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Variability of Attention Bias in Socially Anxious Adolescents: Differences in Fixation Duration toward Adult and Adolescent Face Stimuli

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Abstract

Prior research on attention bias in anxious youth, often utilizing a visual dot probe task, has yielded inconsistent findings, which may be due to how bias is assessed and/or variability in the phenomenon. The present study utilizes eye gaze tracking to assess attention bias in socially anxious adolescents, and explores several methodological and within-subject factors that may contribute to variability in attention bias. Attention bias to threat was measured in forty-two treatment-seeking adolescents (age 12 to 16 years) diagnosed with Social Anxiety Disorder. Bias scores toward emotional stimuli (vigilant attention) and bias scores away from emotional stimuli (avoidant attention) were explored. Bias scores changed between vigilance and avoidance within individuals and over the course of stimulus presentation. These differences were not associated with participant characteristics nor with self-reported social anxiety symptoms. However, clinician rated severity of social anxiety, explained a significant proportion of variance in the bias scores for adult, but not the adolescent, stimuli. Variability in attention bias among socially anxious adolescents is common and varies as a function of stimulus duration and type. Results may inform stimulus selection for future research.

Keywords

attention bias; social anxiety disorder; adolescents; eye-tracking

Social anxiety disorder (SAD) is characterized by fear or embarrassment and interpersonal evaluation, as well as avoidance of social situations, including absence of direct eye contact (APA, 2013). SAD is also marked by selective attention toward perceived social threat (e.g., Waters, Mogg, Bradley, & Pine, 2011), termed ‘attention bias’, which predicts behavioral avoidance and social withdrawal (e.g., Shechner et al., 2012).

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Traditionally, attention bias is measured through use of the dot-probe (Bradley, Mogg, & Millar, 2000; Waters et al., 2011), from which bias scores are derived from reaction time (Price et al., 2016). The dot probe task has generated a relatively consistent profile of attention bias within anxious adult samples (e.g., Shechner et al., 2013). However, findings from the dot-probe task in anxious youth yield an inconsistent profile (Shechner et al., 2012). Some studies report positive effects relative to the placebo and others report similar effects for both the active and placebo conditions (e.g., Shackman et al., 2016; for a review). Additionally, Kappenman, Farrens, Luck & Proudfit (2014) reported low psychometric properties (i.e., internal reliability) of the dot-probe as well as lack of correlation with trait anxiety, suggesting a need for new tasks.

Visual attention to threat cues, measured via eye-tracking, may be a complementary gauge of attention bias as it taps overt gaze patterns across the duration of the stimulus presentation, whereas the dot probe only assesses initial, essentially covert (automatic), orientation. Eye-tracking allows for a thorough examination of what specific aspects of a stimulus the individual either attends to or avoids. Moreover, eye-tracking methodology offers the ability to delineate bias in initial orientation from subsequent disengagement from threat through the analysis of continuous gaze across stimulus duration. Since attention bias might play a pivotal role in both the etiology and maintenance of social anxiety symptoms (Waters, Mogg, & Bradley, 2011), it is important to explore attention among adolescents across stimulus duration, with particular attention to stimulus type.

Although youth with SAD often struggle with fear of evaluation specifically in relation to similar age peers and are slower to orient to adult than child faces (Benoit, McNally, Rapee, Gamble, & Wiseman, 2007; Gamble & Rapee, 2009), most attention bias research has utilized adult facial stimuli. Given that same-age face stimuli may be more salient and the possibility that attention varies across child/adult faces, adolescent facial stimuli may be important to studying attention bias in youth with SAD.

In the current study, we examine attention bias, through eye gaze, to anger and neutral stimuli within a sample of adolescents with SAD with stimuli portraying both adolescent and adult faces. We hypothesized that adolescents would demonstrate vigilant attention bias, especially initially (i.e., during the first 500ms following stimulus onset). Given that prior research suggests that socially anxious adolescents exhibit primary fears around same-age peers (e.g., Erath, Tu, & El-Sheikh, 2012), we hypothesized that vigilant attention bias would be greater and more consistent for adolescent facial stimuli compared to adult facial stimuli. Given inconsistent findings regarding the directionality of bias to threat, as an exploratory aim, we examined if bias scores (i.e., fixation duration to socially threatening stimuli compared to neutral stimuli) were associated with within-person variables (i.e., participant sex, age, IQ, or symptom severity), which have varied across samples in the extant literature.

Method

Participants

Data were obtained from a randomized controlled trial (RCT) of computerized attention retraining (Ollendick et al., in press). Data were collected pre-intervention and included only participants with complete eye-tracking data, yielding a final sample of 42 adolescents (31 female, 11 male) with SAD between the ages of 12 and 16 years ($M = 14.40$; $SD = 1.35$). In order to be included in the study, adolescents had to: a) meet SAD as determined by the Anxiety Disorders Interview Schedule for DSM-IV (Silverman & Albano, 1996); b) have at least average cognitive functioning as determined by the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler, 2011); c) have stable dosage for at least four weeks, if on psychiatric medication; and d) not receiving psychosocial treatment for anxiety. Psychosocial treatments for other diagnoses were not exclusionary. Participants who met criteria for autism spectrum disorder, schizophrenia, and/or psychopathology that warranted more immediate care were excluded.

Measures

Anxiety Disorders Interview Schedule for DSM-IV-Child and Parent Versions (ADIS-IV-C/P; Silverman & Albano, 1996).—The ADIS-IV-C/P is a semi-structured clinical interview which facilitates the diagnosis of psychiatric disorders in youth. During both the interviews, graduate-level clinicians assessed the severity of the adolescent's social anxiety and other potential psychological problems. Clinicians assigned a severity rating (CSR) on a 9-point scale (0–8, with any rating ≥ 4 indicating probable diagnosis and clinical interference). Separate clinicians administered the ADIS-C and ADIS-P to the child and parent, respectively. Final diagnoses were derived based on composite rules such that, if either interview yielded a diagnosis, that diagnosis and the associated CSR rating was retained as recommended by Silverman and Albano (1996). The mean CSR was 4.76 ($SD = 1.16$).

Brief Fear of Negative Evaluation Scale (BFNE; Leary, 1983).—BFNE is a brief, self-report version of the Fear of Negative Evaluation Scale (Watson & Friend, 1969) which assesses the degree to which individuals experience worry or fear about negative evaluation from others. Using only the eight BFNE items with straightforward wording has been found to yield the best diagnostic sensitivity and specificity (Carleton, Collimore, McCabe, & Antony, 2011). Only these eight items were summed for the total BFNE score in the current study ($\alpha = .959$). Sample mean BFNE score was 27.49 ($SD = 9.26$).

Wechsler Abbreviated Scale of Intelligence, 2nd edition (WASI-2; Wechsler, 2011).—The two-subtest version of the WASI-2 (Vocabulary and Matrix Reasoning) provided an estimate of cognitive ability. The 2-subtest IQ score was deemed appropriate for this study, as 4-subtest and 2-subtest WASI-2 scores correlate between .91 to .95 for children aged 12 to 17 (Wechsler, 2011). The sample's mean IQ score was 109.19 ($SD = 13.86$).

Eye-tracking tasks.—Participants completed two separate eye-tracking tasks. In the first task, participants were presented with face stimuli of color photographs from the NIMH

Child Emotional Faces Picture Set stimuli (NIMH-ChEFS; Egger et al., 2011), which consisted of male and female images of children and adolescents aged 10–17 years. In the second task, participants viewed face stimuli from the NimStim Set of Facial Expressions (Tottenham et al., 2009) which consisted of male and female images of adults expressing emotions.

For both tasks, the images were standardized such that the faces were approximately the same size and visual properties such as brightness and luminance were controlled for. In addition, all non-facial features (e.g., clothing, background) were removed. Faces were an equally sized oval shape (each face 19.05 cm long X 16.51 cm wide, with 11.43 cm of gray space between the two faces, all subtending 37° visual angle) against a gray background.

Each trial contained a pair of photographs of the same actor or actress, with one photo depicting a target emotion (i.e., anger) and the other depicting a neutral expression, presented for 3 seconds. This methodology is consistent with previous eye-tracking research in anxious youth (e.g., Shechner et al., 2013) which suggests that attention bias is more likely to occur when two or more stimuli compete for attention (In-Albon, Kossowsky, & Schneider, 2010). Face pairs used in the eye-tracking task were centered horizontally on the screen and counterbalanced such that the emotion presented appeared equally on both sides of the screen.

In the task presenting NIMH-ChEFS stimuli, 32 face pairs were presented (16 anger-neutral pairs, and 16 happy-neutral pairs). In the tasks presenting NimStim adult facial stimuli, sixty pairs of faces, were presented (20 anger-neutral pairs, 20 disgust-neutral pairs, and 20 happy-neutral pairs). In order to assess attention bias across both tasks, only the neutral-anger pairs were examined.

Apparatus

Eye-tracking was completed using a Tobii T60 XL eye tracker. Participants were seated 70 cm from the 18" monitor. In order to detect gaze, the eye-tracking system was calibrated to the participants' eyes using a five-point calibration procedure involving tracking a pulsating red circle located at five predefined locations across the screen (i.e., the four corners and the center of the screen). Following the calibration, participants were instructed to look at the screen in any way they pleased.

Data Analyses

The Tobii eye tracker collected the raw eye movement data points which were processed into fixations. The area of interest, the face region, was predefined, using the oval-shaped area of interest (AOI) tool available in Tobii T60 (Studio Professional). The duration of fixations made to these regions was calculated using MATLAB code which converted raw eye movement data into fixation duration for each predefined area of interest (available upon request). The fixation durations were computed for the entire duration of the stimulus (3000ms), as well as for six separate time frames or epochs (first 500ms; 500–1000ms, 1000–1500ms, 1500–2000ms, 2000–2500ms, 2500–3000ms). Fixation data were excluded for off-task trials (i.e., participant was not gazing at the screen for ≥ 100 ms). Fixation data

were excluded per trial if the participant showed major tracking loss (i.e., less than 50% of viewing time across stimulus presentation; Wieckowski & White, 2017).

To measure vigilant and avoidant attention bias, bias scores were calculated. Consistent with Price and colleagues (2016), bias scores were calculated for each participant as a difference score (i.e., fixation duration to anger face minus fixation duration to a neutral face). Positive scores were indicative of vigilant attention bias, with negative scores being indicative of avoidant attention bias (Price et al., 2016).

Two linear regression models were run to explore the relationship between bias scores for NIMH and NimStim stimuli and all predictor variables of interest, including gender (dummy coded), age, IQ, BFNE score, and CSR on the ADIS-IV-C. Only the child report on the ADIS-IV was analyzed to maintain consistency in using measures generated by the youth informant. All assumptions for running a linear regression were met. Secondly, in order to explore potential differences between the two stimulus sets, a series of paired samples *t*-tests were run comparing the fixation duration to NIMH-ChEFS stimuli compared to the NimStim stimuli. A significance level of .05 was used across statistical tests.

Results

Bias Scores

NIMH-ChEFS adolescent stimuli.—Across the entire NIMH-ChEFS presentation the majority of participants ($n = 28$) showed vigilant attention bias marked by greater looking toward anger faces. However, the bias pattern changed over the course of the stimulus presentation from vigilance to avoidance. Only one participant showed consistently biased attention toward anger stimuli. No participants showed a consistent bias away from anger stimuli across the six epochs. Table 1 shows the average bias scores for each epoch, in addition to the standard deviation and range. There was considerable variability in bias scores across participants. On average, participants showed avoidant gaze patterns to anger faces across half of the epochs for the NIMH-ChEFS stimuli.

NimStim adult stimuli.—Across the entire NimStim stimulus presentation, the majority of participants ($n = 32$) showed vigilant attention bias toward anger faces, similar to what we found with the adolescent face stimuli. As with NIMH-ChEFS stimuli, bias pattern changed over the course of the stimulus presentation, from one of vigilance to avoidance. Eight of the participants demonstrated a consistent vigilance pattern while viewing the NimStim stimuli. On average, participants showed a vigilant pattern of looking toward anger faces across all six epochs for the NimStim stimuli, as evident by positive bias scores (Table 1).

Prediction of Bias Scores

NIMH-ChEFS adolescent stimuli.—The overall model with participant's gender, age, IQ, BFNE score, and CSR for NIMH-ChEFS stimuli was not significant ($F(5, 41) = .96, p = .46$). These predictors therefore did not significantly predict bias scores for anger-neutral stimulus pairs across stimulus presentation (Table 2).

NimStim adult stimuli.—The overall model for NimStim adult stimuli was significant ($F(5, 41) = 2.99, p = .023$). While participants' gender, age, IQ, and BFNE score did not significantly predict bias scores across stimulus presentation for NimStim stimuli, CSR significantly predicted bias scores for NimStim stimuli (Table 2). Across the six epochs, for the NimStim stimuli, CSR significantly predicted bias scores for the first and fourth epochs only ($b = .48, t(35) = 2.11, p = .04$; $b = .55, t(35) = 2.37, p = .02$, respectively).

Fixation Duration

Fixation duration to faces.—Given our findings on attention bias differing across stimulus type, we explored whether the difference stemmed from the way participants viewed these stimuli. When comparing fixation duration to the face region for the NIMH-ChEFS, participants spent no more time fixating toward the face region of the anger compared to the neutral stimuli ($t(41) = 1.01, p = .32$). However, for the NimStim task, participants spent more time fixating on the anger faces ($M = 1329.64\text{ms}$, $SD = 281.15$) compared to the neutral stimuli ($M = 1088.59\text{ms}$, $SD = 268.89$; $t(41) = 3.67, p = .001, d = 0.57$).

Comparing fixation duration across the two tasks, participants spent more time fixating on the NimStim anger faces ($M = 1329.64\text{ms}$, $SD = 291.15$) compared to NIMH-ChEFS anger faces ($M = 934.47\text{ms}$, $SD = 296.06$, $t(41) = 8.78, p < .001$).

Fixation duration across time.—The fixation duration to the anger stimuli changed over time, with the highest fixation duration to the face region of the anger stimuli occurring during the second epoch (i.e., 500ms to 1000ms) for both stimuli sets. Comparing fixation duration to anger faces over time between the two stimuli sets revealed differences for all epochs exclusive of the first epoch (i.e., first 500ms; [$t(37) = 1.48, p = .15$]). Fixation duration to anger faces was significantly higher when viewing NimStim faces compared to NIMH-ChEFS stimuli for the second epoch [$t(38) = 8.06, p < .001$], third epoch [$t(41) = 5.53, p < .001$], fourth epoch [$t(41) = 2.89, p < .001$], fifth epoch [$t(41) = 5.98, p < .001$], and sixth epoch [$t(39) = 4.44, p < .001$].

Discussion

To clarify the potential processes underlying inconsistent findings regarding visual attention bias in anxious youth, we examined eye gaze patterns in relation to methodological and within-subject factors given that anxious adolescents process adult and adolescent stimuli differently (e.g., Benoit et al., 2007). The use of adolescent stimuli allowed for an exploration of attention bias using stimuli that more closely approximated the peer-based fear experienced by adolescents with SAD (e.g., fear of peer rejection). Consistent with the study's hypothesis, participants showed a vigilant pattern of attention in the first 500ms of stimulus presentation, but only for the adult stimuli. Results did not support our hypothesis that the vigilant pattern would be observed more consistently for the adolescent stimuli compared to the adult stimuli. The reverse pattern was observed.

Overall, the results suggest there is considerable variability, marked by both vigilance and avoidance, in how socially anxious adolescents view adolescent and adult faces. Gamble and

Rapee (2009) reported that anxious youth demonstrated an initial bias in orienting; however, sustained attention was not uniform across the epochs. Our study highlights variability in initial orienting in a well-characterized clinical sample of adolescents with SAD. This variability cannot be attributed to any of the explored participant characteristics (i.e., age, gender, IQ). However, for adult stimuli, clinician rated severity of social anxiety, as indexed by the CSR on the ADIS-IV-C, significantly predicted the observed bias. This relationship was observed for first and fourth epochs only (i.e., 500–1500ms), suggesting variability of attention bias.

In order to elucidate these differences, fixation durations were compared across the two stimulus sets. Participants fixated more toward angry adult faces compared to the angry adolescent faces, highlighting differences in how socially anxious adolescents attended to the stimuli. Although opposite of what was predicted based on the peer-based evaluative fears, this finding is consistent with prior research that adult stimuli may provide especially salient cues for children and adolescents (i.e., Benoit, et al., 2007). The observed variability of attention bias in socially anxious adolescents suggests that bias, assessed via gaze, is nuanced and dependent in part on stimulus type. Therefore, consideration of stimuli and within-person differences should be considered in interpreting inconsistencies in the extant research.

These results should be interpreted with caution, given differences in both number of stimuli participants viewed and prior validation of the stimuli sets. Although the NimStim stimuli have been widely used and are well-validated relative to the NIMH-ChEFS, stimuli from the latter were all rated above 70%. This study focused on attention bias within adolescents with SAD, without a non-anxious comparison sample, a limitation that is not unique to our study (e.g., Price et al., 2011), however important to address in future research. Furthermore, we explored only a few predictors that might be responsible for the observed variability in attention bias. There are other constructs (e.g., alexithymia, depression) that may account for the observed variability and should be explored in future studies. Our analyses also focused on exploring attention to anger-neutral stimulus pairs only given the primary interest of this study was biased attention to negative social information across both stimuli sets. Future studies should explore attention bias to other emotions (e.g., disgust and sadness) to assess whether attention bias is emotion-specific. Such findings could have implications for treatment design for adolescents with SAD, for example by individually tailoring treatments for adolescents with SAD who show variability in their attention. Lastly, given the relatively small sample size, the sample may not be representative of all individuals with social anxiety and therefore, the results need to be viewed as preliminary and need to be replicated to assure that the pattern of findings hold. Future studies should consider pre-registering the study protocols to prevent accrual of multiple small sample size studies with variable findings.

Conclusion

This study is the first to explore attention bias across stimulus presentation, across both adolescent and adult face stimuli, in adolescents diagnosed with SAD. The findings suggest variability in attention bias across participants, across stimuli, and perhaps most notably –

within participants over time, which is not attributable to assessed participant characteristics or clinical severity. Clinician rated severity of social anxiety appears to be a significant predictor of bias when viewing adult facial stimuli. Therefore, it may be important to account for social anxiety severity not only while assessing attention bias, but also when determining whether treatments targeting attention (e.g., Attention Bias Modification; ABM; Bar-Haim, 2010) are clinically indicated. Given the variability observed in both ABM methodology and the disappointing effects reported for child and adolescent samples (Bar-Haim, 2010), modifications are certainly warranted (MacLeod & Clarke, 2015; Mogg & Bradley, 2016). Specifically, ABM may be a more viable treatment option for those with higher social anxiety, compared to adolescents diagnosed with SAD who are rated as less severely distressed. Understanding the variability in attention bias in adolescents with SAD may aid in determining which treatments are beneficial for whom, ultimately increasing treatment effectiveness.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Bias Scores Across Epochs

Time Frame	NIMH-CHEFS Stimuli	NimStim Stimuli
	<i>M (SD)</i> Range	<i>M (SD)</i> Range
500ms	-11.54 (61.20) -200.04 – 71.23	40.66 (68.41) -80.57 – 255.61
500–1000ms	52.92 (104.41) -143.36 – 311.17	118.74 (112.55) -156.17 – 337.10
1000–1500ms	10.55 (113.65) -350.07 – 193.09	38.36 (115.28) -229.21 – 269.28
1500–2000ms	19.64 (144.28) -400.08 – 383.41	4.21 (90.48) -247.42 – 179.2
2000–2500ms	-30.70 (122.32) -466.76 – 175.03	17.91 (107.32) -255.31 – 226.71
2500–3000ms	-12.88 (111.59) -300.06 – 192.75	22.16 (99.12) -249.22 – 204.21

Table 2.

Prediction of Bias Scores

	NIMH-ChEFS Stimuli <i>b / t (p)</i>	NimStim Stimuli <i>b / t (p)</i>
Gender	.04 / .21 (.84)	-.24 / -1.51 (.14)
Age	-.23 / -.32 (.20)	-.20 / 1.30 (.20)
IQ	-.25 / -1.55 (.13)	-.21 / -1.43 (.16)
CSR	.19 / .81 (.42)	.52 / 2.44 (.02) *
BFNE	.12 / .56 (.58)	.19 / .96 (.34)

Note. Predictors including gender, age, IQ, CSR, and BFNE score are explored for bias for NIMH-ChEFS Stimuli and NimStim Stimuli. Standardized Beta Coefficient (*b*) as well as the *t* values and *p*-values from the Linear Regression are reported in the table with

* indicating significant predictor of the bias scores.