HHS Public Access

Author manuscript

J Exp Child Psychol. Author manuscript; available in PMC 2020 March 20.

Published in final edited form as:

J Exp Child Psychol. 2019 March ; 179: 90–102. doi:10.1016/j.jecp.2018.10.011.

Looking for the Negative: Depressive Symptoms in Adolescent Girls are Associated with Sustained Attention to a Potentially Critical Judge during In Vivo Social Evaluation

Mary L. Woody[1,*], **Dana Rosen**[2,*], **Kristy Benoit Allen**[3], **Rebecca B. Price**[1], **Emily Hutchinson**[2], **Marlissa C. Amole**[2], **Jennifer S. Silk**[1,2]

[1]University of Pittsburgh, Department of Psychiatry

[2]University of Pittsburgh, Department of Psychology

[3]University of Tennessee, Department of Psychology

Abstract

Attention biases toward negative stimuli are implicated in the development and maintenance of depression. However, research is needed to understand how depression impacts attention biases as they unfold in a dynamic social environment, particularly during adolescence when depression rates significantly increase due to enhanced reactivity to social stress. To examine attention biases in a live, socially evaluative environment, 26 adolescent girls from the community gave a speech in front of a potentially critical and a positive judge while wearing mobile eye-tracking glasses. Girls' depressive symptoms were measured using the Moods and Feelings Questionnaire. Across the sample, girls looked at the positive judge more frequently and for longer periods of time compared to the potentially critical judge. In contrast, higher depressive symptoms were associated with looking at the potentially critical judge for longer periods of time. When directly comparing attention to the potentially critical judge *relative* to the positive judge, dysphoric girls looked at the potentially critical judge more frequently and for longer periods of time compared to the positive judge. Findings suggest that adolescent depressive symptoms are related to sustained attention toward potentially critical evaluation, at the exclusion of positive evaluation. This novel approach allowed for an in vivo examination of attention biases as they unfold during social evaluation, which begins to illuminate the interpersonal significance of attention biases. If replicated and extended longitudinally, this research could be used to identify adolescents at high risk for future depression and potentially be leveraged clinically in attention bias modification treatment.

Address correspondence to: Dana Rosen, M.S., Department of Psychology, University of Pittsburgh, Pittsburgh, PA 15213, USA. dkr19@pitt.edu.

*Denotes shared first-authorship

The authors declare they have no competing or potential conflicts of interest.

Keywords

Attention biases; adolescent depression; social evaluation

Rates of depression increase considerably during adolescence, affecting 15 to 25% of adolescents (Kessler et al., 2001; Kessler and Walters, 1998). Sex differences in depression emerge during this same developmental period, with adolescent girls at two-fold risk for meeting criteria for major depressive disorder (MDD) compared to their male counterparts (Andersen and Teicher, 2008; Hankin et al., 1998; Kessler and Walters, 1998; Saluja et al., 2004; Sheeber et al., 2001). Although increasing levels of depressive symptoms in adolescence are commonly considered normative, subclinical depression can double or triple the risk for a major depressive disorder as an adult (Pine et al., 1999). Both MDD and subclinical depressive symptoms in adolescence are linked to serious affective, interpersonal, and academic deficits, and are significant risk factors for suicide (Gotlib et al., 1995; Thapar et al., 2012).

Longstanding cognitive models of depression implicate attention biases in the onset, maintenance, and recurrence of depressive symptoms and disorders (e.g., Beck, 1976; Clark and Beck, 1999). Depression is theorized to be associated with sustained processing of and difficulty disengaging attention from negative socio-affective stimuli, as well as a lack of the positivity bias that is typically seen among healthy individuals (Mogg & Bradley, 2005). There is considerable empirical evidence for these biases in adult depression; as compared to their euthymic counterparts, individuals with current MDD display greater sustained attention to negative socio-affective stimuli relative to positive or neutral socio-affective stimuli (for reviews, see Armstrong and Olatunji, 2012; Peckham et al., 2010). Research has also shown that individuals with MDD exhibit significantly less attention to positive stimuli compared to healthy controls (Peckham et al., 2010). Attention biases persist following the acute phase of the disorder and are thought to increase risk for subsequent depressive episodes. This is supported by evidence that individuals with remitted MDD exhibit sustained attention to negative socio-affective stimuli (Fritzsche et al., 2012; Joormann et al., 2007; Sears et al., 2011; Soltani et al., 2015; Woody et al., 2017), which predicts MDD recurrence (Woody et al., 2016) and prospective increases in depressive symptoms (Beevers and Carver, 2003; Beevers et al., 2011).

Studies examining attention biases in youth with, or at high-risk for, depression also support the role of attention biases to negative socio-affective stimuli in the development and maintenance of depression (for a review, see Platt et al., 2017). Attention biases to negative socio-affective stimuli develop well before the first onset of depressive disorders among youth at high familial risk for depression (Joormann et al., 2007; Kujawa et al., 2011), and youths' sustained attention to negative socio-affective stimuli is enhanced during depressive episodes and persists into remission (Hankin et al., 2010). However, some research has suggested that youth with, or at high familial risk for, depression may also exhibit attentional avoidance of negative socio-affective stimuli (Gibb, Benas, & Grassia, 2009; Gibb, Pollak, Hajcak, & Owens, 2016; Harrison & Gibb, 2015) and that this attentional avoidance may predict later depressive symptoms among youth with a history of anxiety disorders (Price et

al., 2016). Taken together, these studies suggest that attention biases for negative socio-affective stimuli develop before the onset of adolescent depression and, similar to adults, serve to maintain and increase risk for depressive symptoms and disorders. However, the direction of these effects in youth (i.e., preferential attention vs. attentional avoidance of negative socio-affective stimuli) remains unclear and deserving of additional research.

Although attention biases to negative socio-affective stimuli clearly play a role in the development of depression, there has been little investigation into how attention biases manifest during real-world situations. This is in part due to the constraints of prior methodology. Specifically, research assessing attention biases in depression has generally used reaction time measures, such as the widely-used computerized dot-probe task (MacLeod et al., 1986). In this task, participants first view a pair of emotional faces, one negative and one neutral. The stimuli disappear, and a probe appears in the prior location of either the negative or the neutral stimulus. Participants then make a motor response to indicate the location of the probe. When participants are slower at responding to probes that replaced the neutral stimulus compared to probes that replaced the negative stimulus, these individuals are considered to have an attention bias toward negative information. However, manual reaction time studies do not precisely delineate the time course of attention and instead provide a "snapshot of attention" at the moment in time when the probe appeared (Armstrong and Olatunji, 2012). Eye-tracking methodology has become a popular method for measuring the time course of attention, which may be especially critical for depression research given that attention biases occur after initial orientation and during sustained processing stages. Furthermore, and perhaps most important, recent technological advances have enabled eye tracking technology to move beyond computer-based paradigms and track attention to socio-affective information during in vivo social interaction. Thus, eye tracking paradigms have the potential to illuminate how selective attention biases manifest within a dynamic social environment.

Increasing sensitivity to social rejection is thought to partly underlie the rapid rise in depressive disorders and elevated depressive symptoms commonly seen during adolescence (Kupferberg et al., 2016; Silk et al., 2012). Interpersonal theories of depression suggest that depression is linked to sustained processing of and difficulty disengaging attention from rejection cues, which serves to maintain dysphoria via a perseverative focus on perceived or anticipated social rejection (Slavich et al., 2010). Notably, these biases may be especially heightened for adolescent girls and may partially explain emerging gender differences in adolescent depression (Hammen, 2003; Rudolph and Flynn, 2014). The recent advent of mobile eye tracking glasses, which allow researchers to measure in vivo indices of attention during social interaction, opens novel and more ecologically-valid avenues to explore the role of attention to perceived or anticipated social rejection in the context of depression. Therefore, the goal of this study was to examine the link between depressive symptoms and in vivo attention biases to signals of positive and potentially critical social evaluation among adolescent girls recruited from the community. Of note, the current study did not include or exclude participants based on clinical diagnoses of depression, and, thus, the sample likely characterized depressive symptoms across both typical and clinical adolescent girls.

To test our hypotheses, we employed a novel paradigm where adolescent girls wore eye tracking glasses while giving a speech to two female confederate judges. During the speech, the positive judge provided signals of approval (i.e., smiling, paying close attention) whereas the potentially critical judge provided signals of mild disapproval by maintaining a neutral face and projecting potential disinterest in the speech. Despite the neutral facial expression of the potentially critical judge, we classified this judge as potentially critical because of her cues of disinterest in the adolescent's speech, as well as research suggesting that neutral facial expressions are interpreted as negative in the context of social evaluation (for a review, see Wieser and Brosch, 2012). Given that adolescence is a developmental period defined by the tendency to seek out social reward (Gilbert, 2012), we expected the majority of adolescents to display an attention bias toward the positive judge during the speech, compared to the potentially critical judge. Further, consistent with the majority of past adult and child research, we hypothesized that dysphoria would disrupt this positivity bias such that adolescent girls exhibiting greater levels of depressive symptoms would fixate attention on the potentially critical judge more frequently and for longer durations of time, compared to the positive judge. Finally, we explored whether adolescent girls' levels of depressive symptoms would be associated with attentional avoidance of looking at the judges.

Method

Participants

Participants were 32 adolescent girls (ages 11–16) recruited from the community through internet and flyer advertisements, and the University's Clinical and Translational Science Institute research portal. Exclusion criteria included ongoing and serious health problems, psychoactive or cardiovascular medications, and parent-reported history of autism spectrum disorder, bipolar disorder, neurological disorder, psychosis, or active substance abuse. Participants were also excluded if they had ocular conditions that would impede eye tracking measurement and/or if they were unable to see clearly without prescription glasses. Descriptive statistics and correlations among study variables can be found in Table 1.

Measures

Speech Task.—The speech task was designed as a novel measure of attentional deployment in the context of an ecologically-valid stressor, which probed where (and to whom) participants chose to look when giving a speech (Allen et al., submitted). Girls were instructed to give a two-minute speech as if they were auditioning for a reality TV show for teens, and they were told to explain why they should be picked for the show in their speech. Girls were told that they would be given two minutes to prepare with their mothers before giving the speech and that mothers would be seated behind them during the speech. The girls were also informed that two judges would be seated across from them, evaluating and taking notes, and would provide feedback after their speech. Critically, these two judges (both of whom were young adult females) were study confederates who were instructed to act in predetermined ways (see Supplement Table S1 for detailed descriptions of how each judge was instructed to behave). Positive and potentially critical judges' seat positions (left or right) were counterbalanced across participants. During the speech, the positive judge was instructed to smile, nod, and take notes at designated intervals. The potentially critical judge

was instructed to maintain a neutral face, take notes, shuffle feet, and spend time looking away from and toward the girl at prescribed intervals. Due to ethical considerations, the potentially critical judge did not display overtly negative expressions or behavior.

After the speech, girls were provided with pictures of each judge and asked to complete a questionnaire evaluating how stressed and happy each judge made them feel on a Likert scale from 0 to 10, with 10 being the most stressed or happy. Girls reported feeling more stress in response to the potentially critical judge ($M = 4.85$, $SD = 3.13$) compared to the positive judge ($M = 2.92$, $SD = 2.88$), $t(25) = 2.43$, $p = .023$, Cohen's $d = .64$. Similarly, girls reported feeling less happy in response to the potentially critical judge ($M = 3.96$, $SD = 3.17$) compared to the positive judge ($M = 5.46$, $SD = 3.04$), $t(25) = -2.12$, $p = .044$, Cohen's $d = .48$. This manipulation check validates that girls viewed the potentially critical judge as more negatively valenced than the positive judge. Of note, after completing the speech and questionnaires, girls were given predetermined positive feedback from each judge to minimize potential stress and discomfort following completion of the task.

Eye Tracking Glasses.—To track attention toward the positive and potentially critical judge during the Speech Task, girls wore binocular Tobii Pro Glasses 2 (Tobii Technology, Inc., Falls Church, VA). Tobii eye tracking glasses look similar to reading glasses but are equipped with a high definition camera that captures the participant's visual field, measuring approximately 80° horizontal and 52° vertical. The glasses feature four eye tracking sensors with a sampling rate of 50 Hz, as well as infrared (IR) illuminators that brighten the eye and support the eye tracking sensors. Advanced image-processing algorithms were used to estimate the eye's position and gaze point using Tobii's standard software. Tobii has published a series of quality tests to determine the accuracy and precision of the Tobii Pro Glasses 2, which reveal that the average difference between the fixation target location and the measured gaze location is 0.62° (Tobii AB, 2017).

Eye tracking data were processed using Tobii Pro Glasses Analyzer (Tobii Technology, Inc., Falls Church, VA). A customized specified filter was used to classify eye movements (e.g., fixations, saccades), and fixations were identified by a consecutive chain of raw data points below the velocity threshold of 30 degrees/second. The Tobii Real-World Mapping function was used to automatically map fixations to areas of interest (AOI) using proprietary Tobii algorithms. In brief, an AOI was created around the entire face and body of each judge, and regions of interest analyses were used to identify whether or not the girl's eye gaze was fixated on each judge at each sampling point. To do so, the automatic mapping procedure mapped raw gaze data and fixations from the video captured by the glasses camera onto a still snapshot, which was created using a representative still image, generated from a single frame, taken from each girl's glasses camera. To ensure that this procedure was accurate, a research assistant verified frame by frame whether the automatic mapping data matched the fixation data captured by the eye tracking sensors and glasses camera. If there was a discrepancy (e.g., due to the participant moving their head), then the error was manually corrected by a research assistant. Information regarding reliability training for automatic mapping procedures can be found in the online supplementary materials.

Since biased attention to emotional information can be assessed via distinct attentional components, we selected multiple eye tracking indices of interest. As demonstrated by prior research (for a review, see Gibb et al., 2016), the components most relevant to depression are frequency of attentional allocation (i.e., negative stimuli are looked at more frequently) and sustained attentional capture (i.e., longer overall time spent looking at negative stimuli and longer time to disengage from a negative stimulus once attention is allocated to it). In the current study, we selected eye tracking indices that aligned with these attentional components.

These indices were derived by quantifying "visits" to each judge, which were 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 measure frequency of attentional allocation, we looked at how many unique visits were made to each judge (number of visits). To measure sustained attentional capture, we looked both at the total duration of visits to each judge across the two-minute speech (total visit time) and the average time it took to disengage from each judge across visits (average visit time).

Girls who did not achieve adequate eye tracking calibration ($n = 2$) and girls who had less than 50% valid gaze data (i.e., where gaze coordinates could be estimated by Tobii) ($n = 4$) were excluded from analysis, leaving a sample of 26 girls for analyses. Outliers for each eye tracking index were Winsorized by first identifying scores that were 3 times the interquartile range (IQR) above or below the median. Scores that exceeded this threshold were corrected by being reassigned to the maximum or minimum value (i.e., 3*IQR +/− the median).[1]

Adolescent Depressive Symptoms.—Girls' depressive symptoms were measured using the self-report version of 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 questionnaire has been shown to validly index depressive symptoms in community youth (Banh et al., 2012; Sund, Larsson, & Wichstrom, 2001) and discriminate youth with major depressive disorder from youth with other mood disorders and from youth with no mood disorders (Daviss et al., 2006; Kent, Vostanis, & Feehan, 1997). On the MFQ-C, participants rate each statement as 0 (not true), 1 (sometimes true), or 2 (true). All items were summed, with a higher score indicating greater depressive symptoms. The MFQ-C has demonstrated excellent internal consistency and validity in previous research (Daviss et al., 2006; Wood et al., 1995) and exhibited excellent internal consistency in the current sample ($\alpha = .92$). MFQ scores in the current sample demonstrated moderate skew ($z > 2.50$; cf. Tabachnick and Fidell, 2007), thus MFQ scores were square-root transformed prior to further analysis to satisfy assumptions of normality.

Procedure

Upon arrival to the laboratory, caregivers were asked to provide informed consent and girls were asked to provide assent to be in the study. Before the Speech Task, participants put on

[1]Significant findings were maintained when analyzing raw distributions without Winsorization.

the Tobii mobile eye tracking glasses and were seated about eight feet away from the two judges. Before beginning the Speech Task, girls completed a calibration procedure where they were instructed to look at a specific target on a small card while a research assistant checked the equipment for accuracy (see supplement for more details). Next, as part of a larger series of interaction tasks not described here, girls engaged in the Speech Task. Finally, girls completed questionnaires for the study. As part of a larger study, caregivers and girls were compensated $60 and $90, respectively. All study procedures were approved by University's Institutional Review Board.

Results

For each eye tracking index, we used repeated measures analysis of variance (ANOVA) to examine whether there were significant differences in how adolescent girls allocated attention to the potentially critical and the positive judge during the Speech Task and whether these effects were moderated by girls' levels of depressive symptoms. For each ANOVA model, Judge Type (potentially critical, positive) served as the within-subject variable with a) average visit time, b) total visit time, and c) number of visits to each judge included as the dependent variables, respectively. Girls' MFQ scores were included as a continuous factor in each model.

Additionally, to directly compare attention to the potentially critical judge *relative to the* positive judge, we created proportion scores for each eye tracking index and used Pearson correlations to test whether MFQ scores were significantly related to each proportion score. Proportion scores were calculated by dividing the time (or number of visits) gaze was allocated to the potentially critical judge by the total time (or total number of visits) allocated to either judge during the speech. Across participants, mean total time was 120.86 seconds (2.36), and mean total number of visits was 144.08 (49.75). Finally, we conducted tests of robustness on all analyses to determine if our findings would be maintained when statistically controlling for adolescent age and whether age would moderate any of the reported findings. For all analyses, we used Cohen's "Rules-of-Thumb" to interpret effect sizes (Cohen, 1988).

Average Visit Time.

Focusing first on average visit time to each judge, the repeated measures ANOVA revealed a significant main effect of Judge Type, $F(1,24) = 9.22$, $p = .006$, η_p^2 compared to the potentially critical judge (see Table 1). Importantly, this effect was moderated by girls' MFQ scores, $F(1,24) = 7.33$, $p = .012$, $\eta_p^2 = .23$ (large effect), although there was no significant main effect of MFQ scores, $F(1,24) = .24$, $p = .632$, $\eta_p^2 = .01$. To probe the form of the significant MFQ interaction, we examined the correlations between girls' MFQ scores and average visit time to the potentially critical and positive judges, separately. We found that higher levels of depressive symptoms were positively correlated with significantly longer average visit times to the potentially critical judge, $r = .52$, $p = .006$ (large effect). However, this relation was not significant for the positive judge, $r = -.23$, $p = .266$.

Next, to directly test whether MFQ scores were related to the average visit time to the potentially critical judge *relative* to the positive judge, we examined the correlation between

MFQ scores and the proportion of average visit time to the potentially critical judge versus the positive judge. These analyses showed that higher levels of depressive symptoms were correlated with a significantly higher average visit time to the potentially critical judge relative to the positive judge, $r = .40$, $p = .043$ (medium-to-large effect, see Figure 1a).

Finally, tests of robustness revealed that the above findings were maintained when statistically controlling for adolescent age (ps ≤ .050) and that age did not significantly moderate any of the above effects (ps > .050).

Total Visit Time.

Focusing next on total visit time to each judge, the repeated measures ANOVA revealed a significant main effect of Judge Type, $F(1,24) = 4.82$, $p = .04$, $\eta_p^2 = .17$ (large effect), such that girls spent more overall time looking at the positive judge compared to the potentially critical judge (see Table 1). In contrast, the main effect of MFQ scores, $F(1,24) = 0.69$, $p = .415$, $\eta_p^2 = .03$, and the interaction of MFQ scores by Judge Type, $F(1,24) = 2.72$, $p = .112$, $\eta_p^2 = .10$, were non-significant.

Similar to the pattern for average visit time (above), the proportion of time spent looking at the potentially critical judge versus the positive judge was significantly correlated with MFQ scores, $r = .52$, $p = .007$ (large effect, see Figure 1b), suggesting that higher levels of depressive symptoms were associated with a significantly higher amount of total time spent gazing at the potentially critical judge relative to the positive judge.

Finally, tests of robustness revealed that the above findings were maintained when statistically controlling for adolescent age (ps ≤ .050) and that age did not significantly moderate any of the above effects (ps > .050).

Number of Visits.

Finally, focusing on number of visits to each judge, the repeated measures ANOVA revealed a significant main effect of Judge Type, $F(1,24) = 4.62$, $p = .042$, $\eta_p^2 = .16$ (large effect), such that girls made significantly more visits to the positive judge compared to the potentially critical judge (see Table 1). This effect was not significantly moderated by girls' MFQ scores, $F(1,24) = 2.76$, $p = .110$, $\eta_p^2 = .10$, nor was there a significant main effect of girls' MFQ scores, $F(1,24) = .43$, $p = .518$, $\eta_p^2 = .02$.

Similar to the patterns for both average and total visit time (above), the proportion of visits to the potentially critical judge versus the positive judge was significantly correlated with MFQ scores, $r = .51$, $p = .009$ (large effect, see Figure 1c), suggesting that higher levels of depressive symptoms were associated with significantly more visits to the potentially critical judge relative to the positive judge.

Finally, tests of robustness revealed that age did not moderate any of the above findings (ps ≤ .050). However, when adolescent age was included in the repeated measures ANOVA model, the main effect of Judge Type was reduced to non-significance, $F(1,24) = 2.75$, $p = .111$, $\eta_p^2 = .11$.

Exploratory Analyses.

To test the hypothesis that depressive symptoms could be associated with looking away from either judge (i.e., attentional avoidance), we examined the correlation between MFQ scores and the total visit time and number of visits made to visual areas other than the positive and potentially negative judge. We found that MFQ scores were not significantly correlated with the total length of time spent looking away from the judges, $r = -.08$, $p = .709$, or the number of visits made to areas other than the judges, $r = -.19$, $p = .361$.

Discussion

The primary goal of this study was to investigate adolescent girls' in vivo attention biases to live signals of positive and potentially critical evaluation while giving a speech, and to determine whether these attention biases were moderated by girls' depressive symptoms. Using a novel speech paradigm in conjunction with mobile eye tracking glasses, we predicted that, on average, girls would display more in vivo attention, across a variety of eye tracking indices, to a judge who provided signals of positive evaluation during the speech compared to a judge who provided signals of potentially critical evaluation. Further, we hypothesized that dysphoria would disrupt this positivity bias such that adolescent girls who reported higher levels of depressive symptoms would be more likely to allocate attention to a judge who provided signals of potentially critical evaluation, relative to a judge who provided signals of approval. Our results largely supported these hypotheses. First, we found that, across the sample, girls displayed more frequent and sustained attention toward the positive judge relative to the potentially critical judge. Furthermore, consistent with prior research examining the link between depressive diagnoses and symptoms and attention biases using computer-based tasks in both adults (Armstrong and Olatunji, 2012; Peckham et al., 2010) and adolescents (Hankin et al., 2010), we found that adolescent girls reporting greater levels of depressive symptoms took longer to disengage attention from the potentially critical judge. When we compared the frequency and duration of attention to the potentially critical judge *relative* to the positive judge, we found that greater levels of depressive symptoms were associated with more frequent and greater duration of attention to the potentially critical judge compared to the positive judge.

These findings suggest that, in general, adolescents are more likely to pay attention to people who display signals of positive evaluation relative to those who display signals of potentially critical evaluation. However, consistent with cognitive models of depression (e.g., Beck, 1976; Clark and Beck, 1999; Mogg and Bradley, 2005) and prior research (e.g., Gotlib, McLachlan, & Katz, 1998; Joorman & Gotlib, 2007), we found evidence that dysphoria disrupts this positivity bias, as adolescent girls with higher levels of self-reported depressive symptoms looked more frequently and for longer durations at the potentially critical judge relative to the positive judge. Because sub-threshold depressive symptoms during adolescence increase risk for future depressive disorders (Pine et al., 1999), these findings are also consistent with empirical evidence suggesting that youth at high familial risk for future depression display attentional biases to socio-affective stimuli (Joormann et al., 2007; Kujawa et al., 2011). Of note, the depressive symptoms observed in the current study are consistent with symptomatology found in other community samples of adolescents (e.g.,

Sund et al., 2001), suggesting that our results encompass the spectrum of minimal to moderate depressive symptoms typically seen in community samples. Future research will be essential to determine if these findings would replicate in clinical samples of adolescents.

The current study is the first to shed light on how depressive symptoms interact with in vivo attention biases to live signals of positive and potentially critical evaluation during social interaction. These biases may be especially important in the development of adolescent depression as increased processing of and reactivity to perceived social rejection are thought to be central maintenance and risk factors for depression that are heightened during adolescence (Coyne, 1976; Silk et al., 2012; Slavich et al., 2010). Although most individuals experience a strong drive to secure positive social evaluation and avoid negative social evaluation (Baumeister and Leary, 1995), individuals with, or at risk for, depression experience heightened sensitivity to criticism and social rejection, which first emerges during adolescence (Platt et al., 2013). At the neural level, compared to their never-depressed peers, adolescents with current MDD exhibit enhanced neural activation in limbic and ventral brain regions during peer rejection (Kumar et al., 2017; Silk et al., 2014). At the neuroendocrine level, compared to non-dysphoric adolescents, adolescents with elevated sub-threshold depressive symptoms exhibit heightened cortisol response during an evaluated speech given to adult evaluators (Hankin, Badanes, Abela, & Watamura, 2010). Taken together, this evidence suggests that adolescents with, or at high-risk for, depression experience enhanced processing and reactivity to potential cues of rejection. Our findings provide complementary results at the behavioral level as adolescent girls experiencing elevated depressive symptoms were more likely to attend to cues of potentially critical evaluation. This is important as neural hyperreactivity to social rejection is proposed to have downstream effects by increasing sustained attention to signals of negative evaluation (Disner et al., 2011). Increased sustained attention to signals of negative evaluation is then thought to cause a cascade of other maladaptive consequences such as maintaining a perseverative focus on perceived criticism and social rejection and increasing rumination and negative affect (for reviews, Beck and Bredemeier, 2016; Fossati and Hinfray, 2016).

Findings from the current study may also have meaningful clinical implications. Computerized attention bias modification (ABM) treatments have emerged as possible mechanistic interventions for depression with the advantages of being cost-effective and easily disseminated (Jones and Sharpe, 2017). Generally, ABM treatments are modified versions of the dot-probe paradigm and function by systematically manipulating where the probe is placed to implicitly retrain attention away from negative stimuli and toward positive stimuli. Research attempting to train attention away from sad words and toward positive words was found in one study to reduce depression symptoms in a sample of adolescents compared to youth who received a placebo version of the intervention (Yang et al., 2016). Additionally, ABM has been demonstrated to buffer reactions to a social stressor in adolescents at risk for depression (LeMoult et al., 2016). Despite these findings, a recent ABM meta-analysis did not find ABM to significantly reduce depressive symptoms in adults (Jones and Sharpe, 2017). One factor that may mitigate the effectiveness of these interventions is that ABM may not directly target sustained attention biases toward negative stimuli, which are more characteristic of depression and depressive symptoms, as our findings supported. Rather, it appears to target the initial orienting phase of attentional

processing. Newer interventions that have been designed to target sustained attention biases (e.g., Lazarov et al., 2017; Price et al., 2016) may be more beneficial for targeting maladaptive attention biases related to depressive symptoms. In addition, computerized tasks displaying static images of facial expressions and words may not be targeting biases as they exist in the real-world. The recent advent of mobile eye tracking glasses could create exciting new avenues for targeting in vivo attention biases as they manifest in the real-world social environment, for instance in live naturalistic interactions or in controllable virtual reality simulations.

The current study displayed significant strengths, such as providing the first evidence of a link between adolescent depressive symptoms and attention bias to negative socio-affective stimuli during in vivo social evaluation. Importantly, this study functions as a critical proof-of-concept for the use of mobile eye tracking glasses to measure depressogenic attention bias during social interaction. Despite these strengths, there were notable limitations. First, our sample was small ($n = 26$), which limited our ability to detect smaller effect sizes (i.e., the omnibus test examining the moderating effects of depressive symptoms on total time looking at and total number of visits to the positive and potentially critical judge was at a trend level despite medium-to-large effect sizes). Although further replication and extension is necessary, the effect sizes of our findings suggest that the relation between depression and attention biases to cues of potential criticism in the social environment are robust and meaningful and provide an important interpersonal context to cognitive models of depression. Second, the speech task was conducted in the laboratory, which may not be fully representative of an adolescent's typical social environment. Though the laboratory setting provided the opportunity for a more controlled test of adolescent girls' in vivo attention biases to positive and potentially critical judges during live social evaluation, future studies will benefit from tests both in the laboratory and in the real-world. Third, the current study consisted of all female participants. Given the proposed link between sensitivity to social rejection and the development of depression in women and girls (Hammen, 2003; Rudolph and Flynn, 2014), future studies will benefit from the inclusion of boys in order to determine if attention to signals of potentially critical evaluation is enhanced among adolescent girls compared to boys. Fourth, research suggests that biobehavioral responses may not be expressed uniformly across types of stress (for a review, see Denson et al., 2009), thus highlighting the need for examining the impact of different types of social stressors. Fifth, this study was unable to account for behavioral factors (e.g., body posture, vocalization), which may affect gaze patterns and could be an important factor for future research to address. Sixth, mothers were present in the room at the time of the speech as part of the larger study protocol. Given research that suggests that the presence of a caregiver can ameliorate stress response, especially among younger and pre-pubescent youth (Doom, Hostinar, VanZomeren-Dohm, & Gunnar, 2015), future research would benefit from replication without the presence of caregivers. Finally, while this study provided a cross-sectional examination of depressive symptoms and attention biases during in vivo social evaluation, future prospective research is necessary to illuminate how attention biases in the social environment may impact the longitudinal development of depressive symptoms and disorders.

In conclusion, the present study is the first, to our knowledge, to examine the association between adolescent dysphoria and in vivo attention biases during live social evaluation. Adolescent girls with higher levels of depressive symptoms were more likely to look at the potentially critical judge during their speech for longer amounts of time and more frequently compared to the positive judge. These findings support interpersonal and cognitive models of depression and previous research linking depression and sustained attention toward negative socio-affective stimuli. Critically, they extend this prior research by illuminating how attention biases may exist in the real-world social environments of dysphoric adolescents. Interventions designed to ameliorate sustained attention biases toward negative socio-affective stimuli may be warranted for adolescents with, or at risk for, depression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This project was supported by NIMH grant R01 MH103241 awarded to J.S.S. M.L.W. is supported by an Institutional NRSA from NIMH (T32 MH018269) and R.B.P. by NIMH grant K23MH100259.

The authors thank Marcie Walker, Marcus Min, Lindsey Stone, Julianne Griffith, and Sara Naselsky for their help in conducting assessments and data acquisition for this project and the participants of the study for their time and willingness to provide data.

References

Allen KB, Woody ML, Rosen D, Price RB, Amole MC, & Silk JS (Submitted). Validating a mobile eye tracking measure of integrated interpretation and attention bias in youth.

Banh MK, Crane PK, Rhew I, Gudmundsen G, Vander Stoep A, Lyon A, & McCauley E (2012). Measurement equivalence across racial/ethnic groups of The Mood and Feelings Questionnaire for Childhood Depression. Journal of Abnormal Child Psychology, 40, 353–367. [PubMed: 21996979]

Burleson Daviss W, Birmaher B, Melhem NA, Axelson DA, Michaels SM, & Brent DA (2006). Criterion validity of the Mood and Feelings Questionnaire for depressive episodes in clinic and non-clinic subjects. Journal of Child Psychology and Psychiatry and Allied Disciplines, 47, 927–934. 10.1111/j.1469-7610.2006.01646.x

Doom JR, Hostinar CE, VanZomeren-Dohm AA, & Gunnar MR (2015). The roles of puberty and age in explaining the diminished effectiveness of parental buffering of HPA reactivity and recovery in adolescence. Psychoneuroendocrinology, 59, 102–111. [PubMed: 26047719]

Gibb BE, Benas JS, & Grassia M (2009). Children's attentional biases and 5-HTTLPR genotype: Potential mechanisms linking mother and child depression. Journal of Clinical Child and Adolescent Psychology, 38, 415–426. [PubMed: 19437301]

Gibb BE, Pollak SD, Hajcak G, & Owens M (2016). Attentional biases in children of depressed mothers: An event-related potential (ERP) study. Journal of Abnormal Psychology, 125, 1166–1178. [PubMed: 27684964]

Hankin BL, Badanes LS, Abela JRZ, & Watamura SE (2010). Hypothalamic-Pituitary-Adrenal Axis dysregulation in dysphoric children and adolescents: Cortisol reactivity to psychosocial stress from preschool through middle adolescence. Biological Psychiatry, 68, 484–490. [PubMed: 20497900]

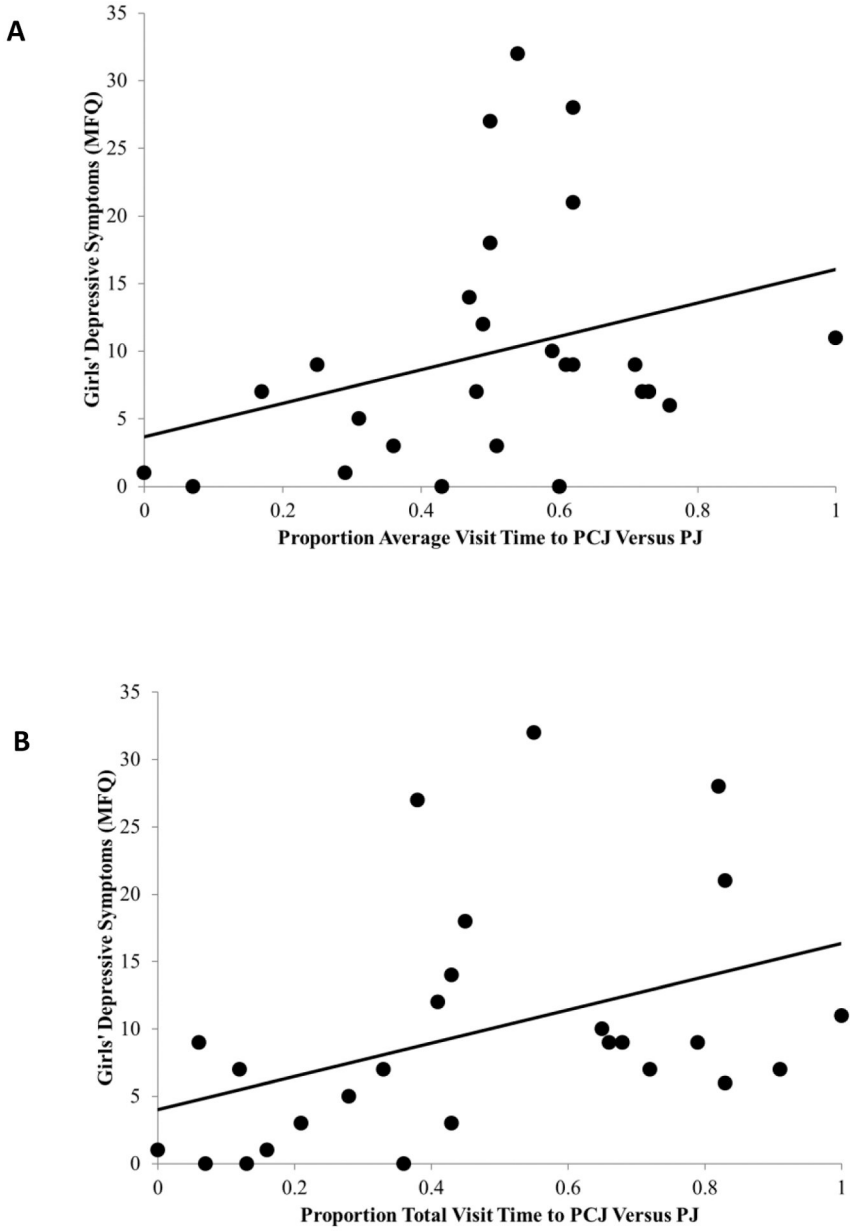
Harrison AJ, & Gibb BE (2015). Attentional Biases in Currently Depressed Children: An Eye-Tracking Study of Biases in Sustained Attention to Emotional Stimuli. Journal of Clinical Child & Adolescent Psychology, 44, 1008–1014. 10.1080/15374416.2014.930688 [PubMed: 25010145]

Kent L, Vostanis P, & Feehan C (1997). Detection of major and minor depression in children and adolescents: Evaluation of the Mood and Feelings Questionnaire. The Journal of Child Psychology and Psychiatry, 38, 565–573. [PubMed: 9255700]

Price RB, Rosen D, Siegle GJ, Ladouceur CD, Tang K, Benoit Allen K, … Silk JS (2016). From anxious youth to depressed adolescents: Prospective prediction of 2-year depression symptoms via attentional bias measures. Journal of Abnormal Psychology, 125, 267–278. [PubMed: 26595463]

Sund AM, Larsson B, & Wichstrom L (2001). Depressive symptoms among young Norwegian adolescents as measured by The Mood and Feelings Questionnaire (MFQ). European Child & Adolescent Psychiatry, 10, 222–229. [PubMed: 11794547]

- Girls look more at live cues of positive evaluation than potentially critical cues
- Dysphoric girls look longer at live cues of potentially critical evaluation
- Dysphoria was not related to looking at live cues of positive evaluation
- Dysphoric girls looked more at potentially critical evaluation *relative to* positive



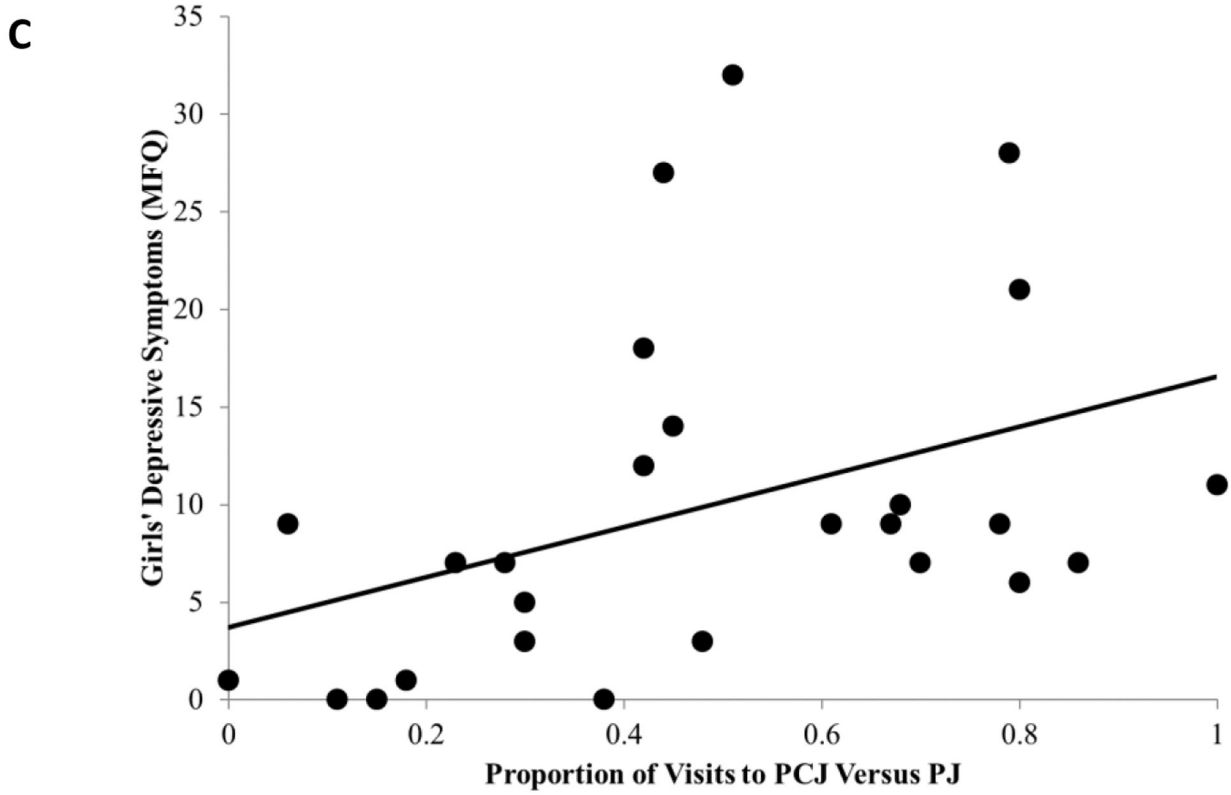


Figure 1.

Relation between Adolescent Girls' Depressive Symptoms and A) Proportion Average Visit Time to PCJ Versus PJ, B) Proportion Total Visit Time PCJ Versus PJ, & C) Proportion of Visits to the PCJ Versus PJ.

Note. To facilitate comparisons with other studies, MFQ scores are shown as untransformed values; PCJ = Potentially Critical Judge; PC = Positive Judge.

Table 1.

Descriptive statistics and correlations among study variables.

	Mean (SD)	1	2	3	4	5	6	7	8	9
1. Age	14.25 (1.65)	-								
2. Family Income	$50,001–60,000	0.29	-							
3. Caucasian	81%	−0.13	0.31	-						
4. MFQ[a]	9.86(8.81)	0.09	−0.10	0.13	-					
5. Average Visit Time to PCJ (seconds)	0.51 (0.34)	0.29	0.19	0.08	0.52**	-				
6. Average Visit Time to PJ (seconds)	0.66 (0.50)	−0.17	0.03	−0.04	−0.23	0.03	-			
7. Total Visit Time to PCJ (seconds)	6.21 (7.43)	0.14	0.17	0.19	0.43*	0.69**	0.16	-		
8. Total Visit Time to PJ (seconds)	9.85 (14.14)	−0.27	0.19	0.29	−0.05	0.20	0.58**	0.49*	-	
9. Number of Visits to PCJ	19.12(16.16)	0.15	0.26	0.20	0.43*	0.71**	0.03	0.94**	0.42*	
10. Number of Visits to PJ	26.58 (29.74)	−0.16	0.20	0.32	−0.06	0.19	0.59**	0.49	0.96**	0.41*

Note. MFQ = Mood and Feelings Questionnaire—child report; PCJ = Potentially Critical Judge; PC = Positive Judge.

[a]To facilitate comparisons with other studies, average MFQ scores are reported as untransformed values; however, correlations between study variables and MFQ scores use square-root transformed values to satisfy assumptions of normality.

*$p < .05$

**$p < .01$