ATTENTION DURING VIRTUAL PEER FEEDBACK IN YOUTH WITH A HISTORY OF ANXIETY COMPARED TO HEALTHY YOUTH

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ATTENTION DURING VIRTUAL PEER FEEDBACK IN YOUTH WITH A HISTORY OF ANXIETY COMPARED TO HEALTHY YOUTH

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Attention bias toward threatening stimuli has long been theorized to play a causal role in the development and maintenance of anxiety disorders. However, most research has examined attentional patterns at initial stages of orienting although later stages of attention may be just as or more of a critical index to study. Research on attentional biases is typically studied in laboratory paradigms that simply present faces as stimuli, therefore limiting the ecological validity of attentional research, particularly when studying youth. In order to evaluate attentional biases toward threat in a paradigm that mimics situations occurring in adolescents' life, this study examined attention in youth using eye-tracking methodology using the Chatroom-Interact task. Additionally this study assessed pupil dilation as an index of cognitive and emotional processing during the Chatroom-Interact task. 25 previously treated anxious youth (18 F, *mean age*= 13.6) and 22 healthy youth (13 F, *mean age*= 13.8) completed this task. In this task, virtual peers are shown to either choose (accept) or reject the participants to talk about a common interest. We hypothesized that the previously-treated anxious youth would spend longer time

looking at their photo when rejected by peers compared to healthy youth. Furthermore, we expected the previously-treated anxious youth would display greater recruitment of attentional resources when coping with rejection, as indexed by greater pupil dilation, compared to healthy youth. Across all participants, we expected that youth would spend longer looking at their own photo and have greater pupil dilation during rejection feedback compared to non-feedback, control trials. In order to examine if hypotheses were specific to rejection feedback, we examined acceptance feedback as well. We found that social feedback from peers (rejection and acceptance) captures attention and is associated with greater pupillary reactivity compared to the non-feedback control condition across all youth. This finding may suggest that psychotherapy treatment ameliorated attentional biases toward threat in anxious youth. Furthermore, during acceptance feedback, the previously treated anxious youth displayed greater pupil response compared to healthy youth, suggesting positive feedback from peers may differentially affect anxious youth.

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1.0 INTRODUCTION

Anxiety is one of the most common problems in children and adolescents, with an estimated 15-20% of youth meeting criteria for an anxiety disorder (Beesdo, Knappe, & Pine, 2009). It is essential to have some levels of anxiety, as fear expedites detection of danger, but anxiety becomes maladaptive when it interferes with daily functioning. Childhood or adolescent anxiety is often associated with both academic and social impairment (Langley, Bergman, McCracken, & Piacentini, 2004), negatively affecting the lives of children and adolescents struggling with these disorders. Therefore, it is critical to identify cognitive and biological risk factors for the acquisition and maintenance of pediatric anxiety disorders in order to develop targeted interventions to better prevent and treat anxiety.

Biased attentional processes have been implicated in the etiology and maintenance of anxiety disorders (Mathews & MacLeod, 2002; Watts & Weems, 2006). However, such processes are typically assessed using paradigms that lack ecological validity, particularly for studying child and adolescent populations. As peer relationships become increasingly important in adolescence (Steinberg, 2005), examination of attentional processing in a social context may better elucidate disordered attentional processing in anxious youth. This study therefore compared a component of attention, dwell time (a proxy for attentional disengagement), in anxious and non-anxious youth during a virtual peer interaction designed to elicit social threat.

Additionally, the study assessed pupillary response during the interaction as a biological marker of neural activity, in addition to being an index of cognitive and affective load.

1.1 LITERATURE REVIEW

The review provides background on attentional processing in anxious youth. First, research on the stages of attentional processing are reviewed. Next, an overview of current methodological problems is presented to provide a rationale for the paradigm and methodology of the study. Finally, research on pupillary measures in anxiety is reviewed.

1.1.1 Biased Attentional Processing in Anxious Youth

1.1.1.1 Early processing of attention

Biased attention toward threat-related information has been thought to contribute to the onset and maintenance of anxiety disorders (Mathews & MacLeod, 2002; Watts & Weems, 2006). Many studies have shown that there is an attention bias toward threatening stimuli in clinically anxious adults compared to non-anxious adults during initial, automatic stages of processing (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007). However, there are equivocal findings when studying children and adolescents (Dudeney, Sharpe & Hunt, 2015; Puliafico & Kendall, 2006; Shechner et al., 2012). Some studies have found parallel results to the adult findings in anxious and healthy child samples (Bar-Haim et al., 2007; Roy et al., 2008), yet others have found evidence for attentional biases toward threat in both

anxious and non-anxious children (Price et al., 2013; Waters, Lipp, & Spence, 2004), and another study found no attentional preference for threat in either healthy children or children with generalized anxiety disorder (Waters, Mogg, Bradley, & Pine, 2008). Such inconsistencies in the developmental literature may be because researchers are studying biases only at the first stage of information processing, and there may be more consistency in attentional biases at other stages of attention. Additionally, contrary findings may be partly due to the nature of the dot probe task—the task that is typically used to assess attention bias in anxious youth. The dot probe task, which generally uses static images of adult faces, may have limited ecologically validity in children, and there is debate regarding whether the dot-probe task is able to delineate biases in initial orienting toward threat from later attentional processes (Shechner et al., 2013).

1.1.1.2 Attention shifting

Although most research has focused on initial orienting, shifting of attention after orientation is also an important process that could be altered in children with anxiety (Mogg & Bradley, 2005). In the attentional system, a "shift" mechanism directs attention, and engage and disengage mechanisms hold and release attention (Posner & Petersen, 1990). Throughout development, children become faster at voluntarily shifting their attention as they age (Brodeur & Enns, 1997). However, youth vary in their ability to shift attention away from a stimulus at will.

Difficulty in disengaging attention denotes a process in which a threatening stimulus captures attention and impairs switching attention from the threat stimulus to another stimulus. Impaired disengagement from threat may characterize anxiety disorders and contribute to the maintenance of anxiety symptoms (Cisler & Koster, 2010). Researchers have found that anxious

adults have an increased difficulty in disengagement from threatening stimuli using reaction time indices (Amir, Elias, Klumpp, & Przeworski, 2003; Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, & De Houwer, 2004). Utilizing eye-tracking methodology, researchers found that trait-anxious adults spent a greater amount of time looking at threatening stimuli at later stages of attention (Buckner, Maner & Schmidt; 2010), suggesting that individuals with higher anxiety may have difficulty disengaging their attention from threat. Price and colleagues (2014) found that anxious children and adolescents, compared to healthy controls, showed abnormal neural processing in bilateral parahippocampal and hippocampal clusters when they were required to disengage their attention away from threat, highlighting neural differences in the disengagement processes in anxious versus healthy children. Furthermore, it has been found that clinically anxious children who have difficulty disengaging attention from threat were less likely to respond to Cognitive Behavioral Therapy (CBT) (Legerstee et al., 2009), the gold-standard treatment for anxiety, suggesting that anxious children with difficulties disengaging attention from threat may yield less benefit from CBT. However, it is not known whether anxious youth differ from healthy controls in their ability to shift attention away from socially threatening stimuli. The study addressed this gap in the literature by examining differences dwell-time index in non-anxious youth and youth with a history of a clinical anxiety disorder.

1.1.2 Current Methodological Problems

One limitation of the current literature on attention processes and child anxiety is that almost all studies have utilized a single task, the pictorial dot probe task (Bar-Haim et al., 2007),

in which participants first view a pair of emotional faces, one emotional and one neutral. The stimuli disappear, and a probe appears in the prior location of either the emotional or the neutral stimulus. Generally, participants make a motor response to indicate the location of the probe. Slower probe detection when the response probe appears where the neutral image was during threat-neutral trials indicates that the individual has increased difficulty disengaging from threat. While some researchers have found the dot-probe task to be low to moderately reliable (Price et al., 2015), other studies have failed to demonstrate reliability (Britton et al., 2013; Dear, Sharpe, Nicholas, & Refshauge, 2011; Schmukle, 2005; Staugaard, 2009; Waechter, Nelson, Wright, Hyatt, & Oakman, 2014), particularly for studying individual differences and using reaction time indices. This is problematic as reliability impacts the theoretical basis of validity and may reduce the ability to generalize beyond the immediate study and predict outcomes (Price et al., 2015). For example, if someone scores very differently on a test each time he or she takes it (i.e., lacking reliability), the test score is unlikely to be meaningfully predictive (i.e., lacking validity). Therefore, it may be beneficial to examine attention biases in youth using alternative paradigms.

1.1.2.1 Ecological validity

As adolescence is often characterized as a period of heightened sensitivity to peer relationships (Steinberg, 2005), researchers have recently begun to examine how anxious youth respond to social feedback from their own peers. However, these ecologically valid paradigms have not yet been incorporated into attention bias research. Ecologically valid paradigms can help us better understand attentional and emotional processing of peer feedback, which is of particular importance in adolescence. The developmental stage of adolescence is marked by an increased amount of time spent with peers (Barnes, Hoffman, Welte, Farrell, & Dintcheff, 2007)

and a rise in peer rejection, due to more volatile relationships occurring during this life-stage (Wang, Iannotti, & Nansel, 2009). Researchers have demonstrated that rejection sensitivity is linked to an increase in adolescent depressive and anxiety symptoms, finding a reciprocal relationship between rejection sensitivity and internalizing symptoms (Marston, Hare, & Allen, 2010). Therefore, studying cognitive processes using ecologically valid peer evaluation stimuli provide us with greater insight into how youth differ in response to real-life situations, such as rejection or acceptance by peers.

Recent research has demonstrated that anxious and healthy adolescents differ in their neural responses to peer rejection. In a task similar to the current study, researchers found that clinically anxious adolescents had heightened amygdala-hippocampal activation following rejection compared to non-anxious adolescents (Lau et al., 2011). While there is evidence that currently anxious youth have differing neural responses to peer rejection, it is unknown whether there are attentional alterations underlying these differences in neural responses.

1.1.2.2 Indices of attention

While most researchers studying attention have used reaction time indices to assess attention allocation, critics have pointed out that manual reaction time studies do not delineate the true time course of attention, due to the increased time it takes to make a manual response (Armstrong & Olatunji, 2012). Eye movements are guided by selective attention shifts (Kowler, Anderson, Dosher, & Blaser, 1995), making them a more proximal measure of attention than manual, motor responses. Furthermore, eyetracking indices on an attention task have been shown to more reliably measure attention bias compared to reaction time measures (Price et al., 2015). For these reasons, the current study will utilize eyetracking methodology to compute time taken

to disengage attention from socially threatening stimuli. The term “dwell time” has been used in previous eye-tracking studies as an index of disengagement or of maintenance of attention (Buckner, Maner, & Schmidt, 2010; Garner, Mogg & Bradley, 2006). Given that it is not be possible to evaluate if time taken to disengage away from a threatening stimuli reflects difficulty disengaging away from a stimulus or a stronger preference for the stimulus itself, we used dwell-time on socially threatening stimuli as a proxy of disengagement in this study.

1.1.3 Pupillary measurement

The present study will utilize pupillary measurements as an additional assessment of cognitive processing. The pupillary response is a temporally sensitive physiological measure that is thought to index overall cognitive load, including both emotional and cognitive processing (Siegle, Steinhauer, Stenger, Konecky, & Carter, 2003). Pupil dilation has been shown to be associated with neural activity related to emotional reactivity (limbic regions) as well as cognitive control (prefrontal cortex) (Siegle, Steinhauer, Friedman, Thompson, & Thase, 2011; Siegle et al., 2003; Siegle, Steinhauer, Stenger, Konecky, & Carter, 2003). The pupil becomes increasingly dilated during tasks that require greater cognitive load or increased emotional intensity (Beatty, 1982; Beatty & Lucero-Wagoner, 2000; Siegle, Steinhauer, Stenger, Konecky, & Carter, 2003). Therefore, pupil dilation provides an index of neural activity in cognitive and emotional brain regions, conveying information on both the time-course and magnitude of neural responses. For example, after viewing negative, personally-relevant stimuli, adults with depression showed a greater sustained increase in pupil dilation compared to individuals without depression, suggesting that pupil dilation may represent a preservative form of negative

attention, such as rumination (Siegle, Steinhauer, Carter, Ramel, & Thase, 2003). Examining pupil dilation after the presentation of negative social stimuli can provide complementary information on attentional processing in youth, providing a richer understanding of the intensity and time-course of neural engagement in the context of threatening stimuli. In addition, as research has shown that pupil dilation is larger in currently anxious youth relative to healthy youth following the presentation of threatening adult faces (Price et al., 2013), a goal of the study was to examine how youth with a history of anxiety and healthy youth vary in their pupillary response to socially threatening stimuli. However, since pupil dilation can be a measurement of both cognitive effort and emotional response, exploratory analyses were conducted to see if pupil dilation was more strongly associated with ruminative processing or increased cognitive effort to shift attention due to poor attentional control ability.

1.2 SCOPE OF THE CURRENT STUDY

Researchers have begun to study eyetracking and pupillary reactivity to peer rejection and acceptance, but only in healthy youth. Silk and colleagues (2012) collected eyetracking and pupillometry measures in healthy youth to understand cognitive and emotional responses to social feedback using the same task as the proposed study, the Chatroom-Interact task. This task involves being chosen as preferable to talk to about a common teen interest topic (e.g., music, TV) over another virtual peer (accepted) or not being chosen (rejected). The researchers found that when healthy youth were accepted, the youth tended to focus on a picture of themselves (self-photo) for the duration of the trial. However, when they were rejected (as indicated by a

large gray “X” through their self-photo), healthy youth avoided looking at their self-photo. The authors posited that for youth, viewing their self-photo may be associated with shame, embarrassment, or anger. By gazing away from their own photo, or disengaging attention away from the threatening gray “X” on their face, youth were potentially protecting themselves from feeling these negative emotions. Gaze aversion has long been known to be an effective coping mechanism for dealing with stressful situations, starting as early as infancy (Rothbart, Ziaie, & O'Boyle, 1992; Toda & Fogel, 1993).

However, anxious youth may differ from healthy controls in their capacity to utilize gaze aversion as a coping strategy. As stated previously, anxious populations may have a decreased capacity to disengage attention away from threatening stimuli, which could contribute to the onset and maintenance of their anxiety symptoms (Cisler & Koster, 2010). Therefore, we predict that anxious youth would have a longer dwell-time on their-self photo compared to healthy youth.

Silk and colleagues (2010) found that healthy youth who reported lower levels of closeness and connection during real-world social interactions with peers were more likely to have greater pupillary response in the wake of rejection, suggesting that youths’ rejection sensitivity may be related to reduced feelings of social connectedness. Furthermore, this real-world finding supports the ecological validity of the Chatroom-Interact task. Therefore, we expect that anxious youth would exhibit increased pupil dilation for rejection feedback compared to healthy youth, as they may experience increased rejection sensitivity (McDonald, Bowker, Rubin Laursen & Duchene, 2010) and thus have to recruit more neural resources to disengage their attention in the wake of rejection.

Finally, as stated earlier, attentional disengagement difficulties are thought to contribute to the maintenance of anxiety disorders (Cisler & Koster, 2010). Therefore, it is proposed that within the anxious group, longer time initial dwell-time on self-photos would be positively associated with current anxiety severity. The present study examined these questions in a sample of youth who previously received psychotherapy for anxiety. Anxious youth were treated for anxiety two years prior to the current study with either CBT or supportive psychotherapy. Although all anxious youth received treatment, there remained significant variability in levels of anxiety at the time of the present study. Research on this sample provides a first step in understanding how anxious and healthy youth differ in their attention in a socially-relevant task. Further, this study may reveal deficits in anxious youth that persist even after treatment, potentially highlighting future targets of treatment and informing the design of treatments to modify attentional problems that contribute the maintenance of anxiety symptomology.

In summary, the current study used pupillary and eyetracking measures during a virtual peer interaction task to examine disengagement from social threat in youth with history of anxiety compared to non-anxious youth. It was expected that anxious youth would show greater dwell-time on peer rejection feedback relative to non-anxious youth. Exploratory analyses were conducted to examine if either dwell time or pupil response were associated with rumination, attentional control, or anxiety severity in order to aid interpretation of results. Furthermore, analyses were conducted to examine if results were specific to negative stimuli, such as rejection feedback, or if they generalized to other affective stimuli, such as acceptance feedback. Since the literature has largely found no bias difference between anxious and healthy individuals in orientation and maintenance of attention to positive stimuli (Bar-Haim et al., 2009; Fox et al.,

2001; Fox et al., 2002; Georgiou et al., 2005), we predicted findings would be specific to rejection feedback.

1.2.1 Main Hypotheses

1. Anxiety will be associated with increased dwell-time on rejection feedback (compared to control).
    a. Both anxious and non-anxious youth will have a longer dwell-time on self-photo during social rejection feedback from virtual peers compared to control trials.
    b. There will be an interaction between *trial-type* (rejection, control) *by diagnosis group* (anxious, healthy youth) in dwell-time, such that the anxious group will have a longer dwell-time on self-photo during rejection feedback compared to the healthy youth, but the groups will not differ in dwell-time during control trials.
2. Anxiety will be associated with greater recruitment of attentional resources when coping with rejection, as indexed by greater pupil dilation in anxious youth relative to non-anxious controls.
    a. Both anxious and non-anxious youth will have larger sustained pupil dilation in rejection trials compared to control trials.
    b. There will be an interaction of *trial-type* by *diagnosis group* for pupil dilation, such that the anxious group will have larger sustained pupil dilation to rejection trials compared to healthy youth, but the groups will not differ in pupil dilation to control trials.

1.2.2 Exploratory Aims

1. In order to aid in interpretation in hypotheses 1 and 2, correlates of dwell time and sustained pupil dilation were explored. We examined if dwell time on self-photo and pupil dilation were associated with anxiety severity, attentional control, and/or rumination.

2. In order to examine if hypotheses are specific to rejection feedback, acceptance feedback was examined as well. We predicted that there would be no interaction between *trial-type* (acceptance, control) by *diagnosis group* (anxious, healthy youth) in dwell-time and pupil dilation.

2.0 METHOD

2.1 PARTICIPANTS

Participants were 28 youth with anxiety disorders who, 2-years prior to the present study, completed a psychotherapy treatment through a randomized controlled trial at the University of Pittsburgh, and 27 healthy youth with no lifetime psychological disorders. Participants ranged in age from 11-16 years at the time of the present study. They were previously recruited for the original study through radio, television, and newspaper advertisements, and referrals from pediatricians, school counselors, and mental health clinics. At the pretreatment time-point, all anxious participants met pretreatment DSM-IV diagnostic criteria for a principal diagnosis of generalized anxiety disorder, social phobia, and/or separation anxiety disorder as determined by the Kiddie-Schedule for Affective Disorders and Schizophrenia (K-SADS) (Kaufman, Birmaher, Brent, Rao, et al., 1997). Healthy participants met no DSM-IV diagnostic criteria for any psychological disorder.

At the pre-treatment time-point, exclusion criteria for all participants included a current primary diagnosis of major depressive disorder, a current diagnosis of obsessive-compulsive disorder, post-traumatic stress disorder, conduct disorder, substance abuse or dependence, attention deficit hyperactivity disorder combined type or predominantly hyperactive-impulsive type, evidence of an autism spectrum disorder, or a lifetime diagnosis of bipolar disorder,

psychotic depression, schizophrenia, or schizoaffective disorder. Exclusion criteria at the pre-treatment time-point also included an IQ below 70 as assessed by the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999), use of psychoactive medications, acute suicidality or risk for harm to self or others, and, because the larger study included a functional magnetic resonance imaging (fMRI) scan, presence of metal braces or other metal objects in their body or history of serious head injury. Finally, participants were excluded from the study if they had problems with their eyes or difficulties in vision not corrected by the use of contacts or glasses at pre-treatment and at time of current study.

2.2 PROCEDURE

The study was approved by the University of Pittsburgh Institutional Review Board. At the pre-treatment time-point, all participants were scheduled for an assessment during which a master's or doctoral level therapist administered the K-SADS and questionnaires to the child and his/her primary caregiver. Anxious youth were subsequently randomized to treatment, with a 2:1 ratio for assignment to CBT vs. Client-Centered Therapy (CCT). Masters and doctoral level therapists administered psychotherapy treatment to the anxious youth. Both CBT and CCT treatment followed manuals and included 14 sessions with the child and two parent sessions, including parental consultation throughout treatment. Although the present study does not focus on treatment outcome, previous research on this sample has shown that both treatments were effective for the majority of the participants (Silk et al., in 2016). Both CBT and CCT resulted in a significant reduction in anxious symptomology (69% for CBT and 60% for CCT), although

youth treated with CBT were more likely than youth treated with CCT to fully recover (61% for CBT vs. 44% for CCT). However, there remained a range of anxious symptomatology at the present time point (2 years after treatment) using clinician report, child self-report, or parent-report. On the child self-report scale, the Screen for Child Anxiety Related Emotional Disorders, Child (SCARED-C) (Birmaher et al., 1997), anxious youth scored an average of 16.62 (scores ranging from 0-36; clinical cutoff of 25), and healthy youth scored an average of 6.46 (scores ranging from 0-25).

The K-SADS and questionnaires were re-administered post-treatment, at a 1-year follow-up, and at the time-point of the current assessment, a 2-year follow-up. Participants completed the Chatroom-Interact Task at the time of the current assessment.

2.3 MEASURES

2.3.1 Diagnostic Assessment

On their first pre-treatment visit, each youth and his or her parent(s) were interviewed using the Schedule for Affective Disorders and Schizophrenia in School-Age Children—Present and Lifetime version (K-SADS-PL, Kaufman, Birmaher, Brent, & Rao, 1997). Parents and youth were interviewed separately, with interviewers integrating data from both informants to determine the final diagnosis. All interviews were carried out by trained bachelor's and master's level clinicians. The results of the interview were presented at a consensus case conference with a child psychiatrist, who reviewed the findings and preliminary diagnosis and provided a final

diagnosis based on DSM-IV (American Psychiatric Association, 1994) criteria. Inter-rater reliability was calculated for 16% of interviews. Reliability for anxiety diagnoses was high (Kappa = .97). The K-SADS was administered again at post-treatment, 1, and 2-year follow-up. At time of the current study, seven anxious participants met full criteria for an anxiety disorder, one participant met criteria for combined-type attention deficit hyperactivity disorder (ADHD), one participant met criteria for obsessive compulsive disorder, and 19 previously anxious participants met no current DSM-IV diagnostic criteria. Healthy participants continued to not meet DSM-IV diagnostic criteria for any psychological disorder.

2.3.2 Anxiety symptomology

2.3.2.1 Screen for Child Anxiety Related Emotional Disorders

Anxiety severity was assessed at pre-treatment and at 2-year follow-up using the Screen for Child Anxiety Related Emotional Disorders, Child (SCARED-C) versions (Birmaher et al., 1997). The full-scale, self-report measure assesses DSM-IV symptoms of panic, separation anxiety disorder, social phobia, generalized anxiety disorder, and school refusal. It has been demonstrated to have good psychometric properties in clinical (Birmaher et al., 1999) and community samples (Hale, Raaijmakers, Muris, & Meeus, 2005).

2.3.3 Pupil and Eyetracking Assessment

Participants sat approximately 68 centimeters from the monitor to complete the Chatroom-Interact Task. Eyetracking and pupil data were collected using a table-mounted RK-

464 eyetracker, which consisted of a video camera and infrared light source pointed at participants' eyes and a device that tracked location and size of the pupil. These data were recorded at 60 Hz (every 16.7 ms) and circulated digitally from the eyetracker to a computer that accumulated the acquired data.

2.3.4 Chatroom-Interact Task

The Chatroom-Interact Task was designed by Silk and colleagues (2012) to examine reactions to social acceptance and rejection from virtual peers in an online setting. The task consisted of two phases on two separate days. On the first day, participants were told they would interact online with several youth their own age at remote sites on their next lab visit. Participants were asked to view the smiling photos and standardized biographical profiles of the age-matched youth (virtual peers) they would have the potential to meet virtually. The photos of virtual peers were of child actors and/or youth residing in a different state who had consented to be photographed by a photographer. Participants were asked to pick the top five youth of same gender that they would be interested in meeting, based on the photos and biological profiles they viewed. Participants were asked to complete their own biographical profile by filling out a questionnaire and to have their photo taken so that the other participants at the remote locations could review their profile and see their picture.

Approximately two weeks after the initial assessment, participants completed the interaction phase of the task. Participants were told that they had been matched with two same-gender youth selected from the first visit and that these peers were ready to participate in a "chat game" via a remote connection. Participants reviewed the profiles and photos from the selected

peers. In the task, participants reviewed pictures of the peers and their own photo on a screen, seeing their own picture and one peer's picture on the screen concurrently. The participant and two virtual peers took turns selecting who they would rather talk to about a series of common interests (e.g., music, television). The photograph of the agent (the one choosing) was shown at the bottom left corner of the screen while the other two players' photographs were shown in the middle of the screen. For each trial, the agent (either the participant or a virtual peer) is asked to choose who they would rather discuss a topic with (e.g., "Who would you rather talk to about music?") for 3.3 seconds (Figure 1). The question sentence was presented at the bottom of the screen. When the participant was rejected, 'rejection trials,' a gray "X" was superimposed on the participants' self-photo for 9 seconds. During trials in which the participant was chosen to discuss a topic, 'accepted trials,' the participant's self-photo was highlighted with a gray box. Participants were asked to indicate, using a button-press, whether the person on the left or right was chosen to maintain task engagement. At the end of the task, participants completed control trials in which they had to indicate where a dot was placed on the monitor using a button-press (Figure 2). This condition was included as a visual, cognitive, and motor control.

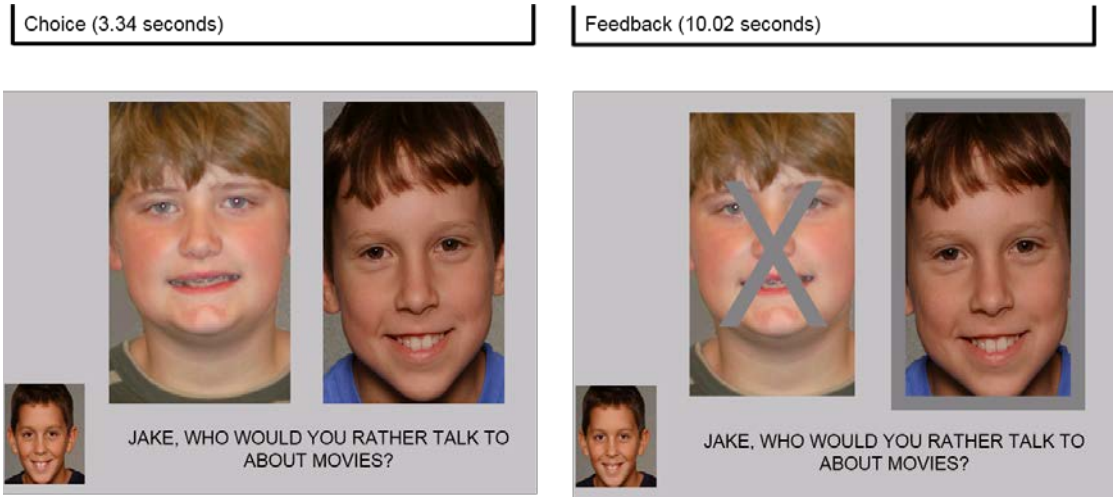

Figure 1. Depiction of trial on Chatroom Interact task

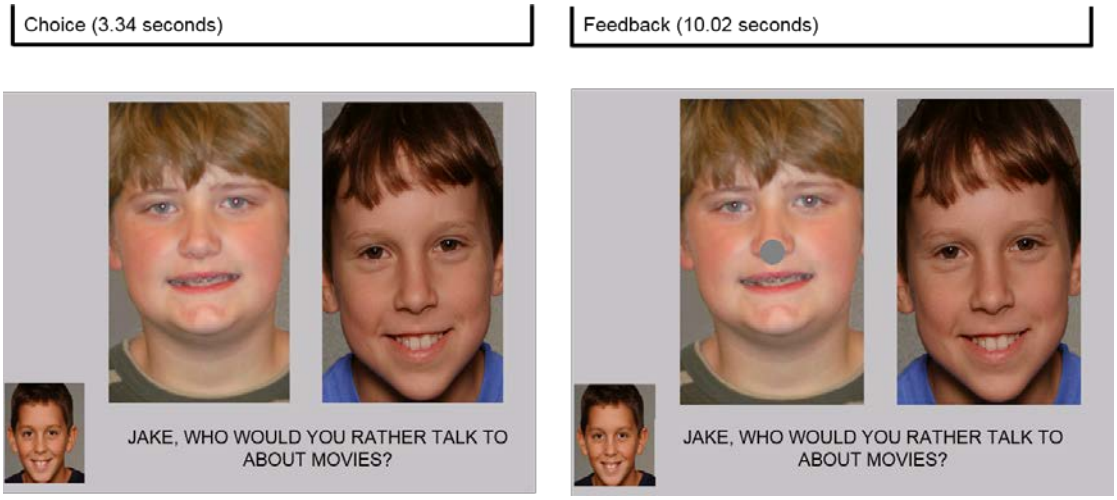

Figure 2. Depiction of control trial on Chatroom Interact task

The task was conducted throughout six blocks. Each block was comprised of 15 trials in which a person was chosen or not chosen as the preferred person to discuss each topic. Topics were presented randomly and repeated in each block. Trials were arranged in blocks so that participants experienced two accept blocks in which they were chosen two-thirds of the time and two reject blocks in which they were rejected two-thirds of the time.

2.3.5 Post-task Questionnaire and Debriefing

Participants were asked to rate how they had felt among six dimensions (happy, sad, angry, nervous, included, and excluded) when they were chosen and when they were not chosen, as well as their level of interest in the task. Ratings were made on a 1-10 point Likert scale. A

research assistant assessed participants to determine if all participants were deceived. One of the participants was rated suspicious of the task, however this subject was not included in the dataset because of missing data. Following this assessment, participants were then debriefed following the task and informed that in reality they had been playing with a preset computer program.

2.3.6 Measures for Exploratory Analyses

2.3.6.1 Rumination measurement

Participants were administered the Children's Response Styles Scales (CRSS) (Ziegert & Kristner, 2002). The scale is a 20-item measure of rumination for children and adolescents. Participants rated statements such as "I think about something that just happened, wishing it had gone better" using a Likert scale (0=Never to 10=Always).

2.3.6.2 Attentional control measurement

Participants' parents completed the Early Adolescent Temperament Questionnaire-Revised Parent Report (EATQ-R) (Ellis & Rothbart, 2001). This questionnaire contains 62 items describing children and adolescents' reactive and regulative temperament traits and includes the following scale: activation control, affiliation, attention, fear, frustration, high intensity pleasure, inhibitory control, pleasure sensitivity. Parents rate statements using a Likert scale (1=Almost always untrue of your child to 5=Almost always true of your child). Analyses used the data from the ratings of attentional control as measured by the parent-report attention subscale, which focuses on the ability to focus and shift attention at will (e.g., "It is easy for my child to really concentrate on homework problems").

2.4 ANALYSES

The present study aimed to 1) examine the main effect of *trial-type* (rejection trials, control trials) on time spent on self-photo (dwell-time index) and on sustained pupil dilation; 2) examine the interaction of *diagnosis group* (anxious, healthy) by *trial-type* for dwell-time index and sustained pupil dilation; and 3) examine correlates of dwell-time index and pupil dilation and specificity of rejection feedback to aid interpretation. Study aims were addressed using SPSS 23.0. Covariates for all tests included pre-treatment anxiety severity (assessed using the SCARED-C), age, gender, and treatment-type.

2.4.1 Data cleaning and processing

Eyetracking data was cleaned using standard procedures (e.g., Siegle, Granholm, Ingram, & Matt, 2001; Siegle, Steinhauer, Carter, Ramel, & Thase, 2003), in which blinks are identified and interpolated throughout. Participants (n = 7) were excluded from analyses if they had less than 70% usable trials or if data exhibited drift upon visual inspection (n = 1). Excluded participants did not significantly differ from included participants on any demographic or clinical measurement (ps >.05). Included participants' demographics are presented in Table 1.

For eyetracking analyses, the X and Y-gaze coordinates were examined as an index of whether the participant was looking at their self-photo or the virtual peer's photo. Dwell-time index was measured as the duration (ms) participants spent looking at their self-photo.

Pupil dilation was calculated by subtracting the pupil diameter prior to stimulus onset (baseline) from the pupil diameter during the trial. Baseline pupil measurements were calculated

by using the first 10 samples (167 ms) of each trial, in which participants looked at the virtual peers' photos, but were not choosing virtual peers to talk to or receiving feedback from virtual peers. Mean pupil change was examined in the period in which participants look at their self-photo in the immediate aftermath of rejection (3.3-5.3 seconds after trial onset; 0-2 seconds after receiving rejection feedback), as well as mean pupil dilation for a later portion of the trial (5.3-9 seconds after trial onset; 2-5.7 seconds after receiving rejection feedback). The early period was selected because previous research examining pupil dilation using the Chatroom-Interact Task found peak pupil change to occur during this time interval (0-2 seconds after feedback), and the late period was chosen to end at 9 seconds after trial-onset to increase the comparability to the previous Chatroom-Interact study, which examined pupil dilation for the same duration (Silk et al., 2012). Average pupil dilation when subject was looking at self-photo during the early window of the rejection feedback (3.3-5.3 seconds after trial onset) was also examined. Finally, control trials, average pupil dilation was calculated by averaging pupil dilation during trials in which participant was supposed to look at self-photo (trials in which a dot was on their face) and trials in which participant was supposed to look at the other participant (trials in which the dot was on the other face) during early and late windows. These indices allow for examining pupillary reaction during early stages of processing and later stages of processing, in which ruminative processing may be occurring.

Table 1. Sample characteristics of included subjects

	Anxious n=22	Healthy n=25
Demographics		
Female (%)	18 (82)	13 (52)

White (%)	20 (91)	17 (68)
Age in years (SEM)	13.63 (.26)	13.78 (.34)
SES (SEM)	$128,333 (6,009)	$72,666 (3,406)

2.4.2 Demographic analyses

Baseline demographic characteristics age, gender, race/ethnicity were analyzed using analysis of variance (ANOVA) models for continuous variables and chi-square test for nominal/categorical variables. Age, gender, and pre-treatment anxiety were used as covariates in all repeated measures analysis of variance (rANOVA). Treatment-type was examined as a covariate in separate ANOVAs analyzing only anxious subjects, as this variable was only applicable to the anxious group.

2.4.3 Main analyses

To examine the main effect of *trial-type* (hypothesis 1a) and interaction of *diagnosis group* and *trial-type* for the dwell-time index (hypothesis 1b), several rANOVA's were used with *diagnostic group* (anxious, healthy) as the between-subject factors and *trial-type* (rejected trials, control trials) as the within-subjects factor.

Parallel rANOVA tests were run to probe the main effect of *trial-type* (hypothesis 2a) and interaction of *diagnosis group* by *trial-type* for pupil dilation (hypothesis 2b).

Exploratory analyses

2.4.3.1 Correlates of findings to aid interpretation

Exploratory analyses were conducted to aid in interpretation of findings. Pearson correlation tests were run to examine the association between attention and pupil dilation indices and degree of rumination, as assessed by the CRSS, attentional control, as assessed by the EATQ-R, and anxiety severity, as measured by the SCARED-C.

2.4.3.2 Specificity of findings

Additionally, parallel rANOVA tests for both hypotheses were run to examine if findings are specific to rejection feedback, or if they generalize to acceptance feedback.

3.0 RESULTS

3.1.1 Demographics

A one-way ANOVA with a between group factor of *diagnosis group* revealed no significant differences in age between the two groups, $F(1, 46) = .11$, $p = .74$. Chi-square tests revealed that there were more females in the anxious than healthy group, $\chi(1) = 4.63$, $p < .05$, but there were no significant differences in race distribution between the two groups, $\chi(3) = .35$, $p = .35$.

3.1.2 Main analyses

The rANOVA analysis to measure the main effect of *trial-type* and interaction of *diagnosis group* by *trial-type* for the dwell-time index during rejection and control trials revealed a main effect of *trial-type*, $F(1, 45) = 21.36$, $p < .01$, which, as predicted, reflected a longer time spent looking at the self-photo on rejection trials compared to control trials (see Table 2 for uncorrected means). There was no significant interaction of *diagnosis group* by *trial-type*, $F(1, 45) = .003$, $p= .96$, contrary to hypotheses.

The rANOVA examining early and late pupil dilation revealed main effects of *trial-type*, $F(1, 45) = 17.52$, $p < .01$ and $F(1, 45) = 18.64$, $p < .01$, respectively, indicating there was greater

pupil dilation for rejection trials compared to control trials for both early and late time periods. However, there was no significant interaction of *diagnosis group* by *trial-type* or main effect for either early, $F(1, 45) = 1.73$, $p = .20$, or late periods, $F(1, 45) = 2.79$, $p = .10$.

Finally, the rANOVA examining pupil dilation when participants were looking at their self-photo, also indicated statistically significant greater pupil dilation during rejection trials compared to control trials across participants, $F(1, 43) = 12.16$, $p < .01$. There was no significant interaction of *diagnosis group* by *trial-type*, $F(1, 43) = .13$, $p = .72$, contrary to hypotheses.

When conducting the analyses controlling for the covariates (age, gender, pre-treatment anxiety, and treatment-type), no main effects or interactions emerged across all indices and no covariates were significant (ps > .05).

3.1.3 Exploratory analyses

3.1.3.1 Correlates of findings to aid interpretation

Pearson correlations examining the association between the dwell-time index during rejection and attentional control revealed a slight negative, but non-significant association, $r(47) = -.20$, $p = .19$ (see Table 3 for correlation matrix). There were no significant correlations of dwell-time and rumination, $r(47) = .01$, $p = .98$. Furthermore, Pearson correlations examining rumination and pupil dilation during rejection indices revealed no significant associations for rumination and early pupil dilation, $r(47) = .05$, $p = .73$, late pupil dilation, $r(47) = -.05$, $p = .74$, or pupil dilation when participants were looking at their self-photo, $r(47) = .04$, $p = .80$. There was a slight positive, but non-significant association of pupil dilation when participants were looking at self-photo during rejection trials and attentional control, $r(47) = .23$, $p = .13$. No

significant associations emerged when examining attentional control and early pupil dilation, $r(47) = .16$, $p = .28$ or attentional control and late pupil dilation, $r(47) = .18$, $p = .24$. There were no significant nor trending associations of anxiety severity and attentional or pupillary indices ($ps > .4$).

Table 2. Dwell-time and pupil indices

		Anxious m (se)	**Healthy** m (se)
Dwell time on Self-Photo			
	Rejection	.37 (.03)	.40 (.03)
	Acceptance	.50 (.04)	.57 (.04)
	Control-Look at other	.28 (.04)	.31 (.03)
	Control-Look at self	.52 (.05)	.62 (.04)
Early pupil dilation			
	Rejection	.10 (.02)	.08 (.02)
	Acceptance	.11 (.02)	.06 (.02)
	Average Control	.01 (.02)	.03 (.01)
Late pupil dilation			
	Rejection	.13 (.02)	.07 (.02)
	Acceptance	.11 (.02)	.05 (.02)
	Average Control	.04 (.02)	.03 (.02)
Pupil dilation when looking at self-photo			
	Rejection	.07 (.03)	.06 (.02)
	Acceptance	.11 (.03)	.06 (.02)
	Average Control	.01 (.004)	.004 (.004)

Table 3. Exploratory correlation matrix

		Exploratory variables			Attentional Features			
		Rumination	Attentional Control	Anxiety Severity	Dwell time	Early Pupil	Late Pupil	Pupil when looking at self-photo
Rumination	Correlation	1	-0.21	.51**	0.01	0.05	-0.05	0.04
	Significance		0.15	0	0.98	0.73	0.74	0.80
Attentional Control	Correlation		1	-.31*	-0.20	0.16	0.18	0.23
	Significance			0.04	0.19	0.28	0.24	0.13
Anxiety Severity	Correlation			1	-0.12	0.04	0.06	0.04
	Significance				0.42	0.80	0.71	0.81
Dwell time	Correlation				1	-0.07	0.04	-0.09
	Significance					0.64	0.77	0.53
Early Pupil	Correlation					1	.60**	.91**
	Significance						0	0
Late Pupil	Correlation						1	.48**
	Significance							0.001
Pupil when looking at self-photo	Correlation							1
	Significance							

Note. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

3.1.3.2 Specificity of findings

The parallel rANOVA analysis to measure the main effect of *trial-type* and interaction of *diagnosis group* by *trial-type* for the dwell-time index during acceptance and control trials revealed a main effect of *trial-type*, $F(1, 45) = 5.27$, $p < .05$, similar to the rejection results, which reflected a longer time spent looking at the self-photo on acceptance trials compared to control trials (see Table 2 for uncorrected means). There was no significant interaction of *diagnosis group* by *trial-type*, $F(1, 45) = 1.12$, $p = .30$ when examining acceptance and control trials.

The rANOVA examining early pupil dilation in acceptance and control trials, indicated an interaction of *diagnosis group* by *trial-type*, $F(1, 45) = 4.86$, $p < .05$, unlike in the rejection

analyses (see Figure 3). Post-hoc pairwise comparisons revealed that anxious children had a significantly greater early pupil dilation during acceptance trials compared to control trials, $p <$ .01.

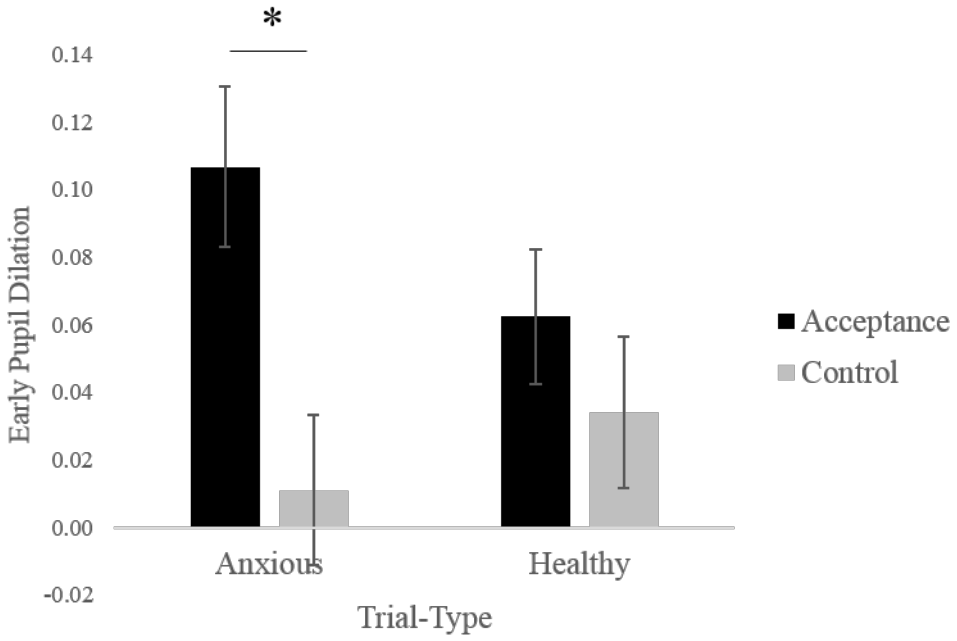

Figure 3. Effects of *diagnosis-group* and *trial-type* on change in early pupil dilation. There was a significant interaction of *diagnosis-group* by *trial-type.* The interaction showed that anxious children had significantly greater pupil dilation in acceptance trials compared to control trials. * p < .01, error bars represent ± SEM

Similar to the rejection trial analyses, the rANOVAs examining late pupil dilation and pupil dilation when participants were looking at their self-photo revealed main effects of *trial-type*, $F(1, 45) = 13.66$, $p < .01$ and $F(1, 43) = 18.53$, $p < .01$, respectively, indicating there was greater pupil dilation for rejection and acceptance compared to control trials for both late pupil dilation and pupil dilation when participants were looking at their self-photo. Furthermore, there was a trend, but non-significant interaction of *diagnosis group* by *trial-type* for late pupil

dilation, $F(1, 45) = 3.92$, $p = .05$, and pupil dilation when participants were looking at their self-photo, $F(1, 43) = .2.02$, $p = .15$.

4.0 DISCUSSION

This study examined how healthy youth and youth with a history of anxiety respond to rejection and acceptance by fictitious peers. Findings showed that social feedback from peers captures attention and is associated with greater pupillary reactivity than a no feedback control condition in both previously treated anxious youth and healthy youth. Positive feedback from peers may differentially affect anxious youth, as evidenced by greater pupil response in the anxious sample during acceptance trials compared to control trials.

The first hypothesis, which predicted that both anxious and non-anxious youth would have a longer dwell-time on their self-photo during social rejection compared to their dwell-time on the self-photo during control trials, was supported, albeit not when controlling for the age, gender, pre-treatment anxiety, or treatment-type covariates. One interpretation of this finding is that individuals who spend more time dwelling on their own faces when receiving negative feedback have less attentional control, a sub-category of executive functioning that is still developing during adolescence (Anderson, Anderson, Northam, Jacogs & Catroppa, 2001). There was a small, but non-significant association between dwell-time during rejection and an attentional control questionnaire, suggesting the effect of social rejection on dwell time may reflect deficits in attentional control in adolescents. Another interpretation could be that the negative emotionality associated with peer rejection may strongly capture and hold the attention

of adolescents, making it difficult for them to look away from socially threatening feedback even without deficits in attentional control. This interpretation is consistent with previous research showing that adolescents are more sensitive to rejection and social exclusion compared to preadolescents (O'Brien & Bierman, 1998; Brown, 2004), perhaps due to the increased prevalence of peer rejection occurring during adolescence (Coie, Dodge & Kupersmidt, 1990; Wang, Iannotti, & Nansel, 2009) and emphasis placed on peer relationships during this developmental stage. Adolescents may spend a greater amount of time pondering why they might have been rejected, reflected in a longer time spent looking at their own, rejected face.

The hypothesis that the anxious group would have a longer dwell-time on the self-photo during rejection feedback, compared to the healthy group, was not supported. There could be several possible reasons for this null finding. First, findings from attention research in anxious youth have been more mixed compared to research in anxious adult populations (Dudeney, Sharpe, & Hunt, 2015; Shechner et al., 2012). A recent meta-analysis found that while anxious youth show a significant bias toward threat-related stimuli and healthy youth do not exhibit such biases, the difference between anxious and control groups is less pronounced in child populations compared to adult populations (Dudeney, Sharpe, & Hunt, 2015). Furthermore, the between-group difference of attentional bias increases across age. Therefore, it may be that attentional biases change across development and are less reliably found in youth, which could factor into why we did not find significant between-group attentional bias differences. Second, it could be that biases emerge depending on the paradigm utilized in the individual studies. The recent meta-analysis found an effect of paradigm used in studies when analyzing attentional bias toward threat in anxious youth compared to healthy youth (Dudeney, Sharpe, & Hunt, 2015). Furthermore, research has shown that the between-group difference in attentional bias toward

threat is even dependent upon small details of the paradigm, such as duration of the threatening stimulus presentation (Bar-Haim et al. 2007; Shechner et al., 2012). No previous study of anxious youth has used the Chatroom-Interact paradigm to study attentional patterns. Therefore, this paradigm may not have been ideal for detecting attention biases in anxious youth compared to healthy youth. The socially-threatening stimuli used in the Chatroom-Interact paradigm might have been so captivating across all youth that subtle differences in attention between the groups were not detectable. Third, the anxious sample in the present study was comprised of youth that were previously treated for anxiety disorder, and most of the youth in the anxiety group no longer met criteria for an anxiety disorder. Differential patterns of attention may emerge depending on the severity of current anxiety symptomology. For example, one study found that children with severe social phobia symptoms had a bias toward threat, while children with lower levels of social phobia symptoms had a bias away from threat, and healthy youth had no threat bias (Waters, Mogg, Bradley, & Pine, 2013). Therefore, we may not have found differences between the anxious and healthy group because the majority of our anxious sample was not clinically anxious at the time of the study.

The hypothesis predicting that both diagnostic groups would have larger sustained pupil dilation in rejection trials compared to control trials was supported. Results indicated that during rejection trials, participants had greater pupil dilation both soon after receiving feedback (3.3-5.3 seconds after trial onset) and in the later stages of processing feedback (5.3-9 seconds after trial onset) compared to control trials. However, as in the eye gaze findings, the results did not hold after controlling for the covariates. Similarly, results showed that there was greater pupil dilation in rejection trials compared to control trials when the participants were gazing at their own self-photo in the few seconds after receiving feedback. Greater pupil dilation in response to rejection

compared to neutral feedback is consistent with previous findings that show that pupils become increasingly dilated with stimuli with greater emotional intensity (Siegle, Steinhauer, Stenger, Konecky, & Carter, 2003), such as negative emotions associated with rejection. The rumination measure was not significantly associated with any of the pupil indices; therefore, we cannot conclude that rumination played a contributory role.

In line with the eye-tracking analyses but contrary to predictions, the anxious and healthy youth did not differ in pupil dilation during rejection trials. This finding contradicts previous research which found that clinically anxious youth have a greater pupil dilation than healthy controls after being presented with threatening adult faces in a dot-probe paradigm (Price et al., 2013). These contrasting results may be due to differences between the paradigms used. The dot-probe task has no social-evaluative component and therefore may be more suited to elicit subtle differences in pupil response between diagnostic groups. The Chatroom-Interact task may elicit strong pupil reactions, irrespective of anxiety, due to the potency of the rejection stimuli. Furthermore, in a task in which anxious and healthy adults and anxious and healthy youth viewed and listened to threatening words (both socially threatening and non-social threatening words), researchers found no main effect of anxiety diagnosis on pupil reactivity (Shechner, Jarcho, Wong, Leibenluft, Pine & Nelson, 2015). Therefore, task differences, such as type of stimuli used, may account for discrepancies in findings.

In order to examine if our findings were specific to rejection trials, we examined whether the rejection findings could be replicated using acceptance trials. Similar to our rejection findings, we found a condition effect indicating that participants showed greater dwell-time and larger pupil dilation during acceptance trials compared to control trials, without controlling for

covariates. Therefore, we cannot assume that rejection uniquely alters attentional and cognitive processing. Instead, social feedback, in general, may modify attentional and pupillary responses.

Unlike in our rejection findings, we found a group by condition interaction effect on pupillary response to acceptance. Specifically, anxious youth had significantly larger pupil dilation in acceptance trials compared to control trials in the earlier part of the trial (3.3-5.3 seconds after trial onset), but healthy subjects did not. Less research has examined reward processing in anxious youth compared to threat processing in anxious youth (Shechner et al., 2012; Silk et al., 2012). However, using a paradigm similar to the Chatroom Interact task, researchers found that young adults with depression and high rates of comorbid anxiety exhibited heightened amygdala response to peer acceptance feedback compared to the healthy control group (Davey, Allen, Harrison, & Yucel, 2011). Given that pupil dilation is innervated by limbic regions of the brain such as the amygdala (Koikegami & Yoshida, 1953), our pupillary findings may reflect an altered limbic response in anxious youth. This is consistent with findings which indicate that increasing levels of reward are associated with corresponding increases in pupil dilation (Bijleved, Custers & Aarts, 2009). In other studies, anxious children have demonstrated a hyper-active neural response to reward in fronto-striatal regions of the brain (Guyer et al., 2012) that are implicated in reward processing and motivation (Mogenson, Jones, & Yim, 1980). Therefore, our finding that anxious youth had a significantly larger pupil dilation for acceptance compared to control trials (that was not found in healthy controls), may suggest a heightened sensitivity for reward in anxious youth. If replicated, this knowledge could be leveraged in clinical settings. In a study examining the efficacy of a family-based group cognitive behavioral therapy treatment for anxious youth, parents rated their children's lesson on rewarding brave behavior as the most useful session (Shortt, Barett, & Fox, 2001). Reward may be particularly

potent for anxious children and could be used to a greater degree in order to strengthen existing treatments for anxious children and adolescents.

Limitations of the present study should be noted. First, our sample size was small. When we controlled for age, gender, anxiety severity, and treatment-type our findings did not remain, yet no main effect of the covariates or interactions with the covariates were significant. Due to our limited sample size (n = 47), we limited the ability to detect a significant interaction when controlling for the covariates. Post-hoc power analyses using G*Power (Faul, Lang, & Buchner, 2007) revealed that there was only enough power (set at 0.80) to detect large effect sizes (Cohen's f = .42) in the performed analyses. Future studies should examine if age, gender, and/or puberty affect attentional and socioemotional processing in a larger sample of anxious and healthy youth. Age, in particular, may affect pupillary findings, as previous research has found that older youth had a greater pupillary response in the wake of peer rejection compared to younger youth (Silk et al., 2012). Second, the majority of the anxious group (17 of 22 subjects) no longer met full criteria for an anxiety disorder at the time of the assessment. Group differences may have emerged if youth in the anxious group were all currently anxious. A final limitation of the present study is that the task used does not measure attentional disengagement directly because the task does not explicitly require adolescents to look at the social threat or reward and then look elsewhere. Therefore, we cannot be certain that dwell-time differences imply differences in attentional disengagement. Alterations to the task, such as requiring adolescents to look away from their self-photo, would more directly assess disengagement.

Despite these limitations, present findings have several strengths and potential clinical implications. Our unique sample of previously treated anxious youth allowed us to examine the pattern of attentional and pupillary responses following peer feedback after youth receive

psychotherapy. Results largely did not show group differences between the treated, anxious sample and the sample of healthy controls. It is possible that significant differences between the groups did not emerge because previous treatment normalized any attention biases that were present in the anxious youth. Psychotherapy, therefore, may alter biases that could contribute to problematic cognitions and behavior. Prospective research is needed to support this possibility, which could have important clinical implications. Furthermore, future work should also examine if anxious youth without a history of treatment have differential patterns of attention compared to healthy youth that contribute to anxiety symptomology. Finally, this is the only study, to our knowledge, to examine attention and pupillary responses in a sample of anxious youth using a developmentally appropriate, ecologically valid paradigm. Future research should more directly investigate how patterns of attentional disengagement in youth differ in ecologically valid paradigms compared to more standardized laboratory paradigms.

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