Paradigm Shift: A Live Real-World Attention Bias Task To Predict Social Anxiety And Depressive Symptoms In Adolescent Girls

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Rates of depression and social anxiety increase dramatically during adolescence, particularly in girls. Cognitive models of depression and anxiety have implicated attention biases, or preferential attention toward negative stimuli, as a possible mechanism by which individuals develop depression and anxiety. Yet, little is understood about how attention biases operate in social anxiety and depression during adolescent development. Furthermore, most research on attention biases have used computer paradigms (e.g., the dot probe task) to study attention; however, such tasks may be limited in their applicability to real-world settings. To examine attention biases in a live, socially evaluative environment, 123 adolescent girls (aged 11-13) gave a speech in front of a potentially critical judge and a positive judge while wearing mobile eye-tracking glasses. To compare this new task to a more traditional measure of attention, participants also completed a stationary, eye-tracking version of the dot-probe task. Clinician and self-report measures of social anxiety and depressive symptoms were collected. Results revealed that attentional bias indices from the live task demonstrated stronger reliability than those from the dot-probe task. Attention indices from the live attention task were not found to be comparable to indices from the dot probe task, suggesting these tasks tap into unique attentional processes. Overall, girls with greater sustained attention to negative compared to neutral stimuli reported higher levels of social anxiety, and girls who were faster to disengage attention from negative compared to neutral stimuli reported higher levels of depressive symptoms in the dot-

probe task. Additionally, girls who spent less time dwelling on the positive judge in the live attention task reported higher depressive symptoms, in line with previous research, suggesting attention patterns in the live attention task may be an important marker for depressive symptoms in adolescence. Future research may benefit from using a prospective, longitudinal research design to examine how attention bias in multiple contexts may be associated with the onset of social anxiety and depressive disorders in order to improve current mechanistic prevention and intervention efforts.

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1.0 Introduction

During adolescence, rates of social anxiety disorder (SAD) and major depressive disorder (MDD) increase sharply (Avenevoli et al., 2008; Costello et al., 2003; Hankin et al., 1998), particularly among girls (Andersen & Teicher, 2008; Hankin et al., 1998; Kessler & Walters, 1998; Saluja et al., 2004; Sheeber, Hops, & Davis, 2001). These disorders are associated with poorer educational outcomes, poorer interpersonal functioning, and increased risk for future psychopathology (Pine, Cohen, Cohen, & Book, 1999) and suicide (Gotlib, Lewinson, & Seely, 1995; Thapar, Collishaw, Pine & Thapur, 2012). Even sub-clinical symptoms have been shown to cause functional impairment and put youth at a higher risk for a later diagnosis of SAD or MDD (Aune & Stiles, 2009; Feng, Shaw, & Silk, 2008; Pine, Cohen, Cohen, & Brook, 1999). Therefore, uncovering processes that influence the development of SAD and MDD are of critical importance, particularly during adolescence when risk for these disorders increases.

1.1 Attention Biases

Attention bias may be a potential shared mechanism underlying both SAD and MDD. According to Beck and Clark's influential cognitive model (1997), biased attention is theorized to contribute to the onset, maintenance, and recurrence of both anxiety and depressive disorders. Attention biases to negative stimuli are believed to affect downstream information processing in individuals, beginning a cascade of biased processing of negative information (Beck & Clark, 1997; Mogg & Bradley, 1998). However, the nature of attention biases as they relate to SAD and

MDD are poorly understood, particularly for youth, for a myriad of reasons. First, much of the existing literature examining attention biases overlooks the complexity of attention processing, which can conflate multiple processes that may be occurring, such as initial orienting and sustained attention. Additionally, there is less research assessing attention biases in pediatric populations and close to no research examining attention biases in adolescents, specifically. Furthermore, attention bias research may be constrained by the existing methodology used to assess attention biases. These methodologies may result in less accurately representing real-world attention patterns, which could lessen the direct clinical implications of existing research. The present study aims to clarify the association between attention biases and social anxiety and depressive symptoms occurring in adolescence by using newer technology and a paradigm that allows for the assessment of attention bias as it unfolds in vivo during a live speech.

1.1.1 Review of Attention Bias Research in SAD and MDD

Overall, a large body of empirical research has supported theoretical claims for attention biases occurring in SAD and MDD and for youth at temperamental risk for SAD and MDD. Adolescents at temperamental risk for both disorders have been shown to have an attention bias toward threat compared to low-risk youth (Pérez-Edgar et al., 2010). Across anxiety disorders, anxious individuals appear to have biased visual attention towards threatening stimuli (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007). Research has shown that adults with SAD demonstrate heightened vigilance toward threatening stimuli, albeit with a small effect size (g = 0.21) (Bantin, Stevens, Gerlach, & Hermann, 2016). Depressed individuals have a bias toward dysphoric stimuli (e.g., sad faces) and possible avoidance of positive stimuli

(Peckham, McHugh, & Otto, 2010). Taken together, while attention bias may be a shared mechanism in the two disorders, attention bias may operate differently in each disorder.

The nature of attention bias in SAD compared to MDD may be differentiated by the time course of the attention bias. Anxiety disorders are most commonly characterized by automatic attention biases toward threatening stimuli (Bar-Haim et al., 2007). Depressive disorders, on the other hand, are largely theorized to be associated with elaborative processing of and difficulty disengaging attention away from negative socio-emotional stimuli (Armstrong & Olatunji, 2012; Mogg & Bradley, 2005). Thus, attention bias in SAD and MDD may emerge at different stages of attentional processing; however, most existing research does not allow for the examination of the time course of attention, which may have clinically meaningful repercussions.

Better understanding of the time course of attentional biases is critically needed to inform mechanism-based intervention efforts. Attention Bias Modification (ABM) interventions have been developed to reduce anxiety and depression symptoms via implicit training interventions that are intended to reduce problematic attention biases (Jones & Sharpe, 2017). Meta-analyses have shown mixed efficacy for ABM in reducing anxiety and depression symptoms (Jones & Sharpe, 2017). One reason for inconsistent efficacy could be that ABM paradigms are not targeting the complexity of attention biases. Better characterization of the nature of attention bias can inform how ABM interventions are designed, which may result in improved clinical outcomes.

1.1.2 Limitations of Attention Bias Field

One major issue in the field of attention bias research is that generally attention bias studies assess attention bias via reaction time assessments, which have limited capability to demarcate the stages of attention and instead provide a measure of attention at a specific time-point (Armstrong & Olatunji, 2012). Eye-tracking methodology has emerged as a way to study visual attention continuously. Furthermore, recent technological advances in eye-tracking have moved beyond computer-based paradigms and are now capable of measuring attention biases during in vivo social interaction (e.g., Hutchinson et al., 2019; Woody et al., 2019). Therefore, eye-tracking paradigms now have the potential to elucidate the nature and time course of attention biases within a real-world social environment, thereby enhancing the ecological validity of attention bias paradigms.

While earlier studies of attention bias have frequently used emotional versions of the Stroop task, critics have considered the emotional Stroop to be more of a measure of inhibition than attention bias (De Ruiter & Brosschot, 1994). Currently, the most commonly used paradigm to measure attention bias is the dot-probe task (DPT; Mathews, Macleod, & Tata, 1986), which is a manual reaction time paradigm that is occasionally used in conjunction with eye-tracking methodology (e.g., Price et al., 2013). In this task, participants first view a pair of faces or words, one emotional and one neutral. After a brief period of time (typically 500 *ms*), the face or word pair stimuli disappear, and a probe appears in the prior location of either the emotional stimulus (congruent trials) or the neutral stimulus (incongruent trials). Participants typically make a motor response to indicate the location of the probe (i.e., a probe location task) or the type of probe (i.e., a probe identification task). When individuals respond faster to congruent trials compared to incongruent threat trials, these individuals are considered to have preferential attention or greater vigilance toward the emotional stimuli and thus display an attention bias for emotional stimuli.

1.1.3 Attention Bias in Anxiety

In adults with SAD, a meta-analysis demonstrated that across dot-probe paradigms, individuals with SAD demonstrated an attention bias toward threatening stimuli (Bantin et al., 2016). A meta-analysis of attention bias studies (in which attention bias was considered as a unitary index) conducted in anxious (varied subtypes) and healthy children demonstrated that children with anxiety display a greater attention bias toward threat-related stimuli compared to non-anxious controls; however, healthy children show a bias as well, albeit to a lesser extent than anxious children (Dudeney, Sharpe, & Hunt, 2015).

Given the clinical importance of attention bias research, studies are needed to test theoretical models of attention bias using technology that allows more complete testing of attention bias models. Three prominent models have been proposed to characterize attention biases in anxiety: the vigilance model, the vigilance-avoidance model, and the attention maintenance model/delayed disengagement model (Weierich, Treat, & Hollingworth, 2008). While the vigilance model only purports to explain the initial orienting stage, and the attention maintenance model only theorizes about later stages of attention, the vigilance-avoidance model makes predictions about initial and later stages of attention. The vigilance model of attention suggests that individuals with anxiety more easily detect threat in the environment and more quickly orient their attention toward threat compared to individuals without anxiety (e.g., Beck & Clark, 1997). This model proposes that exogenous threat cues capture attention faster, due to a decreased threshold for threat detection in anxious individuals. A large meta-analysis of visual attention paradigms found anxious individuals to display vigilance toward threat with a medium effect size (d = 0.45; Bar-Haim et al., 1997).

The vigilance-avoidance model of attention (Mogg & Bradley, 1998) has been proposed to explain anxious individuals' attentional patterns at both the orienting stage and later stages of attention. The vigilance-avoidance model purports that anxious individuals, relative to non-anxious individuals, more quickly orient to threatening stimuli and then later more avoid threatening stimuli. While initial orienting toward threat is thought to be due to bottom-up detection of exogenous threat, later avoidance is considered to be a strategic, top-down process by which anxious individuals are attempting to reduce arousal triggered by a threatening stimulus. However, there has been very limited evidence for this model in research that studies anxious children (Rosen, Price, & Silk, 2019).

The attention maintenance model (also known as the delayed disengagement model; Fox, Russo, Bowles, & Dutton, 2001; Weierich, Treat, & Hollingworth, 2008) focuses on attention shifting. The attention maintenance model proposes that once attention is focused on a threatening stimulus, anxious individuals take longer to shift their attention away from the threatening stimulus relative to non-anxious individuals, perhaps due to difficulty disengaging attention. A meta-analysis of eye-tracking research conducted in adults has found support for this model, but only using certain tasks (Armstrong & Olatunji, 2012). In children, there is less support for this model (Rosen, Price, & Silk, 2019). The current study aims to clarify whether SAD symptoms are better characterized by the vigilance-avoidance model or the attention maintenance model.

1.1.4 Attention Bias in Depression

Compared to anxiety, attention biases in MDD have been much less studied in pediatric populations; however, there is still considerable evidence for attention biases in youth at-risk-for and with MDD. Attention biases to negative socio-emotional stimuli assessed using the DPT have been shown to precede the first onset of depression among youth with mothers with depression, who are at higher risk for future depressive disorders compared to youth with mothers without depression (Joormann et al., 2007; Kujawa et al., 2011). Additionally, youth with depression aged 8-17 with no co-occurring anxiety have largely shown an attention bias toward sad faces that youth with co-occurring anxiety and depression do not exhibit (Hankin, Gibb, Abela, & Flory, 2010). However, some research suggests that depressed youth may display more avoidance of negative stimuli. One study found that attentional avoidance of threatening stimuli predicted depressive symptoms longitudinally (Price et al., 2016), and another study found that depressed children spent less time looking at sad faces and more time looking at positive faces compared to healthy control children (Harrison & Gibb, 2015). Taken together, there appear to be conflicting findings for depressed youth, with some evidence pointing towards an attentional pattern of avoidance of negative stimuli and some evidence for preferential attention toward dysphoric stimuli. The current study aimed to clarify whether depressive symptoms relate to either a pattern of avoidance or preference for negative stimuli.

Depression researchers have suggested that there may be a developmental shift that occurs in attention bias for negative stimuli, adjusting from a pattern of avoidance to a pattern of preferential attention to negative stimuli, which could account for some of the contradicting findings (Harrison & Gibb, 2015). Infants of mothers who are depressed avoid looking at their mothers compared to healthy control infants (Boyd, Zayas, & Mckee, 2006), perhaps using avoidance as an emotion regulation strategy. Yet, adults who have depression generally show consistent evidence for preferential attention to dysphoric stimuli and difficulty disengaging from negative stimuli (Gotlib & Joormann, 2010; Peckham, McHugh, & Otto, 2010). Therefore, there may be a developmental period when individuals at risk for depression or with depression may transition from a pattern of avoidant attention bias to a pattern of preferential attention toward negative stimuli at some point across development. Existing research has been unable to assess if or when this shift occurs because generally studies with pediatric populations have large age ranges which limits the ability to look at precise age or pubertal differences in attention biases.

1.1.5 Development and Attention Biases

One important developmental period in which to examine attentional biases is adolescence. Because the adolescent transition is marked by increases in self-regulation (Keating, Lerner, & Steinberg, 2004), this may be a key time for attentional regulation strategies to change. Cognitive control capabilities become more efficient over the course of development, with children reaching adult-like levels of efficiency by around age 12 (Passler, Isaac, & Hynd, 1985). Therefore, early adolescence may be a time by which attentional control strategies may become more similar to adults; however, research is needed to uncover when this switch occurs. Given that interventions have been designed to reduce attention biases, it is critically important to uncover the developmental differences in attention biases before designing and implementing interventions in adolescents.

Early adolescence is also a period of time in which sensitivity to social evaluation increases, as demonstrated by numerous neuroimaging studies (Guyer et al., 2009; Gunther Moor, van Leijenhorst, Rombouts, Crone., & Van der Molen, 2010; Bolling et al., 2011). Importantly, sensitivity to social evaluation may serve to increase MDD and SAD rates during this time (Kupferberg, Bicks, & Hasler, 2016; Merikangas, et al., 2010; Silk, Davis, McMakin, Dahl, & Forbes, 2012). Patterns of attention may serve to increase or decrease risk for SAD and MDD. Sustained processing of rejection cues may help maintain dysphoria and anxiety via a perseverative focus on perceived or anticipated social rejection (Slavich, O'Donovan, Epel, & Kemeny, 2010). These information processing biases may be especially prominent in adolescent girls, which may help to explain emerging gender differences in adolescent depression (Hammen, 2003; Rudolph & Flynn, 2014). Therefore, ecologically valid paradigms which use acceptance and rejection cues may be particularly potent to early adolescent girls and may better reflect how attention is allocated in the real-world.

1.2 Current Study

To evaluate how attention unfolds in a live context, we examined the newly created Attentional Speech Task (AST) (see Woody et al., 2019), which we tested in a sample of adolescent girls at temperamental risk to develop SAD and/or MDD. This task aimed to improve upon the ecologically validity of attention bias tasks by taking advantage of new, wearable eye-tracking technology and testing attention in the context of social evaluation, which may be particularly salient for early adolescents. As stated earlier, attention bias research heavily relies on the DPT, which generally uses static, adult faces. A primary aim was to examine if attentional indices derived from this new task, which uses live people, would be a better predictor of SAD and MDD symptoms than the standard laboratory task, the DPT. Another aim was to assess which attention models best predicted SAD compared to MDD. A final aim was to uncover the time course of attention bias in a real-world setting in order to inform existing interventions designed to target maladaptive attentional processing.

To measure visual attention using the AST, participants wore eye-tracking glasses while they gave a speech to two female confederate judges. One judge was a positive judge who provided approving gestures (e.g., smiling, nodding), and the other judge was a potentially critical judge who maintained a neutral expression and looked away from the participant (see Table 1 for description of judges' actions). The eye-tracking glasses allowed for the measurement of attention bias to the positive judge and the potentially critical judge in the context of a real-world scenario.

As biased attention to emotional stimuli can be assessed via differentiated attention components, we planned to calculate multiple attention indices that are most relevant to SAD and MDD, across both the traditional DPT and the AST. Because previous anxiety research has most strongly found evidence for heightened vigilance for threatening stimuli, we assessed the latency to fixate on the threatening stimuli and frequency of attentional allocation. Additionally, because the literature in anxiety is unclear if there is evidence for later avoidance or later maintenance on threatening stimuli, particularly for youth populations, we calculated an index of sustained attentional processing, which was time spent dwelling on the threatening stimuli. Previous research has shown that the attention components most related to depression are sustained attentional capture (i.e., longer time spent looking at emotional stimuli compared to neutral stimuli), thus we used dwell time as a predictor of depressive symptoms.

The first aim was to examine if attentional indices in the AST are associated with attentional indices in the DPT. We hypothesized that the corresponding attentional indices for each task will be significantly associated with each other. Therefore, we expected that initial vigilance to threat on the AST would be correlated with initial latency on the DPT, and sustained attention on the AST would be correlated with sustained attention on the DPT.

The second aim was to examine if attentional indices in both tasks were associated with SAD and MDD symptoms and examine if there was disorder-specificity. While we expected heightened vigilance to be associated with SAD symptoms, we expected that greater sustained attention to negative stimuli would be associated with MDD symptoms. Specifically, using the AST, we expected SAD symptoms to be associated with faster time to orient on the potentially critical judge relative to the positive judge, due to increased vigilance to threat that has been shown throughout SAD studies. Given the lack of studies that assessed attentional maintenance in youth with SAD and limited evidence for either attentional maintenance or later avoidance in adult eye-tracking literature (Armstong & Olatunji, 2012), there is not convincing evidence to suggest that SAD symptoms would be associated with attention biases at later stages of attention. We explored, however, whether attention maintenance or avoidance was associated with SAD in the AST. Using the AST, we expected that longer dwell time, representative of sustained attention, on the potentially critical judge relative to the positive judge would be associated with greater MDD symptoms.

We expected parallel results, using the traditional DPT. We expected faster time to orient on the threatening face to be associated with higher SAD symptoms, given research supporting attentional vigilance in SAD. Additionally, we expected that greater dwell time on sad faces would be associated with greater MDD symptoms, given research in youth at risk for depression (Joorman et al., 2007).

Our final aim was to examine if the AST was a better predictor of both SAD and MDD symptoms compared to the DPT. We hypothesized that attention indices derived from the AST would have a stronger association with both SAD and MDD symptoms compared to indices derived from the DPT.

2.0 Methods

2.1 Participants

One-hundred-twenty-nine early adolescent girls ages 11 to 13 were recruited for participation in the study via online advertisements and announcements in the community. This study oversampled for girls with a shy/fearful temperament, given research demonstrating that this temperament is a risk factor for the development of social anxiety and depression in adolescence and adulthood (e.g., Gladstone & Parker, 2006; Chronis-Tuscano et al., 2009). Approximately two-thirds of the sample (85 girls) were recruited with this temperament and were considered to be “high-risk.” Approximately one-third (44 girls) of the sample did not have this temperament and were considered “low-risk” for the development of social anxiety and depression. Risk status was calculated using the Early Adolescent Temperament Questionnaire-Revised (EATQ- R; Ellis & Rothbart, 2001). Girls classified as “high-risk” had scores at least 0.75 standard deviations above the mean on the fear or shyness scales of either the parent- or child-reported EATQ-R, and girls classified as “low-risk” had scores less than 0.75 standard deviations above the mean on both the fear and shyness scales of both parent- and child-reported EATQ-R. Two participants (one high-risk and one low-risk) dropped out of the study before the eye-tracking tasks because of time commitments, leaving a sample of 127 participants.

To be eligible for the study, participants could not meet DSM-5 criteria for a current or lifetime diagnosis of any anxiety disorder (except for specific phobia), obsessive-compulsive disorder, post-traumatic stress disorder, major depressive disorder (MDD), or any psychotic or autism spectrum disorder, as determined by the Kiddie-Schedule for Affective Disorders and

Schizophrenia (K-SADS-PL; Kaufman, Birmaher, Brent, Rao, et al., 1997). In addition, participants had to have greater than a 70 IQ, as assessed using the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). Additional exclusionary criteria include a lifetime presence of a neurological or serious medical condition, the presence of any MRI contraindications (given that the larger study has an fMRI component), presence of head injury or congenital neurological anomalies (based on parent report), reported acute suicidality, taking medications that affect the central nervous system (e.g., SSRIs), ocular conditions that would impede eye tracking measurement and/or unable to see clearly without prescription glasses.

Of the 127 participants who attempted the DPT and AST, 115 participants were eligible and had usable data for the DPT. Participants were excluded from the DPT analysis if they had no fixation data ($n = 9$), did not have at least ten usable trials ($n = 1$), were from a sibling pair ($n = 1$), or had an ocular condition ($n = 1$). Of the 127 participants who completed the AST, 110 had usable data. Participants were excluded from the AST analysis because they did not complete the task due to distress about public speaking ($n = 3$), data were lost due to disconnection with the Tobii program ($n = 6$), were from a sibling pair ($n = 1$), had less than 50% valid gaze data (i.e., where gaze coordinates could be estimated by Tobii) ($n = 5$), had an ocular condition ($n = 1$), or did not have sufficient visual acuity without glasses ($n = 1$). A total of 123 participants had acceptable data in at least one task (see Table 2 for sample characteristics), and a total of 103 participants had acceptable data across both tasks.

2.2 Procedure

The study was approved by the University of Pittsburgh Institutional Review Board. Initial screening occurred in two phases: 1) Initial phone or online screening and 2) In-person interview. As instructed on recruitment ads, interested parents contacted the study coordinator via phone, text, or by completing an online screening survey, in which the parents received a full explanation of the study. If parents contacted via phone, verbal consent was obtained by a trained research staff member, and parents were asked to verbally respond to a short phone screening questionnaire using the parent-report on the Early Adolescent Temperament Questionnaire–Revised (EATQ-R; Ellis & Rothbart, 2001) Fearfulness and Shyness scales, as well as questions to assess the presence of any serious medical conditions, developmental delays, psychiatric history, and medication use. If parents reached out by text or online, they were directed to complete an online screening which was administered via a secure online interface that included an explanation of consent. If parents agreed to consent to the questions, they then were directed to answer the pre-screen questions about their child online. If the participant met study criteria presented in the online pre-screen, parents were directed to a page that asked for their contact information. A trained research staff member then followed-up with the participant to schedule an in-person screening interview.

During their first visit to the lab, parents provided informed consent and youth provided informed assent to acknowledge their voluntary agreement to participate in the study. Following informed consent, the WASI was administered to each participant by a research assistant. The K-SADS-PL (parent and child interviews; Kaufmann et al., 1997) was administered to each participant and her primary caregiver separately by trained interviewers (who were either doctoral graduate students or master's or doctoral level clinicians) to determine current and past

DSM-5 diagnoses for each participant for eligibility purposes. Trained interviewers also administered the Liebowitz Social Anxiety Scale for Children and Adolescents (LSAS-CA; Masia-Warner & Klein., 1999) and the Child Depression Rating Scale-Revised (CDRS-R; Poznanski & Mokros, 1996) to the caregiver and participant together for measures of clinician-rated social anxiety and depressive symptoms. If participants were not disqualified based on exclusion criteria (i.e., IQ < 70, meeting criteria for exclusionary current or past diagnoses), participants and their caregiver were asked to complete several questionnaires (see Section 2.3.5), including the Screen for Child Anxiety and Related Emotional Disorders (SCARED; Birmaher et al., 1997) and the Mood and Feeling Questionnaire (MFQ; Angold et al., 1987). During Visit 2, (generally within two weeks of the first visit), participants returned to the laboratory, where they completed the DPT (see Section 2.3.6) and AST (see Section 2.3.7).

2.3 Measures

2.3.1 Risk Status

Risk status was assessed using the Early Adolescent Temperament Questionnaire–Revised (EATQ-R; Ellis & Rothbart, 2001). The EATQ-R consists of 65 questions and 12 scales. The current study examined only the shyness and fear scales. Both parent-report and participant self-report scores on the EATQ-R shyness and fear scales were considered to determine risk-status (either “high-risk” or “low-risk”). Parent- and child-reported scores on the fear scale ($r = .40$, $p < .01$) and shyness scale ($r = .31$, $p < .05$) have been shown to be significantly correlated for female adolescents (Ellis & Rothbart, 2001). Internal consistency for the EATQ-R shyness scale is high for adolescent self-report (Cronbach's α = .82) and moderate for parent report (Cronbach's α = .72; Muris & Meesters, 2009). Test-retest stability is also moderate for both the EATQ-R shyness scale (r = .73) and fear scale (r = .73; Muris & Meesters, 2009).

To determine risk-status (high or low), participants were compared against established distribution scores of the EATQ-R (Muris & Meesters, 2009). In healthy, female adolescents, the established average score on the shyness scale is 2.88 (SD = 0.75), and the average score on the fear scale is 2.80 (SD = 0.77; Muris & Meesters, 2009). For the current study, participants with a score > 0.75 SDs above the established mean on the fear or shyness scales on either child or parent report are accepted into the study as part of the high-risk group, and participants with a score < 0.75 SDs above the established mean on the fear or shyness scales of both child and parent reports are accepted into the study as part of the low-risk group.

2.3.2 Diagnostic Assessment

The Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children- Present and Lifetime version (K-SADS-PL; Kaufman et al., 1997, updated for the DSM-5 in 2016) was administered by a trained interviewer to caregiver and participant to determine eligibility. The K-SADS-PL is a reliable and valid instrument for diagnosing anxiety and depressive disorder in children (Kaufman et al., 1997). Inter-rater reliability for anxiety and depressive disorders was based on 15% of interviews (kappa = .99).

2.3.3 Brief Intelligence Measure

The Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was administered to each participant to determine eligibility. The WASI is a brief measure of general intelligence that has been shown to have high internal consistency (Cronbach's $\alpha = .93$) and high test-retest reliability (ICC = .95) (McCrimmon & Smith, 2013).

2.3.4 Clinician-Rated Symptom Measures

2.3.4.1 Clinician-rated measure of social anxiety

To determine clinician-rated symptoms of social anxiety, trained interviewers administered the Liebowitz Social Anxiety Scale for Children and Adolescents (LSAS-CA; Masia-Warner & Klein., 1999) to participants and their caregivers together. This instrument has 24 questions that assess anxiety and avoidance in 24 different situations, such as answering questions in class or meeting new people or strangers. The time period for each rating is for the past week. To begin the administration of this measure, the interviewer provided a scale to the participants with the fear/anxiety ratings and the avoidance ratings, both of which use a 0-3 Likert scale. Fear/anxiety ratings range from 0 = no anxiety, to 3 = severe anxiety, and avoidance ratings range from 0 = never (0% of the time) to 3 = usually (68-100% of the time). Participants were asked to rate their fear/anxiety levels and their avoidance levels separately, and parents are asked to corroborate. Final ratings were based on clinicians' judgment. The total global score was calculated by summing all fear/anxiety scores and avoidance scores. Inter-rater reliability based on interviews from 15% of the present sample was shown to be excellent (ICC = .96). This measure also has been shown to have excellent internal consistency (Cronbach's $\alpha = .97$) and high test-retest reliability (ICC = .94) in previous research (Masia-Warner et al., 2003) and excellent internal consistency in the present sample (Cronbach's α = .94).

2.3.4.2 Clinician-rated measure of depression

The Child Depression Rating Scale- Revised (CDRS-R; Poznaski & Mokros, 1996) was used as a clinician-rated measurement of depressive symptoms. The rating scale has 17 items. Most items have a 1-7 Likert scale, but two items (appetite disturbance and listless speech) have a 1-5 scale. The measure was completed with caregiver and participant together, and both were asked to make a rating on 14 of the items. The clinician made the final rating based on her judgment. The other three items (depressed facial affect, listless speech, and hypoactivity) were based solely on the clinician's observations. The scores were summed together to make a global rating. Inter-rater reliability based on interviews from 15% of the present sample was shown to be high (ICC = .86). Internal consistency has been shown to be good for children (ages 7-12; Cronbach's α = .85) and for adolescents (ages 12-18; Cronbach's α = .79 - .92) in previous research (Mayes et al., 2010; Poznaski & Mokros, 1996) and adequate in the present sample (Cronbach's α = .68).

2.3.5 Self-Report Symptom Measures

2.3.5.1 Self-report measure of social anxiety symptoms

Self-reported social anxiety symptoms were measured using the modified (44-item) version of the self-report Screen for Anxiety and Related Emotional Disorders (SCARED; Birmaher et al., 1997). The original SCARED is a 41-item self-report checklist that assesses multiple symptoms of anxiety across several domains – generalized anxiety, social anxiety, school avoidance, panic symptoms, and separation anxiety over the previous week. The modified version used in this study combined the 41-item SCARED with three additional social phobia subscale questions (e.g., “I am afraid to embarrass myself when other people are around.”) from the SCARED-71 (Bodden, Bogels, & Muris, 2009) in order to create a 44-item version. The total SCARED and SCARED subscales have good internal consistency (Cronbach’s α = .74 to .93) and good test-retest reliability in previous research (ICCs = .80 to .90; Birmaher et al., 1997). The SCARED social subscale had acceptable internal consistency in the present sample (Cronbach’s α = .69).

2.3.5.2 Self-report measure of depressive symptoms

Self-report depressive symptoms were measured using the Mood and Feelings Questionnaire (MFQ-C; 33-item questionnaire) (Angold et al., 1987). This questionnaire assesses adolescent depressive symptoms over the previous two weeks. The MFQ-C has demonstrated excellent internal consistency (Cronbach’s α = .95) and good test-retest reliability (ICC = .80; Burleseon Daviss et al., 2006) in previous research and good internal consistency in the present sample (Cronbach’s α = .88).

2.3.6 Dot-Probe Task

Participants completed a modified version of the computerized DPT (MacLeod et al., 1986) as a standard laboratory assessment of attention bias during Visit 2. Participants sat approximately 60 cm from the computer monitor. Stimuli for this task were photographs of pairs of faces, one emotional (angry, happy, or sad) and one neutral from a standardized stimulus set

(Tottenham et al., 2009). The stimuli set contained both male and female adult actors of varied races.

Each trial (182 total) began with the presentation of a central fixation cross (see Figure 1 for task procedure). Participants had to fixate on the cross before the trial proceeded. Then, paired facial stimuli were presented for either for 500 *ms* (64 trials) or 1000 *ms* (128 trials). The 500 *ms* trials were included because they are the most common stimuli duration for the DPT, and 1000 *ms* trials were included because of increased interest in assessing sustained attentional processing. After the faces disappeared, a probe appeared (either one or two asterisks) in the location of either the emotional or the neutral face. Participants were instructed to indicate how many asterisks appeared by either pressing the 1-key with their index finger or the 2-key with their middle finger). Congruent trials are trials in which the probe replaces the emotional face, and incongruent trials are when the probe replaces the neutral face. Inter-trial intervals varied randomly between 750 and 1250 *ms*. Participants began the task by completing ten trials, in which they were given feedback on their correctness of response, and then completed two blocks of the task (96 trials each) with a small break in between blocks.

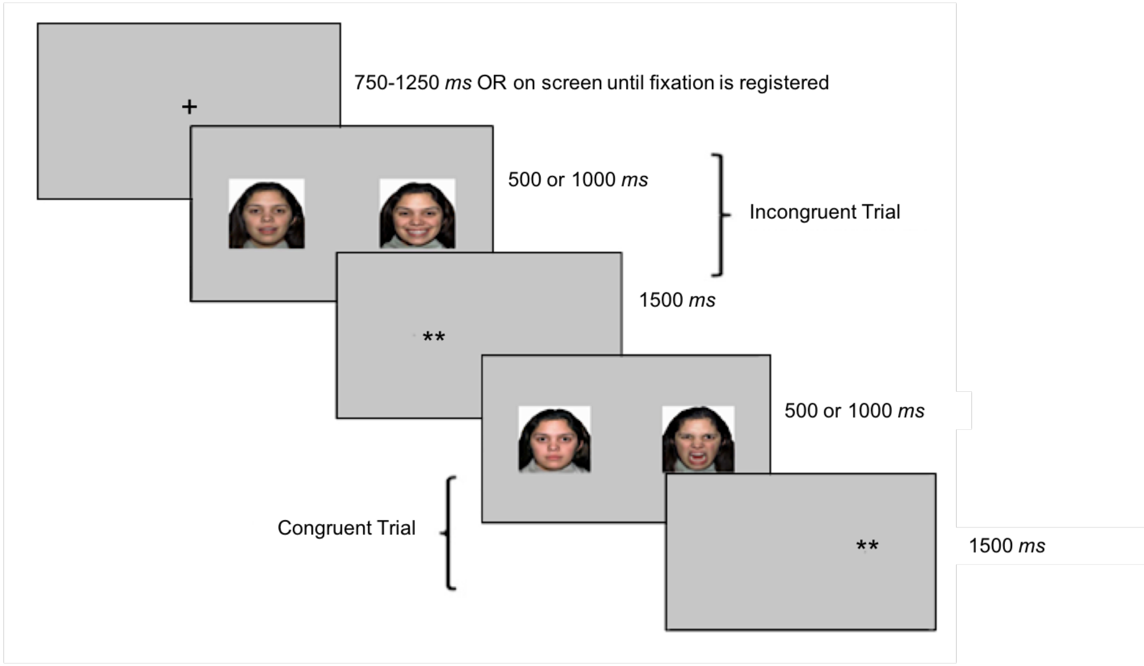

Figure 1. Dot-Probe Task

Gaze data were measured using the Tobii T60XL eye-tracking monitor, which captures eye data at a sampling rate of 60 Hz (Tobii Technology, Inc., Falls Church, VA). The eye-tracker functions by projecting infrared light on the eyes that is captured using sensors. This information was used to calculate gaze direction that can be mapped onto the images on the monitor. Before beginning the task on the second visit, all participants completed a 9-point calibration, in which participants followed the location of a red dot that moves across the monitor. Accuracy of calibration was determined by a research assistant who provided a visual inspection of the calibration. Tobii's standard fixation filter (I-VT) was applied to classify fixations. Next, areas of interest (AOI) around the facial stimuli were created in order to determine the location of each fixation. Participants were excluded from the dataset if they had less than 50% valid gaze data, as determined by Tobii software.

To capture various ways attention could be biased, we selected eye-tracking indices that were most aligned with the attentional components of interest. To assess initial vigilance to threat, we measured the latency to look at either the threatening face compared to the neutral face, creating a bias score (i.e., time taken to look at neutral face – time taken to look at threatening face) for both 500 *ms* and 1000 *ms* trials. Higher, more positive bias scores reflect greater vigilance to threat and lower, more negative scores reflect greater avoidance of threat. To measure sustained attentional capture, we used time of total duration of time spent fixating on the negative face relative to the neutral face (total dwell time), creating a bias score (i.e., fixation time on negative face – fixation time on neutral face) during 1000 *ms* trials, with higher, more positive scores reflecting greater attentional capture from negative faces and lower, more negative scores reflecting greater attentional avoidance of negative faces. Additionally, as a measure of difficulty disengaging, we assessed time taken to look away from the negative face and fixate on the probe that appears in the opposite location of where the negative face was presented (time to disengage), compared to time taken to look away from the neutral face and begin an eye saccade in order to fixate on the probe that appears in the opposite location of where the neutral face was presented (i.e., time to disengage from negative face – time to disengage from neutral face) during 1000 *ms* trials. Higher, more positive scores reflect greater difficulty disengaging from negative faces, and lower, more negative scores reflect greater avoidance of negative faces. Because there were fewer overall trials that met the aforementioned criteria for disengagement trials, we excluded participants with less than five usable trials for analyses using the disengagement indices.

2.3.7 Attention Speech Task

Participants completed the AST during Visit 2. The AST was designed as a novel measure of attention bias in a real-world, socially evaluative context (Allen et al., submitted). In this task, a research assistant instructed participants to give a two-minute speech. Participants were told to pretend that they were auditioning for a reality TV show for teens and explain why they should be the one to be picked for the show in their speech. They were given examples of what they could talk about, such as how smart, likeable, or fun they are. Before giving their speech, participants were told that they would be given two minutes to prepare with their mothers and that their mothers would be in the room with them during the speech, but that they would be seated behind them. Participants were also informed that two judges would give them feedback after their speech.

When it was time for the speech to begin, two judges (both of whom were young adult female study confederates) walked in silently with clipboards and took seats opposite the participant. A bell indicated that participants could begin their speech to the judges. The two judges were instructed to act in predetermined ways that contrast each other (see Table 1 for detailed descriptions of how each judge was instructed to behave). One judge was predetermined to be a positive judge, and the other judge was predetermined to act as potentially critical judge. During the speech, the positive judge was instructed to smile at the participant and take notes at designated intervals. The potentially critical judge was instructed to maintain a neutral face throughout the speech, take intermittent notes, shuffle feet, and spend time looking away and toward the participant at prescribed intervals. Due to ethical considerations, the potentially critical judge did not display overtly negative expressions or behavior. However, although the potentially critical judge was not overtly negative, research suggests that neutral faces are often interpreted as negative in the context of social evaluation (e.g., Wieser & Brosch, 2012).

After the speech, girls were provided with pictures of each judge and were asked to complete a questionnaire evaluating how stressed and happy each judge made them feel on a 0-10 Likert scale, with 10 being the most stressed or happy. This questionnaire was included as a manipulation check to provide evidence that participants were viewing the potentially critical judge more negatively compared to the positive judge. Previous research using this questionnaire with this task has found participants to report significantly more stress and less happiness in response to the negative judge compared to the positive judge (Woody et al., 2019). After questionnaires were completed, participants were given predetermined positive verbal feedback (e.g., "Great job on your speech") from each judge to minimize potential stress following completion of the AST.

2.3.7.1 Eye tracking glasses for Attention Speech Task

Participants wore Tobii Pro Glasses 2 (Tobii Technology, Inc., Falls Church, VA) to track gaze direction and duration towards positive and negative judges in the Speech Task. These wearable eye-tracking glasses are made to look and feel similar to reading glasses. The glasses have four eye tracking sensors with a sampling rate of 50 Hz and infrared illuminators to support the eye tracking sensors. Additionally, the glasses have a high definition camera (located above the nose) to capture the participant's visual field, which extends approximately 80° horizontal and 52° vertical, in order to map the location of the participant's gaze onto what the participant is viewing. Tobii's standard software was used to estimate the eye's position and gaze point.

Before beginning the AST, participants completed a calibration procedure. Participants were instructed to look at a specific target on a small card in front of them. A research assistant completed the calibration procedure on a tablet that received information from the glasses. To ensure that the calibration procedure was correct, a research assistant asked participants to look at various objects in the room while checking that the gaze point was accurate on the tablet.

Eye tracking data were processed using Tobii Pro Glasses Analyzer (Tobii Technology, Inc., Falls Church, VA). A custom fixation was used to classify eye movements (e.g., fixations, saccades), based on previous research using this technology (Allen et al., submitted; Woody et al., 2019) and is based on the I-VT filter that is used on the stationary eye-tracker system on which the DPT is used. Fixations were identified by a consecutive chain of raw data points below the velocity threshold of 30 degrees/second. Tobii's "Real-World Mapping" procedure superimposed both raw gaze data and fixations onto a still snapshot, which was created using a representative still image from each participant's glasses camera. A research assistant manually checked whether the location of each fixation point on the video captured by the glasses camera appeared in the same location as the fixation projected onto the still snapshot and corrected the fixation point if necessary. A research assistant then created an area of interest (AOI) around each judge (the entire head and body) to identify whether the participant's eye gaze was fixated on either judge at each sampling point. Both the head and body were included in the AOI because judges were instructed to use facial (e.g., smiling) and body language cues (e.g., crossing legs) of approval and disapproval (see Table 1). Following previous procedures (Woody et al., 2019), participants were excluded from the dataset if they had less than 50% valid gaze data, as determined by Tobii software.

In the current study, we selected eye-tracking indices that were most aligned with the attention components of interest. These indices were derived by quantifying "visits" to each judge, which are defined as the time interval between the first fixation on the active AOI (i.e., one of the two judges) and the end of the last fixation within the same active AOI where there have been no fixations outside the AOI. To assess vigilance to threat, we measured the latency to at the potentially critical judge when the judge looks away from the participant, which is the first obvious negative gesture in the task (see Table 1). To measure sustained attentional capture, we examined the total duration of visits to each judge across the two-minute speech (dwell time), creating a bias score (i.e., fixation duration on potentially critical judge – fixation duration on positive judge).

2.4 Analytic Plan

The study had the following three aims: 1) To examine if attentional bias indices in the AST were associated with attentional bias indices in the DPT; 2) To examine if attentional bias indices in both tasks were associated with SAD and/or MDD symptoms, and 3) To determine which task is a better predictor of SAD and/or MDD symptoms.

2.4.1 Preliminary Analysis

Internal reliability for tasks was measured by computing within-subjects split–half Spearman-Brown correlations for attentional bias scores from both the DPT and the AST. When split-half reliability was found to be unacceptable for the bias scores for either task (i.e., *r*s < .60), we also assessed split-half reliability for raw attention indices for the negative stimuli (i.e., dwell time on threatening face). When split-half reliability was found to be unacceptable (i.e., *r*s < .60), we modified correlations with outcome variables using Spearman's correction for attenuation, which recalculates the correlation of two variables by taking into account the internal reliability of the two indices being correlated (Schmidt & Hunter, 1996).

2.4.2 Aim 1: Compare If Attentional Indices Of The Attention Speech Task Are Associated With The Dot-Probe Task

Pearson correlations were used to assess if there were statistically significant correlations between attention bias indices on the DPT and the AST to determine whether attentional bias indices that are comparable across tasks were significantly related.

2.4.3 Aim 2: Examine Whether Attentional Indices In Both Tasks Are Associated With SAD And MDD Symptoms

Preliminary Pearson correlations were used to examine whether there were significant associations between potential covariates, such as age or race, with the outcome variables, which are SAD and MDD symptoms. If there were significant associations, these variables were planned to be included as covariates in step-wise linear regression models. Two sets of hierarchical linear regression analyses were created to predict the two outcomes: SAD symptoms and MDD symptoms.

To predict SAD symptoms (assessed using the SCARED-C), predictors were entered as follows—Step 1: potential covariates (i.e., age, race); Step 2: vigilance and dwell time, and difficulty disengaging attention indices from the DPT; Step 3: vigilance and dwell time attention indices from the AST. To predict MDD symptoms (assessed using the MFQ-C), predictors were entered as follows—Step 1: potential covariates (i.e., age, race); Step 2: dwell time and difficulty disengaging attention indices from the DPT; Step 3: dwell time attention indices from the AST. Self-report measures were chosen as the primary outcome variable given that almost all previous attention bias research assessing non-clinical samples use self-report measures; however, secondary analyses were also run with clinician-rated measures of SAD (i.e., L-SAS-CA) and MDD (i.e., CDRS-R) as outcomes.

Sensitivity analyses were planned to be used to examine whether significant relationships of attention biases predicting either SAD or MDD symptoms were maintained over and beyond the other disorder (e.g., if attentional indices predicting SAD are maintained controlling for MDD symptoms), and if significant associations were maintained controlling for generalized anxiety disorder, which commonly co-occurs with both disorders (Axelson & Birmaher, 2001).

2.4.4 Aim 3: Determine Which Task Is A Better Predictor Of Anxiety And Depressive Symptoms

Steiger's Z test (Steiger, 1980) was used to determine which task (DPT vs. AST) has stronger associations between attentional bias indices and SAD and MDD symptoms. Additionally, linear regression models from Aim 2 were examined to assess if attentional indices from each task independently and significantly predict SAD and MDD symptoms.

3.0 Results

3.1 Preliminary Analyses

Internal reliability for tasks was measured by computing within-subjects split–half correlations with Spearman–Brown coefficients for attentional bias scores from both the DPT and the AST. DPT split-half reliability was calculated using even-odd trials, and the AST split-half reliability was calculated by comparing the first half to the second half of the speech task. For the DPT, Spearman-Brown coefficients were found to be poor for all bias scores (see Table 3; all coefficients less than 0.33). Spearman-Brown coefficients were found to be unacceptable (all coefficients less than 0.58), except for the dwell time indices, for raw scores in the DPT. The Spearman-Brown reliability coefficient for dwell time on angry face was 0.80 and the coefficient for dwell time on sad face was 0.84. In order to increase comparability to the AST, DPT split-half reliability was also calculated by comparing the first block of the task to the second block of the task. The Spearman-Brown coefficients for all indices were approximately equivalent to or slightly worse for all indices for the split-half reliability using blocks rather than even-odd trials, except for the disengagement bias indices. The Spearman-Brown coefficient for disengagement away from angry faces was 0.63, and the coefficient for disengagement away from sad faces was 0.66 for split-half reliability calculated by comparing block 1 to block 2. For the AST, Spearman-Brown coefficients were found to be acceptable for all bias scores and raw score indices (all coefficients above 0.78). Therefore, there is preliminary evidence to suggest that the AST is a more reliable measure than the DPT, even when calculating split-half reliability multiple ways.

The MFQ-C was found to be skewed significantly to the right, so it was square root transformed to meet conditions of normality required to conduct Pearson correlations. Potential covariates such as age and race were not significantly correlated with any of the outcome variables, including participants' scores on the MFQ-C, SCARED-C, CDRS, or LSAS (*ps* > .06; see Table 4 for correlation matrix). Therefore, they were not included as covariates in any further analyses. However, age was significantly correlated with two dot-probe attention indices (see Table 4). Age was significantly positively correlated with latency to fixate on the angry face (raw score) ($r = .22$, $p = .02$), such that younger youth were faster to orient to the angry face. Additionally, age was significantly negatively associated with dwell time on angry faces relative to neutral faces ($r = -.19$, $p = .04$), such that younger youth had a longer dwell time bias on angry faces compared to older youth.

3.2 Aim 1: Compare If Attention Indices From The Attention Speech Task Are Associated With Attention Indices From The Dot-Probe Task

Total visit time on potentially critical judge and latency to look at potentially critical judge were both skewed significantly to the right, so they were square root transformed to meet conditions of normality required to conduct Pearson correlations. Pearson correlations did not reveal any statistically significant associations between precisely comparable attention bias indices on the DPT and the AST (*p*s > .06; see Table 4). However, there were several significant associations between the latency to look at the potentially critical judge when she made her first overtly negative gesture in the AST with several indices from the DPT that we did not hypothesize. There was a significant, positive association between dwell time bias to the angry face on the DPT and latency to look at the potentially critical judge on the AST when the judge made her first overtly negative gesture ($r = 0.41$, $p < .01$), such that girls who spent longer looking at the angry face relative to the neutral face in the DPT oriented more slowly to the potentially critical judge when she looked away from the participant. Additionally, there was a significant negative association between latency to look at the judge when she made a negative gesture and time taken to disengage attention away from the sad face relative to the neutral face in the DPT ($r = -0.33$, $p = .049$), meaning that girls who took a longer time to disengage from the sad face relative to the neutral face in the DPT were faster to look at the potentially critical judge when she look away. Unexpectedly, latency to look at the potentially critical judge was significantly positively associated with latency bias to look at the angry face relative to the neutral face on 1000 *ms* trials ($r = 0.34$, $p = .04$) and trending negatively with latency to look at the angry face (raw score) on both 1000 *ms* trials ($r = -.28$, $p = .08$) and 500 *ms* trials ($r = -.30$, $p = .07$), such that girls who were faster to orient to the angry face relative to the neutral face in the DPT took a longer time to look at the potentially critical judge when she made a negative gesture.

3.3 Aim 2: Examine Whether Attentional Indices In Both Tasks Are Associated With SAD And MDD Symptoms

Hierarchical linear regression analyses for social anxiety revealed no significant models for attentional predictors at any step (Step 1: DPT indices; Step 2: AST indices) for bias measures or raw scores in predicting SCARED-C (SAD subscale) or LSAS scores (*p*s > .16; see Table 5). While neither model was significant (nor trending significant), there was a significant main effect for dwell time bias on angry faces in predicting social anxiety using the SCARED-C ($\beta = 0.28$, CI: 0.01, 0.55), such that a longer time spent looking at angry faces relative to neutral faces on the DPT was associated with higher levels of self-reported social anxiety symptoms.

Hierarchical linear regression analyses for depression revealed no significant models for attentional predictors at any step (Step 1: DPT indices; Step 2: AST indices) for both bias measures and raw scores and for both MFQ-C and CDRS (*p*s > .08; see Table 6). In predicting MFQ-C scores, the model from Step 1 was a statistical trend, $R^2 = .06$, $F(2, 94) = 2.93$, $p = .06$. While the model was not statistically significant, there was a significant main effect for disengagement bias on sad faces in predicting depressive symptoms using the MFQ-C ($\beta = -0.24$, CI: -0.44, -0.04), such that longer time taken to disengage attention away from the sad face relative to the neutral face in the DPT was associated with lower levels of depressive symptoms.

Bivariate correlations between attentional indices (in both the DPT and AST) and social anxiety and depressive symptoms are found in Table 4. In the AST, dwell time on the positive judge was significantly negatively associated with depressive symptoms on the MFQ-C ($r = -.22$, $p = .02$), with a correlation of $r = -.32$ after correcting for measurement error via attenuation, such that less time dwelling on the positive judge was associated with higher depressive symptoms. In the DPT, there was a trend-level association between latency bias to angry faces relative to neutral and self-reported social anxiety symptoms ($r = -.18$, $p = .07$), with a correlation of $r = .42$ after correcting for measurement error via attenuation, such that longer time taken to fixate on the angry face relative to the neutral face was associated with higher rates of social anxiety symptoms.

3.4 Aim 3: Determine Which Task Is A Better Predictor Of SAD And MDD Symptoms

To examine which task is a stronger predictor of SAD and MDD symptoms, Steiger's Z-test was used to compare correlation coefficients. Steiger's Z-test revealed no significant differences between the tasks in predicting social anxiety or depressive symptoms $|z|$'s < 1.57 (values greater than $|1.96|$ are considered significant; Lee & Preacher, 2013).

Additionally, linear regression models from Aim 2 were examined to assess whether attentional indices from each task independently and significantly predict SAD and MDD symptoms. As stated in the section above, only attentional indices from the DPT were significant predictors of social anxiety and depressive symptoms, contrary to hypotheses.

4.0 Discussion

The present study sought to examine whether a novel method of assessing attention bias in a live task, the AST, is a better predictor of social anxiety and depressive symptoms in adolescents compared to a more traditional computer paradigm, the DPT, and if the attention indices derived from both tasks were associated with each other. Overall, the AST demonstrated stronger reliability over the DPT, but comparable attentional indices of the AST and the DPT were not significantly associated with each other. Using the DPT, it was found that adolescents with greater sustained attention to negative faces reported higher levels of social anxiety symptoms, but adolescents who were faster at disengaging attention away from negative faces reported higher depressive symptoms. Additionally, developmental findings emerged, such that younger youth fixated faster on angry faces and had greater sustained attention bias on angry faces in the DPT. Using the AST, it was found that less time dwelling on the positive judge was associated with greater self-reported depressive symptoms.

This study is the first large-scale investigation of this novel live attention task and the first to compare it to a more traditional measure of attention bias. Dot-probe tasks have been shown in previous studies to have low-to-moderate reliability in past studies, particularly for attention bias measures (e.g., Price et al., 2015; Price, Brown, & Siegle, 2019). There is increasing concern that growing body of research that uses dot-probe tasks may lack validity given the low internal consistency and low test-retest reliability that defy psychometric standards for acceptability, particularly when examining individual differences (MacLeod, Grafton, & Notebaert, 2019; Price et al., 2015). Consistent with previous research, the reliability estimates from the present study demonstrated low to unacceptable reliability for most raw scores and mostly unacceptable reliability for bias scores in the DPT, with the exception of the angry disengagement index. In contrast, the AST had acceptable reliability across attention indices. Therefore, there is some evidence to suggest that the AST may have superior psychometric properties compared to the traditional DPT.

We did not find comparable indices of attention in the DPT and the AST to be significantly, positively associated with each other. Given that the DPT has demonstrated poor internal reliability, its use in correlational research is problematic. Lower reliability impacts the theoretical basis of validity, thus limiting the DPT's capability of covarying with other outcome variables. Furthermore, it may be that these paradigms are tapping into distinct processes because of several important differences between the two tasks. The AST requires participants to engage in self-referential processing when completing their speech about themselves, which could influence attentional processing. When individuals with depression and at higher-risk for depression are instructed to engage in self-referential processing, they experience worsened mood compared to individuals without depression or those with low risk of depression (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). Therefore, the AST could act as a negative mood induction, which has been shown to exacerbate attention bias to negative stimuli for individuals with depression in the majority of studies that use negative mood inductions (see Scher, Ingram, & Segal, 2005). Additionally, the AST is a live, interactive paradigm that promotes a stress-response by having youth give a speech about themselves. Stress conditions have been shown to affect attention bias to threatening stimuli in socially anxious youth, with research showing a stress induction to increase the frequency of initial fixations on threatening stimuli (compared to neutral stimuli) in youth with SAD (Schmidtendorf et al., 2007). Finally, the AST has the caregiver present, which could serve to either increase or decrease the state anxiety of the participant depending on the relationship between the participant and the caregiver. Parent-child relationship factors have been shown to affect attention bias in adolescent girls (Hutchinson et al., 2019). Future research would benefit by examining the relationship between state anxiety, parent-child relationship, and attention bias using the AST.

Overall, mostly indices from the DPT (rather than the AST) were associated with self-reported social anxiety symptoms. While no linear regression model was significant in predicting social anxiety, youth who spent longer time spent looking at angry faces relative to neutral faces had higher social anxiety symptoms. Additionally, at a trend-level, youth who took longer to fixate on angry faces relative to neutral faces had higher levels of social anxiety symptoms. To our knowledge, only two previous studies specifically examined links between attention bias and social anxiety symptoms in youth using eye-tracking methodology, and the studies found conflicting results. In contrast to our findings for initial orienting, two articles did not find a link between social anxiety symptoms and attention bias toward threatening stimuli relative to neutral stimuli in initial attention stages (Schmidtendorf, Wiedau, Asbrand, Tuschen-Caffier, & Heinrichs, 2017; Seefeldt, Krämer, Tuschen-Caffier & Heinrichs, 2014). When looking at later stages of attention, one article found that socially anxious youth had a tendency to relocate attention toward threatening stimuli later on, suggesting also that socially anxious youth may have difficulty disengaging attention away from threat consistent with our findings (Seefeldt, Krämer, Tuschen-Caffier & Heinrichs, 2014), and the other found that more socially anxious youth have longer dwell-time on angry faces when they are paired with neutral, non-social stimuli (Schmidtendorf et al., 2017). Taken together, there is evidence to support our findings that youth with higher social anxiety symptoms exhibit greater sustained attention toward threatening stimuli.

Similar to predicting social anxiety symptoms, generally only indices from the DPT were found to be associated with self-reported depressive symptoms. Less time taken to disengage attention away from the sad face and angry faces relative to the neutral face in the DPT were associated with higher levels of depressive symptoms. These findings are in line with previous research that found that attentional avoidance of threatening stimuli predicted depressive symptoms longitudinally (Price et al., 2016). Additionally, it supports previous research in youth found that depressed children spent less time looking at sad faces compared to healthy control children (Harrison & Gibb, 2015). It should be noted, however, that no significant correlations emerged when examining dwell time overall, thus these findings were specific to disengagement indices.

While generally our study did not find significant associations between predicted attentional indices from the AST and social anxiety and depressive symptoms, one important finding replicated previous research using the AST which found that less time spent dwelling on the positive judge was associated with higher depressive symptoms (Woody et al., 2019). This finding is consistent and had a similar correlation coefficient in the present sample (r = .22) with the only other published study to examine the AST (r = .23; Woody et al., 2019). Furthermore, these findings are consistent with an attention bias meta-analysis that found that depression is not only associated with preferential attention toward negative, dysphoric stimuli, but also less attention bias toward positive stimuli (Peckham, McHugh, & Otto, 2010). Neural research has demonstrated that adolescents with depression display lower striatal response and higher medial prefrontal response compared to youth without depression which may lead to less reward-seeking behavior (Forbes & Dahl, 2012). Therefore, youth who spend less time fixating on the positive judge who is providing social reward cues may be also experiencing both a dampened motivation to seek rewards and also a reduced response to rewards, which could put them at greater risk for depression. Given the heightened salience of positive, social feedback cues for both adolescence and depression, the AST may particularly highlight how biased attention can exacerbate depressive symptoms.

Contrary to our expectations, we did not find that longer time dwelling on the potentially critical judge relative to the positive judge in the AST was associated with depressive symptoms. Previous research using the AST did find that depression was associated with the dwell time bias score (Woody et al., 2019). One explanation is the dissimilarity in the populations that were used to assess attention bias, particularly developmental differences. The previous study by Woody and colleagues (2019) was a community sample with a larger age range (i.e., 11-16 years old). It could be that older youth could elicit differential attention patterns that could account for these conflicting findings, as most literature with depressed adults has shown preferential sustained attention toward negative stimuli (Peckham, McHugh, & Otto, 2010).

Interestingly, there were significant associations between age and certain attentional indices on the DPT, in line with some previous developmental research. Younger youth were faster to orient to angry faces, which is in keeping with previous reviews suggesting that all youth start off vigilant to threatening stimuli (Field & Lester, 2010; Rosen, Price, & Silk, 2019). The moderation hypothesis (i.e., Field & Lester, 2010) posits that all youth exhibit hypervigilance; however, later in development, anxious youth retain hypervigilance to threat, while healthy youth no longer exhibit preferential attention toward threat. During adolescence, youth develop improved capacity in self-regulation (Keating, Lerner, & Steinberg, 2004). Therefore, given that this study examines a non-clinical sample, it may be that we are examining the healthy trajectory of youth during the pivotal adolescent time period (i.e., 11-13 years old) in which adolescents become able to function with similar cognitive control abilities as adults (Passler, Isaac, & Hynd, 1985). Given that hypervigilance to threat is reduced in older participants using the DPT in the present sample, there is some evidence to support that youth may become better over time at regulating their attention over the course of development.

Additionally, age was found to be significantly negatively associated with dwell time on angry faces relative to neutral faces (i.e., dwell time bias). Younger youth spent a longer time fixating on the angry face compared to the neutral face, which may be suggestive of poorer attentional control compared to older youth. This finding supports previous developmental research that finds that as youth age, they may display focus on neutral stimuli compared to negative stimuli, as perhaps a strategy to self-regulate their emotions (Todd et al., 2012). Neural research has demonstrated that attentional control, or the ability to direct attention at will, is associated the lateral prefrontal cortex, which matures later in adolescence compared to other neural regions (Gogtay et al., 2004; Mills et al., 2014). Therefore, it may be that as youth's attentional control capabilities mature, they may be more capable of preferentially fixating on the neutral rather than threatening stimuli in order to proactively regulate their emotions.

While some of the results were only trend-level, there may be clinical implications to the findings. The majority of attention bias modification interventions are reconfigured versions of the dot-probe task, which are unable to distinguish initial orienting of attention from later stages of attention (Cisler & Koster, 2010; Fox et al., 2001). Thus, it is unclear if ABM interventions are training initial attention away from the threatening stimuli or if they are instead training faster disengagement away from threatening stimulus. A critical limitation of ABM interventions is that it is unclear what component of attention ABM is targeting. We found that higher social anxiety symptoms were associated with sustained attention bias toward negative, while higher depressive symptoms were associated with faster disengaging from negative stimuli. Newer ABM interventions have been recently designed to employ eye-tracking and focus on training disengagement away from negative stimuli in adults (e.g., Möbius, Ferrari, van den Bergh, Becker, & Rinck, 2018; Price, Woody, Panny, & Siegle, 2019), which may be essential to employ when designing ABMs for youth with social anxiety disorders. For youth with depressive disorders, it may be important to reduce avoidance of negative stimuli and to direct attention toward positive stimuli.

There were notable strengths to the present study. First, this study used a multi-method approach to assess attention bias. By comparing a novel, in-vivo assessment of attention bias to a more traditional, computer-based assessment of attention, we were able to assess how attentional patterns vary in multiple contexts. The AST offers improved ecologically validity over the DPT and may offer a better insight into adolescents' real-world attentional patterns, although additional research is needed to validate the utility of the task in predicting real-world and clinical outcomes. We were able to demonstrate that in addition to the improved ecological validity of the AST, the AST showed superior psychometric reliability than the DPT, supporting previous research that has found the DPT to have poor reliability (Price et al., 2015). Additionally, we used a restricted age range that allowed us to examine age-related changes in a critical period of development. Furthermore, the present sample was much larger than most current attention research that uses eye-tracking to assess attention bias.

There were also several important limitations to the study. First, the study was cross-sectional in design, which limited our ability to make causal claims about directionality of attention bias. Some research has found attention bias to precede anxiety onset, whereas other studies find the opposite direction to also be true (see Van Bockstaele et al., 2014). Some preliminary evidence in youth shows that avoidant patterns of attention in clinically anxious youth predict depressive symptoms two years later (Price et al., 2016). Longitudinal research is needed to identify how attentional patterns predispose youth to internalizing disorders in samples other than youth with current anxiety disorders. Second, the current sample was composed of all girls. Research is needed to assess how boys compare to girls in how attentional patterns may predict internalizing symptoms. However, sex was not found to be a moderating variable in previous meta-analysis of anxious youth (Dudeney et al., 2015) and was not found to significantly moderate results in previous eye-tracking papers examining depressed youth (Hankin et al., 2010; Harrison & Gibb, 2015). Third, race effects could alter how attention is allocated in both the DPT and AST. The DPT used stimuli with varied races, and the AST used judges who were primarily Caucasian. Research using eye-tracking and dot-probe tasks have shown that race effects can affect attention bias, generally showing higher selective attention toward out-groups (Kawakami, Friesen, & Vingilis-Jaremko, 2018). Finally, while the AST provided an improvement in ecological validity over the more traditional assessments of attention bias in youth, it was still conducted in a laboratory setting and had the caregiver present throughout the interaction, which limits our ability to generalize to other contexts. Given the promising nature of using eye-tracking glasses, there is opportunity to bring the glasses into other real-world scenarios and incorporate peers into the task.

In conclusion, the results of this study show that an in vivo measure of attention bias is not directly comparable to more traditional assessments of attention bias; however, this novel task may have improved psychometric properties over existing paradigms. Overall, greater sustained attention to negative compared to neutral stimuli was associated with higher social anxiety symptoms, while faster disengagement from negative stimuli was associated with higher depressive symptoms in sub-clinical adolescent girls. Additionally, girls who spent less time dwelling on the positive judge reported higher depressive symptoms. It may be important to leverage this information when designing interventions designed to target maladaptive attentional patterns in youth. Future research may benefit from using a prospective, longitudinal research design to examine how attention bias is associated with the onset of internalizing disorders in youth in order to identify targets of preventative intervention.

Appendix Tables

Table 1. Prescribed instructions for positive and potentially critical judge in the Attention Speech Task in ten-second interval time points

Positive Judge	Potentially Critical Judge
0:00 – smile and take notes	0:00 – look at child
0:10 – look at child with neutral face	0:10 – take notes
0:20 – smile and nod head	0:20 – look at child
0:30 – look at child with neutral face	0:30 – look away from child
0:40 – smile and take notes	0:40 – look at child
0:50 – look at child with neutral face	0:50 – take notes
1:00 – smile	1:00 – look at child
1:10 – look at child with neutral face	1:10 – shuffle feet
1:20 – smile and nod head	1:20 – look at child
1:30 – look at child with neutral face	1:30 – take notes
1:40 – smile and take notes	1:40 – look at child
1:50 – look at child with neutral face	1:50 – put hand on chin

Table 2. Sample characteristics

	Mean (*SD*) (n=123)	Range
Age in years (SD)	12.29 (.80)	11.05-13.98
Race		
Black	20%	
Asian	2%	
White	68%	
Biracial	10%	
Native American	1%	
Hispanic	9%	
Family Income (SD)	$106,327 (65,828)	$3,600- $300,000
MFQ-C (SD)	9.27 (7.24)	0-30
CDRS (SD)	20.51 (4.19)	17-39
SCARED Social Anxiety (SD)	3.08 (2.41)	0-11
LSAS (SD)	24.95 (18.42)	0-87

Note. MFQ= Mood and Feelings Questionnaire; CDRS= Child Depression Rating Scale-Revised; SCARED Social Anxiety= Self Report for Childhood Anxiety Related Disorders, Social Anxiety Subscale, Child Version; LSAS= Liebowitz Social Anxiety Scale for Children and Adolescents.

Table 3. Split-half reliability using Spearman Brown coefficients for attention indices

	Mean (SD)	Spearman Brown Coefficient for block 1 and 2	Spearman Brown Coefficient for even and odd trials
Dot-Probe Indices (ms)			
Latency Bias to Angry Face for 500 ms trials	10.20 (47.33)	-.30*	0.27
Latency Bias to Angry Face for 1000 ms trials	-40.62 (100.05)	-.13*	0.33
Latency (raw score) to Angry Face for 500 ms trials	337.49 (38.68)	0.26	0.15
Latency (raw score) to Angry Face for 1000 ms trials	453.97 (72.64)	0.37	0.09
Dwell time bias to Angry Face for 1000 ms trials	65.11 (68.00)	0.19	0.08
Dwell time bias to Sad Face for 1000 ms trials	33.96 (69.26)	0.25	0.21
Dwell time (raw score) on Angry Face for 1000 ms trials	241.18 (86.70)	0.68	0.80
Dwell time (raw score) on Sad Face for 1000 ms trials	225.27 (81.32)	0.70	0.84
Disengagement Bias on Angry Face for 1000 ms trials	-10.83 (133.29)	0.65	-0.19*
Disengagement Bias on Sad Face for 1000 ms trials	-18.15 (120.42)	0.18	-0.10*
Disengagement (raw score) on Angry face for 1000 ms trials	253.51 (102.34)	0.43	0.12
Disengagement (raw score) on Sad face for 1000 ms trials	25153 (106.75)	0.15	0.58
Speech Task Indices (s)			
Total Visit Time Bias Score	-5.55 (17.48)	0.86	
Total Visit Time on Positive Judge	13.06 (16.29)	0.93	
Total Visit Time on Potentially Critical Judge	7.51 (9.32)	0.79	
Proportion of Time Spent on Positive Judge	0.56 (.32)	0.78	
Proportion of Time Spent on Potentially Critical Judge	0.44 (.32)	0.78	
Latency to Potential Critical Judge during Negative Event	3.09 (3.52)		

Note. * Defied split-half reliability model assumptions. For Dot-Probe Indices, Spearman Brown coefficient was calculated using even-odd trials. For the Attentional Speech Task Indices, Spearman Brown coefficient was calculated using the first half compared to the second half of the speech (approximately 61 seconds each). Spearman Brown coefficient could not be calculated for the Latency to Potential Critical Judge during Negative Event because it was a singular event. Split-half reliability <.60 is considered to be unacceptable.

Table 4. Bivariate correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Demographics																					
1. Age	-																				
2. Race	.07	-																			
Symptoms																					
3. MFQ	-.08	.01	-																		
4. CDRS	-.12	.15	.32**	-																	
5. SCARED-C	-.02	-.07	.45**	.28**	-																
6. LSAS-C	.12	.17	.33**	.43**	.52**	-															
Dot-Probe																					
7. Latency Bias AF (500 *ms*)	-.17^{t}	.00	.03	-.03	-.18^{t}	-.12	-														
8. Latency Bias AF (1000 *ms*)	-.02	.05	-.08	-.01	-.04	.06	.04	-													
9. Latency AF (500 *ms*)	.22*	-.17^{t}	.01	-.03	.06	.15	.55**	-.14	-												
10. Latency AF (1000 *ms*)	.06	-.10	.10	-.11	.05	.08	.14	.58**	.32**	-											
11. Dwell Time Bias AF (1000 *ms*)	-.19*	-.10	.05	.09	.01	.05	-.08	-.39**	-.07	-.39**	-										
12. Dwell Time Bias SF (1000 *ms*)	-.01	.10	-.03	-.05	-.09	-.10	-.17^{t}	-.06	-.06	-.03	.12	-									
13. Dwell Time AF (1000 *ms*)	-.17^{t}	.06	-.06	.07	.00	-.05	-.23*	-.28**	-.45**	-.65**	.58**	.10	-								
14. Dwell Time SF (1000 *ms*)	-.08	.18	-.10	.01	-.00	-.09	-.29**	-.15	-.46**	-.47**	.25**	.51**	.79**	-							
15. Disengagement Bias AF (1000 *ms*)	.12	-.02	-.03	-.06	.06	-.05	.15	-.43**	.31**	-.11	-.20*	.00	-.27**	-.21*	-						
16. Disengagement Bias SF (1000 *ms*)	-.06	.02	-.14	-.02	-.19^{t}	-.12	-.08	-.09	.03	-.13	-.20*	-.13	-.08	-.09	.17^{t}	-					
17. Disengagement AF (1000 *ms*)	.07	.08	-.14	-.14	-.01	-.06	.13	-.27**	.09	.14	-.25*	.03	-.45**	-.31**	.57**	.09	-				
18. Disengagement SF (1000 *ms*)	-.01	.07	-.10	-.04	-.11	-.02	-.07	-.09	-.02	.12	-.27**	-.08	-.40**	-.34**	-.12	.48**	.61**	-			
Speech Task																					
19. Total Visit Bias	-.11	-.09	.15	-.05	-.16	-.03	.07	.04	.09	.00	.03	.04	-.05	-.04	.09	.15	.00	.08	-		
20. Total Visit on PJ	.06	.12	-.22*	.05	.02	-.05	-.18^{t}	-.03	.02	.02	-.10	-.08	.03	.04	-.07	-.11	.03	-.01	-.80**	-	
21. Total Visit on PCJ	-.15	.02	-.05	-.02	-.18	-.07	-.16	.02	.16	.00	-.05	-.09	.03	.02	-.01	.13	-.04	.07	.30**	.25*	-
22. Latency to PCJ	.05	.15	-.10	-.13	.05	-.02	-.08	.34*	-.30^{t}	-.28^{t}	.41**	.21	.23	.21	-.12	-.33*	.08	-.08	-.09	-.08	-.19

Note. $^{t}p < .01$, $^{*}p < .05$, $^{**}p < .01$. MFQ= Mood and Feelings Questionnaire; CDRS= Child Depression Rating Scale-Revised; SCARED Social Anxiety= Self Report for Childhood Anxiety Related Disorders, Social Anxiety Subscale, Child Version; LSAS= Liebowitz Social Anxiety Scale for Children and Adolescents; AF = Angry Face; SF = Sad Face; PJ = Positive Judge; PCJ = Potentially Critical Judge.

Table 5. Regression table for attentional indices from both tasks predicting social anxiety symptom outcomes

	SCARED-Social Anxiety Subscale		Liebowitz Social Anxiety Scale for Children and Adolescents	
	Step 1: *DPT Variables* *β*	*Step 2:* *AST Variables* *β*	*Step 1:* *DPT Variables* *β*	*Step 2:* *AST Variables* *β*
Bias Scores				
Dwell time bias to angry face (1000 ms)	0.28*	0.28*	0.06	0.06
Disengagement bias on angry face (1000 ms)	0.09	0.10	-0.19	-0.19
Latency bias to angry face for (500 ms)	-0.14	-0.13	-0.15	-0.15
Latency bias to angry face for (1000 ms)	-0.24[t]	-0.24	0.14	0.14
Total visit time on judges bias score		-0.13		0.01
N		88		87
ΔR^2	0.07	0.01	0.06	0.0001
Total R^2		0.09		0.06
Raw Scores				
Dwell time on angry face (1000 ms)	0.29	0.29	0.12	0.18
Disengagement from angry face (1000 ms)	-0.15	-0.15	-0.36[t]	-0.34
Latency to angry face for (500 ms)	0.23	0.25	0.04	0.03
Latency to angry face for (1000 ms)	0.33	0.34	0.11	0.12
Total visit time on potentially critical judge		-0.10		-0.20
Latency to potential critical judge during negative event		0.10		-0.02
N		35		34
ΔR^2	0.16	0.02	0.21	0.04
Total R^2		0.19		0.25

Note. [t]p<.10, *$p \leq$.05. DPT = Dot-Probe Task; AST = Attention Speech Task; SCARED Social Anxiety= Self Report for Childhood Anxiety Related Disorders, Social Anxiety Subscale, Child

Table 6. Regression table for attentional indices from both tasks predicting depressive symptom outcomes

	Mood and Feelings Questionnaire		Child Depression Rating Scale	
	Step 1: *DPT Variables* *β*	*Step 2:* *AST Variables* *β*	*Step 1:* *DPT Variables* *β*	*Step 2:* *AST Variables* *β*
Bias Scores				
Dwell time bias to sad face (1000 ms)	0.03	0.03	-0.05	-0.04
Disengagement bias on sad face (1000 ms)	-0.24*	-0.25*	-0.05	-0.04
Total visit time on judges bias score		0.09		-0.06
N		95		94
ΔR^2	0.06ᵗ	0.01	0.004	0.003
Total R^2		0.07		0.01
Raw Scores				
Dwell time on sad face (1000 ms)	-0.02	-0.02	0.09	0.09
Disengagement from sad face (1000 ms)	-0.16	-0.17	-0.03	-0.03
Total visit time on potentially critical judge		0.04		-0.03
N		97		96
ΔR^2	0.03	0.00	0.001	0.01
Total R^2		0.03		0.001

Note. ᵗp<.10, *$p \leq$.05. DPT = Dot-Probe Task; AST = Attention Speech Task.

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