such as rumination, impulse control, and general use of emotion regulation strategies (O'Bryan et al., 2017).

Although specific emotion regulation strategies were not explored, broad emotion regulation skills were assessed through parent report. Consistent with previous studies, emotion lability / negativity were found to be moderately correlated with anxiety ($r = .40$, $p < .05$). However, the current study failed to find evidence that attentional control moderates the relationship between these two variables. The lack of a moderating relationship runs counter to the notion in other lines of research that suggest attentional control and related concepts of cognitive control play important roles in these processes (Joormann & Vanderlind, 2014; Mor & Daches, 2015). The lack of a moderating relationship implies that attentional control, as indexed in the current study, may not play

a role in the broad category of lability / negativity or the underlying construct of emotion regulation skills. For example, O'Bryan et al. (2017) found that attentional control skills were related to the use of some, but not all, emotion regulation strategies. Furthermore, multiple studies have examined the relationship between rumination or repetitive negative thinking and attentional control and found there to be specific evidence that attentional control is implicated in use or suppression of these types of strategies (e.g., Mills et al., 2016). The findings of the current study demonstrate that measures of attentional control are not related to broad measures of emotion dysregulation, but they do not necessarily preclude the notion that they are associated with specific types of emotion regulation skills. As a concept, emotion regulation skills encompass a wide variety of skills and it is likely the case that not all are directly impacted by attentional control. For example, attentional control abilities may be more impactful on rumination, as suggested by Mills et al., (2016) or on the ability to shift attention away from frightening objects that capture our attention (e.g. attentional biases).

Are there differences on attentional control variables between the low ASD group and the severe ASD groups? Initial t-tests did not support that hypothesis that the severe ASD group would show a greater deficit in attentional control mechanisms. However, this was probed further per planned analyses using a repeated measures ANOVA to allow for greater statistical power and to control for other variable differences between the two groups. However, this analysis also failed to produce evidence to support the study hypothesis.

The lack of significant findings remains counter to what would be expected given the research suggesting that those with ASD have difficulties shifting their attention away

from objects that have initially captured their attention. It may be the that the stimuli used in the Attention Network Task were not adequately stimulating to elicit the attention shifting deficits often observed in ASD youth. A review of the literature suggested that youth with ASD often have difficulty shifting attention away from stimuli that are dynamic and colorful in nature (e.g., Elsabbagh et al., 2009; Landry & Bryson, 2004; Zwaigenbaum et al., 2005), and mixed findings with stimuli that are static (e.g., Fischer, et al., 2013). Although the stimuli used in the child version of the Attention Network Task are cartoon like in nature, they are relatively static and do not have the dynamic qualities of stimuli used in studies that have demonstrated attention disengagement difficulties. It is possible they may not have been "interesting" enough to elicit difficulties in attentional control in the Severe ASD youth. The lack of significant findings, in the context of previous research suggesting attentional deficits are observed only with dynamic stimuli, suggest that further research would benefit from incorporating even more dynamic stimuli than used in the current study.

Overall, the study failed to find evidence that variables associated with attentional control are related to child anxiety. This pattern of results holds despite the repeated measures ANOVA which showed a significant effect of trial type for each attention network, indicating that the Attention Network Task itself performed as expected. Thus, the failing of the Attention Network Task can be ruled out as an explanation for the null findings. What other explanation may be underlying this lack of support for the study hypotheses?

One potential explanation for the lack of a relationship between anxiety and attentional control variables may be the lack of a multi-method, multi-information

approach to assessing child anxiety. In the design of this study, the decision was made to only use parent-report of child anxiety because of the potential issues with reliability of child-report of anxiety in youth with ASD (Katt & Lecavalier, 2015). However, it may be the case that parent report of child anxiety may not adequately capture aspects of anxiety that are associated with attentional control. It is also possible that the anxiety measure used here did not adequately capture anxiety appropriately in the Severe ASD group. That is, the MASC-P was designed for use with neuro-typical children with anxiety disorders (March et al., 1997). Although it has often been used in studies examining anxiety in ASD youth and has been deemed "appropriate with conditions" (Lecavalier, Wood, et al., 2014), the MASC-P may not capture the unique presentations of anxiety in youth with severe ASD symptoms, particularly as they relate to the inflexibility and restricted interests seen in this population.

Several limitations regarding the current study must be noted. First, the Severe ASD group was comprised of participants who had confirmed ASD diagnoses with the ADOS and those who had scores on the SRS-P that are typically indicative of an ASD diagnosis (Constantino & Gruber, 2005), but without confirmation of an ASD diagnoses via the ADOS. There was not a significant difference between SRS Scores in those with a confirmed diagnoses (via the ADOS) and those without one. Although autism is conceptualized as a spectrum disorder, the attentional deficits describes in ASD youth may be specific to those who meet diagnostic criteria for the disorder. Another limitation, mentioned previously, is the lack of a multi-information measure of emotion regulation skills and child anxiety. Future work in these areas of research would benefit from assessing child anxiety in a variety of manners and from different respondents. In

the current study, multi-informant assessment was made difficult by the lack of a child measure of anxiety and the limited range of the clinician measure of anxiety. By nature of the ADIS-C/P, all youth in the study have a Clinical Rating Scale of 4 or higher (out of 8). This resulted in minimal variability across subjects and hindered use of the clinical rating in this study.

Given the need for continued development of evidence-based approaches to address anxiety in ASD youth, future research should work to fill these gaps. For example, paradigms could be refined to specifically assess attention in this population, perhaps with stimuli that are more suited for this population. It may also be prudent to look beyond tasks which measure visual aspects of attentional control and expand to include paradigms that assess cognitive control more broadly. This might help researchers to further understand how attentional control in those with ASD differs from their peers and, potentially, how this affects the development of anxiety. These lines of research are important to basic science in their own right. However, they also open the possibility that new modes of intervention could be developed for use in ASD populations. For example, the attentional bias modification literature shows one pathway through which address an underlying construct (i.e. attentional control) may have a beneficial impact on anxiety. These types of interventions may prove to be useful for youth with ASD, who do struggle with certain aspects of attentional control that likely has an impact on their development in general, even beyond just anxiety (Fan et al., 2012, Keehn, Muller, & Townsend, 2012).

CHAPTER 2

LITERATURE REVIEW

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterized by impaired communication and social functioning, as well as the presence of restricted, repetitive behaviors, interests, or activities (American Psychiatric Association [APA], 2013). ASD is becoming recognized as a common neurodevelopmental condition; prevalence studies now estimate that 1 out of every 68 children, or 1 in 42 boys and 1 in 189 girls, are affected. Although this statistic captures the prevalence of ASD, it is important to note that ASD itself is a very heterogeneous disorder. Indeed, revisions from the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR)* to the fifth edition provide some insight. In the *DSM-IV-TR* (APA, 2000), there were multiple disorders that fell under the class of pervasive developmental disorders. These included autistic disorder, Asperger's disorder, pervasive developmental disorder—not otherwise specified (PDD-NOS), Rett syndrome, and childhood disintegrative disorder (CDD). The most current edition, *DSM-5,* collapses all of these disorders, save CDD, under the category of autism spectrum disorder (APA, 2013). *DSM-5* also includes specifiers that allow the clinician to indicate the presence of a known etiological factor and indicate the severity of each symptom domain. Although an exhaustive review of other changes from *DSM-IV-TR* to *DSM-5* is beyond the scope of this paper, the inclusion of multiple specifiers to the diagnostic category of ASD highlight the varied ways in which children on the spectrum present: some may have strong verbal abilities, whereas others may be unable to communicate verbally at all. Others may have low intellectual

functioning, while others may have average or above-average intellectual functioning. Many, however, will present with impairing anxiety.

The incidence of anxiety in youth with ASD is high. In an epidemiological sample, Simonoff et al. (2008) found that 71% of children with ASDs had at least one comorbid disorder. Using a structured clinical interview, they found social anxiety to be most common, followed by attention-deficit/hyperactivity disorder, and oppositional defiant disorder. Other samples have largely yielded similar results (e.g., De Bruin, Ferdinand, Meester, De Nijs, & Verheij, 2007; Leyfer et al., 2006). In most of the reports examining comorbidity in individuals with ASDs, anxiety disorders are typically the most frequently reported. Leyfer et al. (2006) looked at the prevalence rates of psychiatric disorders, using a structured diagnostic interview designed with youth with ASD, in children, ages 5 to 17, using a cross-national sample of youth in a longitudinal study. Out of 101 children that had a diagnosis of ASD, 43 met criteria for a specific phobia, 35 met criteria for obsessive compulsive disorder (OCD), 12 met criteria for separation anxiety, 7 met criteria for social anxiety, and 1 met criteria for generalized anxiety disorder. Thus, about 43% of children with ASD also met criteria for at least one anxiety disorder. No large scale, epidemiological studies have been conducted so the exact number of youths with ASDs and clinically elevated anxiety is unknown. Studies put this number between 11% and 84% (S. S. W. White, Oswald, Ollendick, & Scahill, 2009), with the large variability in studies being attributed to both differences in how samples were selected and difficulties in assessing anxiety in those on the spectrum. Across studies and methodologies, however, anxiety does appear to be more common in youth with ASD than their typically developing peers.

Indeed, an ongoing problem in diagnosing anxiety in youth on the spectrum has been the considerable overlap with many of the symptoms of anxiety disorders, including repetitive behaviors and interests (e.g., compulsions seen in children with OCD), avoiding of social situations (e.g., social phobia), and issues concerning speech (e.g., nervous stuttering, dysfluency; Wood & Gadow, 2010). Reviewing the overlap in symptom presentation, Kerns and Kendall (2012) offered three conclusions: that it is unlikely that anxiety is a core feature of ASDs; that there are both typical presentations of anxiety seen in individuals with ASD and variants of anxiety unique to ASD; and that the etiology of anxiety in ASD is unclear although they note there is initial evidence to suggest that core ASD symptoms may contribute to the development of anxiety.

There is evidence to suggest that core ASD symptoms are related to the development of anxiety in ASD youth. Wood and Gadow (2010) outlined a model in which social deficits contribute to the development of anxiety. Their model focuses on the role of ASD-related stressors and their impact on anxiety. They proposed that social skills deficits (e.g., social confusion, lack of skills in navigating social interactions) contribute to the development of social anxiety both by increasing avoidance of social situations and by promoting unique ASD, maladaptive coping strategies (e.g., repetitive behaviors). Other authors have hypothesized similar mechanisms (e.g., White & Roberson-Nay, 2009) and multiple treatments for anxiety in ASD include modules or interventions designed to address social skills deficits (White et al., 2010). There is also evidence to suggest that social deficits interact with physiological hyperarousal and this pathway contributes to the development of social anxiety (Bellini, 2006). Further, initial studies suggest that interventions designed to address social skills deficits in ASD youth show similar outcomes

to standard CBT treatments for social phobia (Beidel et al., 2014). Despite the intuitive nature of the relationship between social deficits and anxiety, particularly social phobia, this is an area in which further research is needed.

There is also a paucity of research examining the relationship between other core ASD problems and anxiety. For example, youth on the spectrum may experience sensory difficulties ranging from over simulation to sounds and light to difficulty with the texture or feeling of clothing or other objects. Green and Ben-Sasson (2010) describe multiple models in which sensory over-responsivity may lead to anxiety, either through classical conditioning, through an unknown third variable (e.g., an overactive amygdala), or they postulate that sensory over-responsivity may lead to anxiety directly. They, however, conclude that there is not currently enough research to determine the exact relationship between sensory difficulties and the development of anxiety. Similar conclusions have been reached when researchers examine other core ASD symptoms, such as repetitive behaviors (Spiker, Lin, Van Dyke, & Wood, 2011).

One potentially informative research path is to examine the pathways through which anxiety develops in typically developing youth and assess the degrees to which these are pertinent in youth with ASD. Given our knowledge about the development and maintenance of anxiety in typically developing youth, it follows to conduct research to determine if similar mechanisms underlie anxiety in youth on the spectrum. This is especially true as we seek ways to improve upon the treatment of anxiety in youth with ASD. Indeed, evidence-based treatments for anxiety in typically developing youth are predicated on research in that population.

Although there are multiple factors that are believed to underlie the development and maintenance of anxiety in youth, cognitive theories of anxiety suggest that attention is one mechanism through which we can understand anxiety. Previous research highlights two important ways that attention and anxiety interact. First, those who are anxious tend to display an attentional bias towards stimuli that are perceived to be threatening. Second, emerging research suggests that attentional control is both influenced by and may be causally related to the anxiety. This literature review will examine the role that attention plays in the development and maintenance of anxiety. These models are the prevailing models of anxiety in both youth and adults and there is evidence to suggest that youth with ASD have deficits in cognitive abilities that are implicated by these theories.

Attentional Biases in Anxiety

Research has focused on the role of cognition in the maintenance and development of anxiety disorders. In one of the earliest theories that focused on the role of cognition, Beck and Clark (1985) proposed that schemata, or broad representations and beliefs emerging from one's life experiences, impacted multiple cognitive processes including attention, memory, and executive functioning. Similarly, Ingram and Kendall (1987) proposed that children experience cognitive distortions that lead to a belief that situations are more threatening or dangerous than they are objectively. Daleiden and Vasey (1997) extended the information-processing account stating that children experience distortions at various stages of cognition: selectively attending to threatening information, interpreting ambiguous information at threatening, making threat-related attributions, expecting negative outcomes, and engaging in safety seeking behaviors over goal-directed ones. Similarly, Beck and Clark (1997) also proposed a three step model by which threatening

information is processed cognitively: threated related information is initially, and rapidly, attended to; a "threat mode" is activated in which behaviors and thoughts important to safety and survived are activated; and meta-cognitive schemas that examine threat likelihood and self-efficacy in the moment are also activated.

Within these models of information processing, there has typically been a distinction drawn between two competing aspects of information processing. One pathway typically includes an automatic pathway that allows for the processing of threat-related information in an automatic manner and another pathway that allows for the processing of threat-related information in a elaborative and controlled manner (e.g., intentional; Cisler, & Koster, 2011; Mcnally, 1995). These can also be understood as operating through two differing cognitive processes: a bottom-up system that responds immediately and shapes the behavioral and emotional response, and a top-down system that serves to regulate and control behavior and emotion (e.g., Metcalfe & Mischel, 1999). There is ample evidence that both aspects of information processing are important to understanding anxiety disorders.

Attentional Biases Towards Threat

There is evidence, for example, that selective attention to threat-related stimuli is related to the etiology of anxiety disorders (e.g., Eldar, Yankelevitch Roni, Lamy, & Bar-Haim, 2010). Research with adults and children has found that anxious individuals (including those who met diagnostic criteria for an anxiety disorder and those with elevated anxiety on self and informant-report measures) show an attention bias towards negative and threatening information, whereas non-anxious individuals do not (for a review of the adult

literature, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007).

Although various paradigms have been used to investigate an attentional bias towards threatening faces, the dot-probe task is prototypic. In a dot-probe paradigm, two words or pictures (e.g., scenes or faces) are presented for a brief interval. Following the presentation, the participants see a probe (e.g., a dot or an arrow) in the central location of one of the two stimuli. Participants then make a response indicating the location of the probe. In most versions, there is a negative – neutral stimuli pairing condition, and the reaction time differential between when the probe replaces a negative stimulus and when the probe replaces the neutral stimulus is used as the measure of attention bias. A negative attention bias is demonstrated when participants are faster to respond to the probe when it has replaced a negative stimulus. This differential in reaction time is indicative of a preferential processing for threatening information, and this is referred to as a bias towards these types of stimuli.

Initial studies using the dot-probe task made use of neutral and threatening words to measure a bias towards threat. Vasey, Daleiden, Williams, and Brown (1995) examined a handful of youth that met criteria for at least one anxiety disorder, as assessed with a structured clinical interview. They found that youth with anxiety disorders exhibited an attentional bias towards emotionally threatening words, whereas the non-anxious control children did not show any bias towards the threatening stimuli. Two later studies extended this finding by showing that the attention bias was specific to threatening words (Taghavi, Neshat-Doost, & Moradi, 1999; Dalgleish et al., 2003), both assessing anxiety through self-report. In both of these studies, youth with a diagnosis of generalized anxiety disorder

showed an attention bias for threatening words but not words that were related to depression. In both studies, youth with mixed anxiety and depression or depression alone did not show an attention bias towards threat. Dalgleish et al. (2003) also sought to determine if there were differential attention biases between anxiety disorders by examining youth with PTSD. Children with PTSD did not show a bias towards threat-related words, but they did show a bias away from depression-related words, replicating some of earlier work by the same group (Dalgleish, Moradi, & Taghavi, 2001). Considering the strong depressive component of PTSD, these studies suggest that the depression-related cognitive schemas may override those cognitive schemas which facilitate attention to threat.

Other research has sought to use more ecologically valid stimuli in the form of pictures. Using general threatening scenes, however, has demonstrated that all youth show attentional biases towards these types of stimuli. Two studies investigated the attentional bias using negative pictures (vicious dogs, snakes, spiders, etc.), positive pictures (kittens, candy, smiling faces), and neutral stimuli (household objects) (Waters & Lipp, 2004; Zimmer-Gembeck & Craske, 2008). In both studies, both clinically anxious and non-anxious youth show a bias towards negative stimuli, with the magnitude of the threat bias in anxious children not larger than those in non-anxious youth. Given the evidence for specialized brain regions involved in the early detection of threatening animals, especially as they relate to our species' evolutionary history (e.g., Le et al., 2013), it may not be surprising that even non-anxious youth showed a bias towards these particular threatening stimuli.

Studies using facial stimuli to assess threat bias have largely found a differential attention bias towards threat between anxious and non-anxious youth. Using a large sample of youth assessed with structured clinical interview, Roy et al. (2008) found that anxious children, but not non-anxious controls, demonstrated an attention bias towards negative faces. In addition, neither controls nor anxious youth demonstrated an attention bias towards happy faces. Furthermore, within the anxious group, there were no differences due to principle diagnosis on the magnitude or presence of the negative attention bias. Using the same task and stimuli, Waters, Mogg, Bradley, and Pine (2008) demonstrated that only a subset of the anxious children that had severe anxiety (i.e., higher clinician rating of anxiety) demonstrated a bias towards threat. Neither the moderately severe or non-anxious children showed a bias towards threatening faces. Although this finding stands in contrast to the results of Roy et al. (2008), Waters, Henry, Mogg, Bradley, and Pine (2010) later replicated these findings as well. Similar to Roy et al. (2008), both studies assessed for anxiety through use of structured clinical interviews. However, it is important to note that the recruitment methods differed across these three studies. Whereas Roy et al. (2008) studied children whose parents were actively seeking treatment for impairing anxiety, both Waters et al. studies (2008; 2010) recruited anxious children from the local communities. It is difficult to make a direct comparison given differences in measures across studies, and non-reporting of scores associated with structured diagnostic interviews. However, it may be the case that the higher anxiety youth in Waters et al. (2008; 2010) more resemble the treatment seeking anxious youth in Roy et al. (2008).

It should be noted that there are other studies which show mixed results as well. For example, a handful of studies have demonstrated an attentional bias away from threatening

faces. Monk et al. (2006) examined 33 adolescents with generalized anxiety disorder and found evidence for an attention bias away from threatening faces. Given that their paradigm was similar in design to that typically used to assess anxiety disorders in anxious youth, the reason for this is unclear. However, a number of the youth included in the study also met criteria for major depressive disorder and had social phobia as well. Interestingly, a similar pattern of results was also found for youth with PTSD (Pine et al. 2005). In this study, co-morbidity was not reported; however, there is meaningful overlap between depressive symptoms and PTSD criteria. Youth with PTSD have traditionally not been examined in studies looking at attentional biases in anxiety disorders. Thus, there may be unique mechanisms specific to PTSD and/or depression that are underlying the bias away from threat.

Other studies have also found attentional biases away from threatening faces. A large study of anxious youth, approximately 8 years old, showed an attentional bias away from threatening faces (Brown et al., 2013). This was not observed in the non-anxious youth that served as the comparison group. In this study, a few methodological inconsistencies must be noted. Criteria for study entry included self-report of anxiety (i.e., was not made by an independent evaluator). Further, the presentation of stimuli in the dot-probe task was longer than the traditional presentation time: 1100 ms versus the traditional 500 ms. Other studies that have found evidence for biases away from threatening information in anxious youth also included dot-probe stimuli that were presented for longer than the standard 500 ms presentation time. In another large scale study of attentional biases in anxious youth, ages 6 to 12, there was no evidence for an attentional bias towards and their data showed a trend which suggested youth with anxiety avoided threating stimuli (Salum et al., 2013).

Again, this was in contrast to typically developing children who showed no bias away or towards threatening information. Importantly, they collapsed across multiple versions of the dot-probe in their data analysis, which included stimuli at brief presentations (e.g., 500 ms) and stimuli at longer presentation times (e.g., 1200 ms).

Lastly, several studies have found no evidence that there is no evidence of an attentional bias using the dot-probe task. Britton et al. (2012) studied attention biases using the dot-probe in a sample of 8 to 18 year old youth, all diagnosed with anxiety using a structured clinical interview. Their version of the dot-probe task used a 500 ms presentation time. However, they failed to find any evidence of an attentional bias towards either threat related stimuli (e.g., faces) in either the control or the anxious group. Two additional studies by the same research group, with identical assessment and stimuli presentation methods, also failed to find evidence for attentional biases in anxious youth (Britton et al., 2013). Given that these tasks were identical to others used in the literature, the discrepancy between these results and others is unclear. Two out of three of their studies were conducted within the context of brain scans and, thus, subjected the participants to potentially stressful situations. However, other studies have showed attentional biases in such an environment (e.g., Monk et al., 2006).

In one of the first meta-analyses of the attention bias literature, Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, and van IJzendoorn (2007) reported that a threat-related bias is reliably demonstrated using a variety of different paradigms, even ones beyond the dot-probe literature reviewed here. In examining various aspects of the threat-related bias, they focused on manipulations in the presentations of threat-related stimuli in various paradigms to compare and contrast other theories of threat-related processing.

Based on their review, they concluded that there is not sufficient evidence of clear support for one model over another. They did conclude that there is evidence that threat-related biases are the result of several cognitive processes, including preattentive, postattentive, and attentional processes. This was supported by a more recent meta-analysis of attention biases toward threating information in children specifically (Dudeney, Sharpe, & Hunt, 2015) although with a smaller effect size than the one reported in Bar-Haim et al. (2007). Given that these attention processes play an explanatory role in the conceptualization of theories of threat-related processing, it would serve to further explore the mechanisms that are hypothesized to underlie these attentional biases.

Difficulty Disengaging Attention Away From Threat

There is a wealth of research that suggests that anxious individuals show an attentional bias towards threat, but the mechanisms that underlie this bias have been debated. Multiple researchers have suggested that attentional biases may represent a difficulty with disengaging attention from threat-related stimuli. Multiple paradigms, including the dot-probe, have been used to examine the hypothesis that anxious individuals have difficulty in shifting their attention away from threatening information.

Although not typically used to examine difficulties in disengaging from threatening stimuli, some researchers have sought to use the dot-probe to examine such difficulties. Using a sample 44, non-anxious undergraduates, Koster et al. (2004) showed that results obtained in their dot-probe task reflected a difficulty in disengaging attention away from threat. Their paradigm was similar in design to the dot-probe tasks reviewed previously. However, Koster and colleagues sought to differentiate between vigilance towards threat and difficulty disengaging attention away from threat. They, as others, argued that the dot-

probe task may reflect both components of sustained vigilance towards threat (e.g., the prioritization of threatening information) and disengagement. Here, disengagement is understood to mean difficulty in the process of disengaging attention, shifting attention to a new point, and engaging attention there. To examine disengagement specifically, they examined reaction time data from the dot-probe task in a novel way. As with the traditional analysis, they calculated the reaction time for the congruent and incongruent effects: the length of time it takes a participant to report the location of a probe after it is replaced with a threatening face (congruent) or neutral face (incongruent). These two measures are then subtracted from each other to get the *congruency effect,* the measure that captures whether individuals are more likely to respond faster to congruent trials.

Koster et al. (2004) argued that the congruency effect must be understood as involving two distinct components, faster response times to congruent trials or slower responses to incongruent trials. Each component is thought to reflect two different processes: a bias towards threat for congruent trials and a difficulty disengaging attention in the incongruent trials. Thus, the authors also created a second way to examine the congruency effect. They compared reaction time in neutral trials, ones in which both initial stimuli are neutral, to reaction time for threat trials. Koster et al. argue that this allowed for a dissociation of bias toward threat (neutral vs. congruent) and difficulty disengaging attention (neutral vs. incongruent). A congruency effect was found to be driven by the difference in reaction times between neutral trials and congruent trials; no effect was found when comparing reaction times for neutral trials and incongruent trials. Participants were just as fast to report the location of the probe in the neutral baseline condition as they were in the congruent trials, where the probe replaced the threatening stimuli. However, there was a

difference between the baseline condition and incongruent trials, where the probe replaced the neutral stimuli. If the overall congruency effect was driven by biased attention toward threatening information, then one would expect participants to respond faster on congruent trials than neutral trials. If the overall congruency effect was driven by difficulty in disengaging from the threatening stimulus, then one would expect participants to respond slower on incongruent trials than neutral trails. The latter was the pattern of results that Koster et al. (2004) observed in their sample of college-aged youth and this supported their initial hypothesis.

Rudaizky, Basanovic, and MacLeod (2014) went a step beyond Koster et al. (2005) and developed a novel version of the dot-probe paradigm to explore attentional disengagement. In their version of the dot-probe, participants begin by viewing two empty rectangles on the left and right side of the screen. An initial cue was presented in one of these two locations and the participants had to report the location of this cue. This was followed by a pair of images, with one being abstract art and the other being representational (e.g., positive, neutral, or negative scenes). The representational image had an equal chance of appearing in either the location of the previous cue or on the opposite location. This was followed by a final probe at either of the two locations and the participants were asked to indicate the orientation of the line. Thus, this modified dot-probe version varies in two important ways. The use of an initial cue allows the researchers to better guide the participant's attention to one of the two locations. The task builds off of this allocated attention by allowing the representational stimulus to be either presented at the same location or a distal location. Further building off of this, one can examine how attention was focused on either the distal representational image or remained focused on the

representational image at the same location as the initial cue. Thus, attentional bias towards representational images (e.g., threat-related stimuli) and difficulties disengaging attention from representational images can be calculated through a series of subtractions within the various conditions. Rudaizky et al. (2014) examined attention biases and disengagement difficulties using their new paradigm with undergraduates who had a range of trait anxiety scores, as measured using the State Trait Anxiety Index (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). They found that the high trait anxiety group showed more of an attentional bias towards threatening pictures and more difficulties disengaging attention away from threat-related stimuli than did the low trait anxious group. They also conducted analyses that allowed them to conclude that the two measures are distinct and contribute their own independent variance when used to predict anxiety severity.

Other paradigms have been created specifically to research these questions, and evidence collected with these tasks also suggests that anxious individuals have difficulty disengaging attention from threatening stimuli. Elaine Fox and colleagues examined these same issues in a series of studies (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002) using an attentional cueing paradigm. In the task, individuals were presented initially with a centralized fixation, flanked on the left and right by empty rectangles. The fixation is replaced by a positive, threatening, or neutral cue on either the left or the right. The cue is "correct" in terms of indicating the probe will be 80% of the time and, therefore, is wrong 20% of the time. The cues disappeared and were replaced by a target (e.g., a probe) and the participant was asked to report on its presence. This task differs from the dot-probe task in multiple important ways. Fox et al. (2001) suggest that the traditional dot-probe paradigm encourages the participants to shift their attention around during the

experiment or to attend to both locations equally. They suggest that this would be an optimal strategy because both the left and the right in a dot-probe task are relevant for the task. The use of a valid and invalid cue in an attention cuing paradigm attempts to overcome these limitations.

Through a series of five experiments with undergraduates, Fox et al. (2001) found that individuals with high levels of anxiety had difficulty in shifting their attention away from threat-related stimuli. Although their sample did not undergo evaluation for meeting diagnostic criteria for an anxiety disorder, they split their sample into high and low anxiety groups based on self-report with the Spielberg State-Trait Anxiety Index (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The researchers found that those with high anxiety had difficulty disengaging attention away from threatening stimuli. When there was a threatening cue (e.g., an angry face) that was invalid (e.g., did not accurately predict the location of the target), those with high anxiety took longer to provide a response than with either positive (e.g., happy face) or neutral cues. Importantly, this was found only in those with high trait anxiety, thus confirming their initial hypothesis that high anxiety is associated with difficulties in disengaging attention from threat-related stimuli. In further follow-up studies using a similarly designed attention cueing paradigm, members of the same research team found that those with high trait anxiety also had difficulties disengaging attention away from threat-related stimuli (Fox et al., 2002).

Further studies in high-trait individuals also support the delayed disengagement hypothesis. Leleu, Douilliez, and Rusinek (2014) used an attentional shifting paradigm to explore the link between anxiety and attentional disengagement. Each trial began with a centrally presented asterisk, followed by a face presented in the center of the screen. The

face was either neutral, angry, or fearful in expression and lasted for either 500 ms or 200 ms. It was followed, concurrently, by a target stimulus (a letter) in one of the four corners of the screen, and participants were asked to report its location. If individuals have difficulty disengaging attention from threat-related stimuli, this should be represented in a longer latency to make correct responses for these trials, as compared to neutral trials. The use of 200 ms and 500 ms allowed for a dissociation between disengagement taking place when only during conscious awareness (e.g., 500 ms) and subliminal presentation (e.g., 200 ms). In their experiment, Leleu et al. (2014) examined undergraduates who had high or low levels of trait anxiety on the STAI (Spielberger et al., 1983). For both fearful and angry faces, those with high trait anxiety were slower to respond to the location of cue than were individuals with low trait anxiety. However, this was only observed at the 500 ms presentation time; no differences between the high and low anxiety groups were noted for 200 ms. Whereas both groups were able to disengage attention from a briefly presented threatening stimulus, only those with high trait anxiety had difficulty disengaging attention at longer durations. These findings are consistent with other work using similar paradigms in adults who score high on measures of self-reported anxiety (Moriya & Tanno, 2011).

Research looking at deficiencies in disengaging from threat stimuli has also examined individuals with anxiety disorders more specifically. Amir, Elias, Kulmpp, and Prezworski (2003) used a similar paradigm to those by Fox and colleagues (2001, 2002). In this study, each trial began with a centrally located fixation, followed by a cue word on either the left or right side of the fixation. A probe followed the presentation of the word, and participants were asked to report the location of the word. As with the task designed by Fox et al. (2001, 2002), some of the cues were valid (e.g., predicted accurately where the target would

be) or were invalid (e.g., did not accurately predict the location of the target). Amir et al. (2003) chose to use either neutral, positive, or threat-related words as their emotional cues. Participants were adults who met criteria for social phobia based on a structured clinical interview. As predicted, the individuals with social phobia took longer than non-anxious controls to disengage their attention from threat-related words with either neutral or positive words. They also found that those with social phobia did not differ from controls with respect to the response times to validly cued threat stimuli. This suggests that there was not a facilitated attention to threat related stimuli, as this would have been evidenced by a faster response time in trials with a valid than threatening cue.

The studies reviewed here suggest that high trait anxiety and, in one case, those who were diagnosed with social phobia, had difficulties disengaging attention from threat-related stimuli. This difficulty in disengagement was not presented at subliminal presentation times (e.g., 200 ms), instead being observed only at 500 ms (Leleu et al., 2014; Moriya & Tanno, 2011). At this presentation time, top-down control of attention processes can be engaged and this may be one underlying reason why there is a dissociation between the presentation times. The relationship between attention control mechanisms and anxiety will be explored further below. Despite the multiple studies that have provided evidence for delayed disengagement from threatening stimuli, several issues remain to be addressed. Primarily, these types of studies have not extensively been conducted in those who have anxiety that has been diagnosed per a structured clinical assessment.

Attentional Control and Anxiety

Research supports the hypothesis that anxiety is linked to attentional biases towards threatening information. This is particularly true in adults (Bar-Haim et al., 2007) and with

children (Dudeney et al., 2015), albeit with smaller effect sizes and more variability than observed in adults. These attention biases can take the form of preferential attention provided to threatening stimuli, avoidance of threat-related stimuli, or difficulty disengaging from threatening stimuli once they have been captured by attention. What is clear is that attentional mechanisms are an important element in understanding anxiety. Attention itself is a multifaceted construct, and much of the framework for the attention bias literature stems from the research of Posner and his colleagues.

From a cognitive neuroscience perspective, Posner and his colleagues view attention as a multiple-component system (Posner & Rothbart, 1998; Posner & Petersen, 1990). Within this multi-component system, there are several processes that are both voluntary and involuntary. Falling under the involuntary domain is the alerting network. The altering network is one that maintains a level of sensitivity to process incoming information. The alerting network is typically divided into two states: tonic alertness, or a state of general arousal, and phasic alertness, or a transient state of alertness typically brought about by a change in the environment. The orienting network helps to select information from the environment and involves the processes of disengaging attention, shifting attention, and reengaging attention. Lastly, the executive control network is a higher level attentional system that aids in the processes of inhibition, planning, set shifting, working memory, cognitive flexibility, and error monitoring. Years of cognitive research into attentional mechanisms have supported the notion that these networks, although working in concert with each other, also serve as distinct components of the attention process (e.g., Petersen & Posner, 2012).

Within this framework, attentional control can be understood as the ability to regulate attentional allocation of the orienting and executive function networks. The alerting network is reactive and immediately responds to changes in the environment. This is in contrast to the other attentional system that carries out more voluntary and regulatory functions. The executive control system, for example, serves to regulate processes of attention as reviewed above. The orienting network is important in its own right for shifting and disengaging attention but also for its ability to regulate the alerting system as well. Attentional control is a relatively new construct combining the attentional focusing, shifting, and disengagement of attention (Bardeen & Orcutt, 2011). The notion that attentional control is an important part of the information processing account of anxiety has been implicit in multiple theories of anxiety. For example, it was suggested that individual differences in selective attention might be underlying observed biases towards threat, and that those susceptible to anxiety (e.g., those with high trait anxiety) may be less efficient at using effortful control strategies that would serve to reduce the influence of threatening information (Mathews & MacLeod, 1994).

Attentional Control Theory

In seeking to understand the relationship between anxiety and attentional control, researchers have taken two broad approaches: the notion that anxiety leads to impairment in emotional control and the notion that poor attentional control may be an underlying factor in the development or maintenance of anxiety disorders. One of the most significant theories in the former category is the Attentional Control Theory. At its core, attentional control theory states that anxiety impairs multiple cognitive processes, including the efficiency of the central executive, inhibition functioning, and shifting functioning

(Eysenck, Derakshan, Santos, & Calvo, 2007). Importantly, their theory is a broad one that focuses on the broad effects of acute, state anxiety (e.g., due to a test) as opposed to looking at anxiety as a clinical disorder. They do, however, suggest that there are two possible effects of anxiety on attentional control. It may be that anxiety is associated with impaired recruitment of attentional control resources, or it may be associated with intact abilities, but impaired recruitment of attentional control resources. Other researchers have also demonstrated that anxiety is associated with impairments in attentional control. Bishop (2009) performed an fMRI study that showed that individuals with high trait anxiety, as measured by self-report on the STAI (Spielberger et al., 1983), have reduced recruitment of the dorsolateral prefrontal cortex, an area of the brain that is believed to be important for attentional control. Importantly, they found this to be the case only when the task demands were low such that the primary task did not occupy full attentional resources. Bishop uses her evidence to suggest that poor attentional control may be a type of processing style or deficit that could underlie clinical anxiety, threat-related biases, and "more general, day-to-day problems in concentration and work-related cognitive function" (Bishop, 2009, p. 97).

Attentional Control Deficits Leading to Anxiety

Given that attentional biases towards threat have been widely reported in the literature (e.g., Bar-Haim et al., 2007), researchers have begun to examine the moderating role of attentional control. In an early influential study, Derryberry and Reed (2002) found evidence to suggest that attentional control moderated the relationship between anxiety and bias for threat-related stimuli. To test their hypothesis that attentional control would moderate the effect of trait anxiety on biases for threat-related stimuli they designed a

spatial orienting task included both a threatening and non-threatening condition, as well as a delay between presentation of a cue and the target. Derryberry and Reed found that undergraduates with high trait anxiety, as measured by self-report (i.e.. STAI; Spielberger et al., 1983) showed a stronger bias towards processing threatening cues and had a strong bias towards processing safe cues at trials that had a longer delay between the cue and the target. Importantly, they also found that the threat bias was moderated by individual differences in attentional control. Individuals with poor attentional control and high trait anxiety had difficulty disengaging from threat-related stimuli at longer delays, and those with high trait anxiety and good attentional control were better at shifting their attention away from the threat-related stimuli. Their data suggest that strong attentional control abilities could serve as a protective factor and, importantly, that poor attentional control skills may be a vulnerability to clinical levels of anxiety.

Other studies have also examined the moderating role of attentional control and threat-related stimuli. Bardeen and Orcutt (2011) examined bias towards threat-related stimuli using a dot-probe task and attentional control in adults who suffered from post-traumatic stress disorder (PTSD). As with Derryberry and Reed (2002), Bardeen and Orcutt (2011) found that individuals with high PTSD symptoms, as measured by self-report, and lower attentional control abilities, also measured by self-report, had more difficulty shifting attention away from threat-related stimuli than those with high PTSD symptoms and stronger attentional control abilities. Building on this work, a more recent study found that attentional control also moderated the relationship between social anxiety and bias towards threat-related stimuli (Taylor, Cross, & Amir, 2016). The authors found that those with stronger attentional control and high social anxiety were more likely to be able to shift

attention away from threat related stimuli, in comparison to those with high social anxiety and poor attentional control skills, both measured via self-report. Importantly, this was only the case for those with high trait anxiety and only when examining the ability to shift attention *away* from threat-related stimuli. That is, a similar finding was not observed when examining initial orientation towards threatening stimuli. Across the studies that have examined the moderating role of attentional control on attentional biases, such an effect has been found only when examining disengagement from threatening stimuli. Moderating effects for the role of attentional control have not been found when looking at the initial orienting towards threatening stimuli, and this suggests that attentional control plays a larger role in the voluntary, later stage of attentional allocation.

Attentional Impairments in ASD

ASD is associated with multiple impairments in multiple domains of cognitive functioning and some theories posit that executive dysfunction impairment plays a key role in understanding ASD (Hill, 2004b). Further, deficits in attention itself are often seen in those with ASD, such that there is some research that suggests disrupted attentional processes specifically are related to core ASD features (Sacrey, Armstrong, Bryson, & Zwaigenbaum, 2014). Given that many of these processes are implicated in anxiety, as reviewed above, the nature of these deficits will be explored.

Impaired Attentional Disengagement.

Disengagement of attention, or the ability to shift attention from a fixed stimulus, is the first process in drawing attention away from one stimulus to another. Researchers have studied attentional disengagement using a variety of paradigms, including the Gap-Overlap task. The Gap-Overlap task is a measure of visual attention and provides an index of the

latency to begin an eye movement from a centrally presented stimulus to new stimulus presented in the periphery (e.g., a saccade). The task typically includes two or three trial types. There are overlap trials, in which the centrally presented stimulus remains in view as the novel, peripheral stimulus is presented. There are gap trials, in which there is a temporal gap between the centrally presented stimulus and the presentation of the novel, peripheral stimulus. Some studies also include baseline trials, in which the centrally presented stimulus is immediately removed and the peripheral stimulus is presented. The task examines the ability to shift attention away from the centrally presented fixation stimulus. On baseline and gap trials, the individual passively disengages attention away from the central fixation. However, on overlap trials, the individual purposefully disengages attention from the central fixation to the peripheral stimulus.

In one of the first studies to examine disengagement of attention in children with ASD, Landry and Bryson (2004) used the Gap-Overlap task with children with ASD and compared them against children with Down's Syndrome and typically developing children. The children were approximately 5 years in age, with diagnoses of ASD being confirmed through a child psychiatrist or developmental pediatrician, with use of validated tools (i.e., the Autism Diagnostic Inventory [ADI-R]; Lord, Rutter, & Le Couteur, 1994). Down's Syndrome was not confirmed diagnostically but youth were recruited from an early intervention program for special needs children and local service organizations. In their version of the Gap-Overlap task, dynamic geometric shapes (e.g., triangles or rectangles) filled with bright colors (e.g., red, green, purple, blue, etc.) were used. The Down's Syndrome and the typically developing children were used as control groups and were matched to non-verbal mental age. The authors found that there were no differences across

the groups in reaction times for Gap trials. However, there was a group difference on overlap trials that was specific to the ASD group. Those children took longer to examine the peripheral stimulus when the central stimulus was also present, indicating that there was some difficulty in disengaging attention. Further, a small minority (18%) of the ASD children failed to move their attention at all from the central stimulus, compared to the rarity of this occurrence in both the typically developing and Down's Syndrome groups (7.7% and .08%, respectively). The inclusion of the Down's Syndrome control group suggests that this impairment in disengaging attention is specific to ASD and not a part of a picture of developmental delays.

Other studies have shown similar findings across development. For example, the Gap-Overlap paradigm was used to track development of attentional disengagement at 6 months and 12 months of age (Zwaigenbaum et al., 2005). Over the course of two years, the authors followed two groups of children: those who had a sibling with ASD and control subjects who did not have a family history of ASD. Those with a sibling who has ASD were identified as being high-risk because of the heritability of ASD. They were compared against infants who were identified as low-risk (e.g., no family history of autism and no history of difficulties at birth). The research team also verified the diagnosis of ASD in the older siblings with a clinical interview and the ADOS (Lord et al., 2000). Furthermore, both the low and high risk infants underwent an ASD assessment at 24 months using the ADOS (Lord et al, 2000). These children were identified as having a high risk of autism, given the heritability in ASD. They were compared against 75 infants who were identified as low-risk (e.g., no family history of autism and no history of difficulties at birth). Using the same paradigm and stimuli as Landry and Bryson (2004), several findings unique to

ASD were reported. Overall, there was no difference between the high-risk and the low-risk infants across gap or overlap trials at 6 months of age. By 12 months, however, high-risk ASD infants were, on average, slower than the low-risk group on overlap trials only. When they examined individual differences in the change from latency on overlap trials from 6 to 12 months of age, all of those infants who had an increase in latency (e.g., took longer to disengage attention) were classified as having autism at 24 months. These findings were unique to the overlap trials and suggest a lack of improvement in the ability to disengage attention is related to the presence of core ASD symptoms.

Similar findings were reported by other research teams. Elsabbagh et al. (2013) studied the development of attentional disengagement at 7 months and 14 months, followed by an evaluation of ASD at 36 months. The Gap-Overlap paradigm, with similar dynamic, colorful stimuli, was used to examine attentional development in high risk and low risk infants, as well as infants who were at risk for developmental delays. High-risk infants had a sibling with ASD that was confirmed by the research team through a combination of parent report and clinical judgment by the study authors. ASD was assessed for study participants with the ADOS (Lord et al., 2000), a structured clinical interview, and clinical judgments. Finally, infants were deemed at risk for developmental delays if they were found to have a low IQ scores (i.e., <1.5 standard deviations) on standardized cognitive testing and did not meet criteria for ASD. Their analysis focused on the diagnostic status of the study participants at 36 months: at-risk ASD (e.g., diagnosed with ASD), at-risk-other (e.g., low IQ), at-risk-typical (e.g., not diagnosed with ASD but high risk), and control participants. At 7 months of age, no differences in disengagement were observed across the four groups. At 14 months, however, the infants categorized as at-risk-ASD had

a longer latency on overlap trials compared to the other three groups. Further, 40% of those children who had an increase in their disengagement latency were diagnosed with ASD at 36 months, similar to the findings in Zwaigenbaum et al. (2005).

The Gap-Overlap paradigm has also shown difficulties in attentional disengagement in older children (Sabatos-DeVito, Schipul, Bulluck, Belger, & Baranek, 2016). Fifty children from ages 4 to 13 years were tested using this paradigm, which utilized static stimuli, dynamic and colorful stimuli, and dynamic stimuli that included an auditory component. The sample included an ASD sample, a developmentally delayed sample, and a typically developing sample. ASD was confirmed through the ADOS-2 (Lord et al., 2006) and the ADI-R (Le Couteur et al, 2003), and the developmentally delayed sample was assigned to youth who scored more than 1.5 standard deviations in two or more domains on standardized cognitive testing. The authors found that there was a significant difference across the groups in disengagement latencies (e.g., a main effect on this variable) but pairwise comparisons did not find any differences between the groups on overall disengagement latencies. There was also a significant interaction between group and stimulus type, such that those with ASD were more impaired than typically developing and developmentally delayed children when faced with a dynamic object that also included an auditory component. Examining trial accuracy, those with ASD did have significantly fewer trials than both groups in which they successfully disengaged their attention from the central objects and trials in which they were able to shift their attention towards the novel objects. The results of this study are consistent with the other reviewed studies, which show that children with ASD do have difficulty disengaging attention and that this is especially noted when presented with stimuli that contain more than one sensory-

component. Although a specific difficulty in the ASD group was not found with respect to attentional disengagement latency, this may be due to a small sample size across the three groups.

While multiple studies have found clear difficulties among participants with ASD in disengaging attention using the Gap-Overlap paradigm, others have not found evidence for such an impairment. Comparing a sample of ASD children, ages 5 to 12 years, to a sample of typically developing children, a recent study found no evidence to suggest any difficulty in disengaging attention for ASD youth (Fischer et al., 2015). The sample included youth with a previous ASD diagnosis that was confirmed through the administration of the ADOS-2 (Lord et al., 2006) and also assessed overall cognitive abilities. Unlike the previously reviewed trials, their stimuli consisted of social stimuli (e.g., faces) or non-social stimuli (e.g., fruit, vegetables, vehicles). They found no evidence that there was an impairment in disengagement of attention, either for social stimuli or non-social stimuli. They were able to replicate their findings in a study of toddlers as well (Fischer et al., 2015).

These recent studies join previous studies, also using the Gap-Overlap paradigm, that have also found mixed evidence for a deficit in attentional disengagement in youth with ASD. For example, one of the first studies to examine attentional disengagement in ASD youth did not show evidence of any impairment in ASD youth around 10 years of age (Van der Geest, Kemner, Camfferman, Verbaten, & Van Engeland, 2001). Their stimuli were non-social in nature and consisted of small crosshairs for the fixation and a white square with a black outline for the peripheral stimulus. The ASD children met criteria either for ASD or Pervasive Developmental Disorder Not Otherwise Specified, an autism spectrum

disorder that captures an atypical ASD presentation. The children in this category, approximately one-third, were diagnosed as PDD-NOS and exhibited deficits in social-reciprocity characteristic of ASD. These researchers found that there was no difference between the ASD group and the typically developing group on overlap trials, suggesting that the two groups did not differ in attentional disengagement abilities. There were also no overall differences between groups on gap trials as well. However, they also examined the gap-effect, a measure of attentional engagement that is taken by subtracting average reaction time from overlap trials and gap trials. That is, the gap-effect is the difference between reaction time when the target is visible (overlap trials) and when the target is not visible (gap trials). The effect was driven by no significant differences between groups on overlap trials (where ASD was faster) and gap trials (where ASD was slower). The non significant differences make it difficult to make a strong claim, but the authors suggest that this represents a lower level of attentional engagement since the difference in the gap effect was driven by less attention being spent at the central stimulus.

Another study of adolescents with ASD also yielded mixed findings (Goldberg et al., 2002). Participants were youth between the ages of 12 and 18, with a diagnosis of ASD that was confirmed through the use of the ADOS (Lord et al., 2002) and the ADI-R. The stimuli consisted of simple LED lights that flashed on and off during the task. Interestingly, the ASD group was impaired across all trial types, indicating a widespread impairment in attentional mechanisms. These findings were similar to another study of ASD children 5 – 15 (Todd, Mills, Wilson, Plumb, & Mon-Williams, 2009). In this study, ASD was confirmed through the ADOS (Lord et al., 2000) and the ADI-R (Lord et al., 1994). Stimuli again consisted of simple visual stimuli, with a small "x" as both the central and peripheral

stimuli. For older children, between the ages of 9 to 15, there was a significant difference across all trial types between the ASD youth and typically developing controls. They found no differences between trial types in the younger subset of children. As with the previous findings, the results of Todd et al. (2009) also suggest a widespread impairment in attentional mechanisms.

Across the studies that did demonstrate a specific deficit in attentional disengagement, the use of dynamic, colorful stimuli was common (e.g., Elsabbagh et al., 2009; Landry & Bryson, 2004; Zwaigenbaum et al., 2005). In contrast, the stimuli across the other experiments used static stimuli of either pictures (e.g., faces or objects, J. Fischer, Koldewyn, Jiang, & Kanwisher, 2013) or simple shapes (e.g., "x" or boxes, Goldberg et al., 2002; Todd et al., 2009). It may be that these simple shapes did not capture attention in the same way that dynamic, colorful stimuli do. Looking at the pattern of results across these studies also reveals an interesting pattern. There was evidence of widespread attentional impairment when simple stimuli were used. There was no evidence of attentional impairment when common stimuli were used, such as faces, cars, and other objects. But when there were dynamic stimuli used, there was evidence for a deficit in attentional disengagement in ASD youth. Only one study to date has examined static versus dynamic stimuli within the same participants (Sabatos-DeVito et al., 2016), and they found that youth with ASD showed a greater deficit with disengaging attention when presented with dynamic stimuli that also included an auditory sound, but did not find any specific differences in the ASD group between static and dynamic stimuli attentional disengagement. However, it must be noted that there was an overall effect of group on reaction times of attentional disengagement, with the ASD group showing slower latencies

compared to the other groups. It may be the case that those with ASD have more difficulty disengaging their attention from dynamic stimuli because they capture the attention of ASD youth more than typically developing or other developmentally disabled youth. Attentional disengagement may not be a generalized deficit, but children with ASD may have difficulty disengaging attention under certain conditions, such as when presented with stimuli that have unique visual properties.

Shifting.

In addition to evidence suggesting that attention shifting, in the form of attentional disengagement, is impaired in ASD, youth with ASD also show impairments in cognitive flexibility more broadly. For example, behavioral rigidity and perseverations are part of the diagnostic criteria for ASD (APA, 2013). Data from the Wisconsin Card Sorting Task, a widely used measure of executive functioning and cognitive flexibility, supports this notion. This task requires that individuals sort cards per an unknown rule and the individual has to shift the rules to sort the cards along another dimension. As this shift takes place, the individual is given feedback to help them learn the new rule themselves; they are never told directly. Across multiple studies, people with ASD have been shown to have difficulties in shifting their responses once they learn the initial rule. That is, they tend to perseverate on their previously learned responses and have difficulty in adapting (i.e., shifting) their responses even in the face of feedback (Hill, 2004). Research using other paradigms has also yielded similar results. The Intra-dimensional / Extra-dimensional set shift (ID/ED) of the CANTAB test battery has also been used to examine set-shifting in ASD. The ID/ED task is similar to the Wisconsin Card Sorting Test in that it requires individuals to learn rules about a given set of stimuli that vary based on two dimensions:

shape or line. Participants learn to select the correct stimuli based on feedback and the rules eventually change such that there is an intra-dimensional shift and an extra-dimensional shift. The intra-dimensional shift (e.g., within the shape dimension) requires that attention be shifted to a new exemplary of a category to a stimulus that is, or was previously, relevant. The extra-dimensional shift requires that attention be shifted to a different category that was previously irrelevant. Those with ASD have been found to have impairment in making the extra-dimensional shift, providing further evidence that individuals with ASD have difficulty in shifting attention from one concept to another (Ozonoff et al., 2004).

Inhibition of Dominant Responses.

A related aspect of attentional control is response inhibition. Indeed, difficulty in inhibiting inappropriate behavior is an often seen part of the clinical picture of ASD. Inhibition specifically refers to the ability to cancel or suppress an action and is often divided into prepotent response inhibition and resistance to distractor interference (Friedman & Miyake, 2004). Tasks that examine the ability to suppress a dominant motor response include the Go/No-Go tasks. In such tasks, individuals are asked to respond as fast as possible to a stream of quickly presented stimuli and asked to withhold a response (e.g., inhibit) to specific stimuli that are infrequently presented. Resistance to distractor interference is often measured by tasks such as the Flanker Task. In these types of tasks, individuals are presented with a stimulus and asked to make a correct response as quickly as possible. On some trials, distracting information is presented that is designed to evoke the opposite response and the challenge is to ignore the irrelevant information.

Research examining inhibition has yielded mixed and contradictory findings (e.g., Hill, 2004). However, a recent meta-analysis examining 41 studies showed that there was sufficient evidence to suggest that individuals with ASD show impairments in both prepotent response inhibition and interference control, when compared to typically developing individuals (Geurts, van den Bergh, & Ruzzano, 2014). When examining response inhibition, a total of 23 separate studies showed an overall effect size of .55 (Hedges' g) and when examining interference control, a total of 28 studies showed an overall effect size of .31. They were also able to examine moderating variables given their large sample size. Age was found to be a moderating variable only for prepotent response inhibition but not for interference control. The authors were not able to examine ASD symptom severity as a moderating factor. However, previous studies have examined both aspects of inhibition across the ASD spectrum (e.g., by DSM-IV-TR [APA, 2011] diagnoses) and have not found any differences (Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006).

Impact of Difficulties in Attentional Processing in ASD and its Relation to Anxiety

Attentional factors are believed to play an important role in the development and maintenance of anxiety. As reviewed above, various attentional factors are implicated in anxiety, including early attention diverted to threat-related stimuli to dysfunction in later voluntary control of attention (e.g., Cisler, Koster, & Ernst, 2011; Derryberry & Reed, 1994). Attentional control is a multifaceted construct, and many processes that underlie attentional control are impaired in those with ASD. These include dysfunction in shifting attention (e.g., orienting), shifting mental concepts, and inhibiting the influences of distracting information and dominant motor responses (Dawson et al., 2004; Geurts et al.,

2014; Hill, 2004b). Indeed, impairment in the broader concept of executive functioning is believed to be an important element in understanding ASD (Hill, 2004a).

Impairment in these processes could lead to the development of anxiety in multiple ways. In the most straightforward explanation, it is likely the case that impairment in attentional control leads to anxiety in a similar way as it leads to anxiety in typically developing children. As previously reviewed, poor attentional control can lead to anxiety through many ways, including preferential orientating to threat-related stimuli and in difficulty disengaging attention from threat-related stimuli. Given that individuals with ASD have been shown to have deficits in areas such as attention shifting, disengaging attention, and suppressing irrelevant distractors, it follows that this may lead to a situation in which there is a heightened risk for the development of anxiety. This would support the hypothesis that anxiety develops in such a way that is similar to typically developing children (e.g., Wood & Gadow, 2010).

However, it may also be the case that the unique characteristics of those with ASD also give rise to the development of anxiety in youth with ASD (e.g., Kerns & Kendall, 2012). One example of this is the lack of orienting to social stimuli seen in those with ASD (e.g., Dawson et al., 2004). Such a basic dysfunction may lead to heightened anxiety by removing a potentially calming stimulus (e.g., a mother trying to soothe a fussy infant or an anxious child). Although there is some debate regarding whether individuals with ASD find social interaction as inherently pleasurable as typically developing children often do, even a neutral stimulus could provide a counter point to attention being focused on a threat-related stimulus.

Whereas it was observed that youth with ASD have difficulty disengaging from dynamic, brightly colored visual stimuli (e.g., Landry & Bryson, 2004), some studies suggest that youth with ASD do not have difficulty disengaging attention from social and non-social objects (e.g., Fischer et al., 2013). This discrepancy suggests that the impairment may be specific to stimuli that highly capture their interest. Indeed, youth with ASD often fixate on small details (e.g., Happe & Frith, 2006) of objects and often exhibit difficulty redirecting from their specialized interest. Attentional disengagement in these moments may lead to a bias towards nonsocial aspects of the environment and prevent the learning of other strategies that could be useful in the face of fear. For example, youth with ASD may attempt to self soothe during anxious moments by retreating into their own specialized interests and, as this strategy becomes reinforced over time, it may be more difficult to redirect children's attention and teach more adaptive coping skills.

It is also possible that under-attending to social stimuli may lead to increased anxiety through other pathways. For example, it is documented that individuals with ASD have difficulty processing faces at a global manner and often have difficulty in identifying emotions in others (Tanaka et al., 2012). Those on the spectrum may have fewer opportunities to develop an ability to infer the emotions of others because of decreased attention to faces and may be more likely to interpret a neutral face as a threatening one (Kuusikko et al., 2009).

Treatment Implications

Attention Bias Modification Treatment

Developing a better understanding of the role that attention plays in the presentation and etiology of anxiety in youth with ASD has important implications for developing

further treatments. This is especially true, as current first-line behavioral treatment approaches for anxiety often emphasize the need to remain and stay focused on the feared object or situation and drifting attention or shifted attention is thought of an as form of situational avoidance, counter to the overarching aim of creating new consequences with the feared objects or situations.

One approach that has received extensive research within the last decade focuses on training biases away from attention, stemming from the finding that those with anxiety have biases towards threat-related stimuli. These attention bias modification treatments are believed to target the automatic trajectories of attention and aim to loosen the initial orienting towards threat-related stimuli (Bar-Haim, 2010); a previous meta-analysis of adult studies shows a moderate treatment effect on attention retraining (d = .61; Hakamata, Lissek, Bar- Haim et al., 2010).

There have also been a handful of studies that have examined the effects of attention bias modification training with youth. For example, Bar-Haim, Morag, and Glickman (2011) trained 34 anxious youth to disengage attention away from threatening faces. Their attention training program was similar in design to dot-probe tasks: each trial began with a central fixation, followed by a picture of either a neutral or threatening face on one half of the screen. The face was followed by the target on either half of the screen, and participants had to report which side (left or right) the target was on. Trials either had valid cues (e.g., the target appears where the face is) or invalid cues (e.g., the target appears on the opposite side). Importantly, all of the threatening faces were invalid cues and the majority of the neutral faces were valid (75%). Thus, the task trains youth to disengage attention from the angry face towards the opposite side of the screen. Bar-Haim and

colleagues found that two sessions of attention training (768 total trials) were successful in helping children to disengage attention away from novel threat-related stimuli. Additionally, those who completed the training reported less anxiety after a stress induction task (being asked to complete three difficult puzzles while being filmed), as compared to youth who received a control training where the majority of both angry and neutral faces were valid (75%). However, both the control group and the training group showed decreased self-reported trait anxiety, suggesting that there was some benefit that the control group gained from general task practice.

Rozenman, Weersing, and Amir (2011) published a case series of an attention bias modification training with 16 anxious youth with diagnosed anxiety disorders. Their attention training program was also based on the dot-probe methodology. Unlike Bar-Haim et al., (2011), Rozenman and colleagues designed their training such that each trial began with a central fixation, followed by the simultaneous presentation of both a neutral and a threatening face, followed by a target. Importantly, the target appeared at the space previously occupied by the neutral face 80% of the time. Thus, the program was designed to allow the youth to learn to focus their attention towards the neutral face. After twelve 15-minute training sessions delivered over four weeks, 75% of youth no longer met criteria for an anxiety disorder at post-treatment. However, they did not find evidence that there was a statistically significant change in attention biases, as measured by a standard dot probe task, from pre- to post-treatment. The general trend of the changes, towards a reduced attention bias, was observed across subjects.

Other researchers have opted for another direction in attention training, focusing on training attention towards positive stimuli. In one study, youth with an anxiety disorder

were trained to find positive stimuli (a happy face) among a three by three array of threatening stimuli (angry faces; Waters, Pittaway, Mogg, Bradley, & Pine, 2013). They were compared to a control group, also consisting of anxious youth, who received a control training condition where they searched for birds among an array of flowers. After completing a minimum of 10 training sessions (each consisting of 160 trials), the researchers found that the group training to attend to positive stimuli saw improvement in their anxiety. Fifty percent of them no longer met criteria for an anxiety disorder, compared to only 8% in the attention training control group. The positive attention training group also saw an increase in attention biases towards happy faces, with no changes found in attentional biases towards threatening stimuli. In a larger study that compared a similar version of the positive attention training to a waitlist control condition, youth who completed 12 sessions of the training saw improvements in self- and parent-reported anxiety measures and 32% of the group no longer met criteria for any anxiety disorder (compared with no change in the control group; Waters et al., 2015). As in their earlier study, there was no change in attention biases towards negative stimuli; however, the youth in this study who received the attention training treatment did not show an increase in attention bias towards positive stimuli post treatment.

The attention bias modification training programs reviewed here do suggest that training attention can lead to improvement in anxiety symptoms and they highlight the important role that attentional control plays. Indeed, the studies reported above suggest that changes in voluntary attentional control abilities may be a key mechanism of action for what is called attention bias modification training. For example, Bar-Haim et al. (2010) found that both their active attention training program (e.g., promoting disengagement from threat

related stimuli) and the control condition (e.g., which did not promote attention away from threat related stimuli) both led to decreases in self-reported anxiety. It may be the case that both the control and the active trail led to improvements in attention control by promoting the efficient use of these abilities. Even in the control condition, participants were still instructed to find the cue as quickly as possible and, given the lack of an entirely reliable cue, would still have to engage mechanisms of attentional control throughout the task.

Of the other youth attention training programs reviewed, all failed to find a change in biases toward threatening stimuli. Some showed a trend for such a change (Rozenman et al., 2011) and others did not show any evidence at all (Waters et al., 2013, 2015). However, all three training programs led to improvements in anxiety severity. In the case of the attention program designed by Waters and colleagues (2013, 2015), there is clear evidence that training was successful in inducing a bias towards positive stimuli. Despite the lack of changes in biases toward negative stimuli, these studies, and those in the adult literature, do suggest that attentional control processes are malleable. In the adult literature, similar findings have been reported and researchers suggest that other processes, such as the ability to disengage from threat, may be more important than change in attentional biases per se (e.g., Amir, Elias, Klumpp, & Prezworski, 2003).

Researchers have begun to examine the question as to whether attention bias modification improves attentional control more directly. Heeren, Mogoaşe, McNally, Schmitz, and Philippot (2015) trained 61 adults with social anxiety disorder using an attention training program similar to the one used by Rozenman and colleagues (2011). However, they added additional conditions to explore the role of attentional control. They trained participants to either focus on the non-threat (e.g., neutral) cue, the threat cue, or to

neither (e.g., control condition). In the non-threat and threat conditions, the target replaced the cue on 95% of the trials. In the control condition, the target replaced each neutral or threatening face 50% of the time. Additionally, they included a measure of attentional control, the Attention Network Task, that was given both before and following training. The attention network task assessed the efficiency of the alerting, orienting, and executive control network. Heereen and colleagues found that participants across all three conditions showed improvement in the alerting and executive control network, with a trend for improvement in the orienting network as well. Additionally, all training groups saw similar improvements in behavioral and self-reported measures of anxiety associated with giving an impromptu speech. The results from this study, the first to explore the impact of attention bias modification training on all three attention networks, suggest that the mechanism works through increasing top-down attention control. Importantly, this finding was observed in all versions tested, providing further support that is it not necessarily the training of attention to one specific cue, either positive or negative, but that providing a structured opportunity for individuals to practice their guided allocation of attention.

Cognitive Training in ASD

Outside of attention training, cognitive training more generally has been used to improve cognitive abilities of youth (e.g., youth with attention-deficit/hyperactivity disorder; Klingberg et al., 2005). However, there is limited research examining cognitive training in youth with ASD. Although some cognitive behavioral therapy programs provide social skills training that includes cursory problem-solving training (e.g., Bauminger, 2002; Solomon, Goodlin-Jones, & Anders, 2004), only a handful of interventions have been developed to target cognitive functions directly. In one study,

youth with ASD in third through fifth grade were randomized to two treatment conditions: social skills training and executive function training (Kenworthy et al., 2014). The social skills training was intended as a control condition and consisted of interventions designed to teach basic social skills, such as turn-taking, proper etiquette, and interacting positively with peers. The executive function training was designed to teach new skills and introduce accommodations for impairments in flexibility, goal setting, goal planning, and problem solving (Ylvisaker & Feeney, 1998, 2008). Unlike the attention training reviewed above, the executive functioning training in this program was taught through direct parent and teacher interventions that use concrete examples, activities, games, and role plays. Thus, it was similar in nature to how the social skills training was conducted. Training was provided over the course of one school year, in 28 sessions approximately 40 minutes in length in small group settings (e.g. 3 – 6 children). Surprisingly, they found that youth in both groups demonstrated positive development in prosocial behavior, as measured by parent and teacher report of appropriate social behavior. However, only the executive function training led to improvements in various measures of executive function, such as problem solving, flexibility, organizing, and planning. Further, only youth in the executive function training group saw improvements in classroom behavior (e.g., participating, handling new situations, following rules, transitioning with ease, etc.). The results from this training program highlight the malleability of executive functioning in youth with ASD, despite broad impairment. Although attentional control was not directly training or assessed in this intervention, many related mechanisms were directly trained and these youth saw improvement not only in lab-based assessment, but also real-world observation of behavior.

Conclusion

Attentional processes, such as attentional control abilities, and their contribution to the biased processed of threat-related stimuli have been implicated in the development and maintenance of anxiety in typically developing children. Many of the cognitive mechanisms that underlie attentional control are often impaired in those with ASD. Does the dysfunction in attention set the stage for the development of anxiety in those with ASD? Not every individual with ASD suffers from anxiety; however, anxiety is overrepresented in ASD compared to typically developing individuals (e.g., Simonoff et al., 2012). Understanding the cognitive factors that are often, though not universally, disrupted in those with ASD provides one pathway to understanding how anxiety might be likely to develop in an individual with ASD.

Research is needed to understand the role that cognitive and attentional factors play in the development of anxiety in ASD. Although a case has been made regarding the contributions of attentional control to ASD and to anxiety, no research has directly examined these pathways. However, several possibilities for further study emerge from the literature. It may be the case that deficits in attentional disengagement impact the development of important skills involved in emotion regulation and these deficits in emotion regulation lead to overrepresentation of anxiety in individuals with ASD. Yet, emotion regulation skills are, by definition, broad and are implicated in multiple disorders beyond anxiety. It is likely that they interact with a host of other factors to influence the development of anxiety. Here, we also reviewed the attentional control literature which suggests these mechanisms are also directly implicated in the development of anxiety disorders themselves. Further, we provided evidence that these mechanisms are often

impacted in youth with ASD. These deficits may represent one pathway in which anxiety develops in youth with ASD.

Within the research on ASD there is extensive work studying executive function abilities related to attentional control and an emerging literature focusing on the presentation of anxiety. That said, the literature needs a focus on the more basic pathways. This is especially true as it can help shape treatment approaches. For example, if basic attentional processes are, indeed, related to anxiety in those with ASD, this type of intervention might represent a viable treatment approach. In typically developing children and adults, novel treatments such as attention bias modification training have emerged as a promising line of treatment (Bar-Haim et al., 2011). In paradigms such as these, children learn to focus their attention away from threat-related stimuli to either positive or neutral ones. Importantly, evidence suggests that it is not the training of diverting attention to positive stimuli per se that is important. Rather, the mechanism of action appears to be the general training of attention shifting. The specific modification of attention has been identified as an important part of the treatment approach and studies that have failed to find positive outcomes with attention training paradigms have often failed to find evidence of a modification of attentional processes (MacLeod & Clarke, 2015). In other words, attentional control is improved through attention bias modification training. If such attentional mechanisms are also found to be important in those with ASD, training programs such as attention bias modification training may prove to be a viable treatment strategy for those with ASD and co-occurring anxiety.

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