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Suicidal ideation and attentional biases in children: An eye-tracking study

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Abstract

Background—Despite theoretical and empirical evidence for a heightened responsiveness to signals of social-threat in suicidal individuals, no studies to date have examined whether this responsiveness might also manifest in the form of specific biases in attention to interpersonal stimuli. The current study, therefore, examined the presence and nature of attentional biases for facial expressions of emotion in children with and without a history of suicidal ideation (SI).

Method—Participants were 88 children (44 with a history of SI and 44 demographically and clinically matched controls without such history) recruited from the community. The average age of children was 9.26 years (44.3% female; 67.0% Caucasian). Children’s history of SI was assessed via structured interviews with children and their parent. Attentional biases were assessed using a dot-probe task and included fearful, happy, and sad facial stimuli and focused on eye tracking and reaction time indices of attentional bias.

Results—Children with a history of SI exhibited significantly greater gaze duration toward fearful faces. The findings appeared to be at least partially independent of children’s history of major depression or anxiety disorders or their current depressive or anxious symptoms.

Limitations—The study is limited by its cross-sectional design, which precludes any causal conclusions regarding the role of attentional biases in future suicide risk.

Conclusions—Our results suggest that children with a history of SI exhibit biases in sustained attention toward socially-threatening facial expressions. Pending replications, these findings might represent a new avenue of suicide risk assessment and intervention.

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Contributors

Aliona Tsypes and Brandon Gibb conceived of the study idea. Aliona Tsypes analyzed the data under the supervision of Brandon Gibb and wrote the first draft of the manuscript. Aliona Tsypes, Max Owens, and Brandon Gibb provided critical revisions of the article for intellectual content. All authors contributed to and have approved the final manuscript.

Conflicts of interest

none.

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Keywords

suicide; children; attention; eye tracking

1. Introduction

Suicide is the second leading cause of death for 10- to 14-year-olds in the United States (Centers for Disease Control and Prevention, 2014) and thus constitutes a major public health concern. Despite the numerous efforts of researchers and clinicians to prevent suicidal thoughts and behaviors (STBs) and consequent deaths by suicide, there was a 45% increase in the suicide rates among females and a 16% increase in the suicide rates among males between 1999 and 2014, with those aged 10–14 having the greatest increase (National Center for Health Statistics, 2016). This suggests a strong and urgent need for better ways of identifying and examining the correlates and risk factors of STBs. Specifically, to develop more targeted suicide prevention and intervention efforts, we need a better understanding of the processes that make children more likely to think about suicide in the first place. This is essential because such early efforts might prevent the transition from suicidal thoughts to suicidal behavior in these at-risk children.

Cognitive models of psychopathology and suicide highlight the role of information processing biases (e.g., attention biases) in contributing to risk for these problems (e.g., Beck, 2008; Disner et al., 2011; Wenzel & Beck, 2008; Williams et al., 1997). In testing these theories, the majority of research has focused on attentional biases in depression and anxiety. These studies consistently demonstrate the presence of attentional biases for threat-relevant information in anxiety disorders, perhaps particularly in terms of initial orienting of attention, and attentional bias for depression-relevant information (e.g., sad faces) in depression, particularly in terms of increased sustained attention to, or difficulty disengaging attention from, these stimuli (for reviews, see Armstrong & Olatunji, 2012; Bar-Haim et al., 2007; Gibb et al., 2016; Peckham et al., 2010). This highlights the disorder-specific nature of attentional biases both in terms of focus (threat-relevant vs. depression-relevant) and time course (initial orienting vs. sustained attention).

In contrast, relatively little is known about attentional biases to interpersonal stimuli among individuals with a history of STBs. We cannot simply infer from the depression and anxiety literature because STBs are transdiagnostic and occur both in conjunction with depression and/or anxiety as well as in the absence of these disorders. However, there is evidence that biased processing of interpersonal information may increase risk for STBs transdiagnostically. Indeed, according to the neurocognitive model of suicidal behavior that attempts to integrate the “cry of pain” model of suicidal behavior (Williams & Pollock, 2001) with neuropsychological and neuroimaging findings for a more comprehensive and dynamic understanding of suicidal behavior (for a review, see Jollant et al., 2011), suicidal individuals might be particularly sensitive to social events. Specifically, the authors argue that biases in identifying, interpreting, and experiencing the social environment are implicated in the first step of the “suicidal process” due to the resulting inability of these individuals to correctly assign value to external events (Jollant et al., 2011). The authors

argue that this altered modulation of value attribution is linked with deficiencies in regulating emotional and cognitive responses, which in turn might facilitate suicidal acts in emotional contexts (Jollant et al., 2011).

Supporting this theory, there is evidence that suicidal individuals tend to overvalue signals of social threat. Specifically, individuals with a history of SA, compared to those with no SA history, exhibit greater activity in the orbitofrontal cortex (OFC), a brain region implicated in deriving a value signal during reward processing (Wallis, 2007), in response to socially-threatening facial expressions compared to patient controls with no history of SAs (Jollant et al., 2008; Olie et al., 2015). Importantly, this difference was specific to socially-threatening facial expressions and was not observed for happy or neutral faces, suggesting specificity to signals of social threat in one's environment. This said, although it is unclear whether this attentional bias may be in the form of biases in initial allocation of attention, sustained attention, or both.

The focus on interpersonal stimuli is not unique to Jollant et al.'s (2011) theory and a number of other prominent theories of suicide (e.g., Joiner, 2005; O'Connor, 2011) highlight the importance of social influences in suicide risk. However, despite theoretical rationale and empirical evidence for a heightened responsiveness to signals of social-threat in suicidal individuals, no studies to date have examined whether this responsiveness might also manifest in the form of specific biases in attention to interpersonal stimuli, such as positive or negative facial expressions, which represent powerful sources of social information (Darwin, 1872/1998). In addition, in line with the RDoC initiative, having a transdiagnostic behavioral marker of suicide risk in the form of a specific attentional bias might significantly contribute to suicide prevention and intervention efforts by providing a potential target for its modification.

The goals of the present study, therefore, were to extend previous research in two key ways. First, because rates of STBs increase dramatically during the transition from childhood to adolescence (e.g., Kessler et al., 2005), understanding early pre-pubertal markers of risk, such as specific biases in attention, would be highly beneficial for early suicide prevention and intervention. In the current study, therefore, we focused specifically on children with and without a history of suicidal ideation. Second, we directly examined attentional biases for interpersonal stimuli (facial expressions of emotion) within the context of a dot probe task (cf. MacLeod et al., 1986) using eye tracking, which allowed us to specifically examine potential biases in initial orienting of attention and sustained attention to emotional (sad, fearful, happy) versus neutral facial expressions. In choosing threat-relevant facial stimuli, we chose to focus on fearful rather than angry faces because research has shown that attentional biases are driven by a combination of heightened amygdala reactivity that is not effectively downregulated by prefrontal regions (Bishop, 2008; Disner et al., 2011) and fearful faces elicit greater amygdala activation than angry faces (for a review, see Fusar-Poli et al., 2008), suggesting that they may be stronger elicitors of threat-relevant attentional biases. Importantly, to examine the specificity of the findings to SI, we used a demographically and clinically matched sample of children. Based on the theory and research reviewed above, we hypothesized that children with a history of SI, compared to children with no history of SI, would exhibit biased attention toward fearful, but not sad or

happy, faces. Given the lack of previous research in this area, we made no hypotheses about the specificity of our findings to initial versus sustained attention to fearful faces.

2. Methods

2.1. Participants

Participants in this study were 88 children recruited from the community. Using a 1:1 matching ratio, we had 44 children with a history of SI and 44 children with no history of SI. The two groups were equated on (i) age, (ii) sex, (iii) race, (iv) household income, (v) lifetime MDD or anxiety diagnosis history, and (vi) current levels of depressive and anxious symptoms. The only inclusion criteria were that children be between the ages of 7 and 11 years and, per parent report, have no learning or developmental disorders that would preclude completing the study protocol. The average age of the children was 9.26 years ($SD = 1.40$) and 44.3% were female. In terms of race, 67.0% of the children were Caucasian, 14.8% were African American, 17.0% were Biracial, and 1.1% were Asian/Pacific Islander. In terms of ethnicity, 10.2% of the children were Hispanic. The demographic and clinical characteristics of the SI and no SI groups are presented in Table 1.

2.2. Measures

2.2.1. Diagnoses and Symptoms—The Schedule for Affective Disorders and Schizophrenia for School-Age Children – Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997) was administered by trained interviewers to assess for current and past DSM-IV Axis I disorders. A total of 7 children (8.0%) met criteria for a lifetime history of MDD and a total of 7 children (8.0%) met criteria for a lifetime history of at least one anxiety disorder. Specifically, 4 children (4.5%) had a history of separation anxiety disorder, 4 children (4.5%) had a history of generalized anxiety disorder, 3 children (3.4%) had a history of social phobia, 2 children (2.3%) had a history of posttraumatic stress disorder, 1 child (1.1%) had a history of obsessive-compulsive disorder, 1 child (1.1%) had a history of panic disorder, and 1 child (1.1%) had a history of agoraphobia. Symptoms of depression were assessed using the Children’s Depression Inventory (CDI; Kovacs, 1981) and symptoms of anxiety were assessed using the Multidimensional Anxiety Scale for Children (MASC; March et al., 1997). The CDI and MASC in our sample exhibited internal consistency of $\alpha = .79$ and $.84$, respectively.

2.2.2. History of Suicidal Ideation—As part of the K-SADS-PL assessment, the interviewers assessed for the presence of suicidal ideation (SI) in children by asking the questions “Sometimes children who get upset or feel bad, wish they were dead or feel they’d be better off dead. Have you ever had these types of thoughts?” and “Sometimes children who get upset or feel bad think about dying or even killing themselves. Do you have these thoughts?” Affirmative responses were probed for further details to verify the correct interpretation of these questions by the interviewees. Parents and children were interviewed separately to assess for children’s history of SI, and children were classified as having a lifetime history of SI versus no lifetime history of SI using a best estimate approach (i.e., summary classification based on information from parents and children).

2.2.3. Dot-Probe Task—A modified dot-probe task (cf. MacLeod et al., 1986) was used to assess children’s attentional biases for facial displays of emotion. Stimuli for the dot-probe task consisted of pairs of facial expressions that contained one emotional (fear, happy, or sad) and one neutral photograph from the same actor taken from a standardized stimulus set (Tottenham et al., 2009). Photographs from each actor (10 males and 10 females) were used to create fearful-neutral, happy-neutral, and sad-neutral stimulus pairs (60 pairs total). Children sat a distance of 65cm away from the computer monitor and each of the two facial stimuli was 15.5 cm tall × 12.75 cm wide, with 26 cm between the center of each picture. Each stimulus pair was presented in random order in each of the 2 blocks, with a rest in between blocks (120 trials total). Each trial began with the presentation of a central fixation cross, and participants were required to make a central fixation before stimuli were presented. Facial stimuli (one emotional and one neutral from the same actor) were presented for 1000 ms, followed by a probe (the letter “E” or “F”) appearing in the nose region of one of the faces. We used a probe discrimination rather than a probe location (i.e., indicate whether the probe appears on the left versus right side of the screen) design because the latter can be completed without an actual shift in overt attention. The faces and probe remained on the screen until a manual response using a game controller was made indicating whether the probe consisted of an “E” or “F”. The probe was presented with equal frequency in the location of the emotional and neutral faces. The inter-trial interval varied randomly between 500 and 750 ms.

Gaze location and duration during the dot probe task was measured using a Tobii T60XL eye-tracking monitor (60Hz data rate; 1920 × 1200 pixels), which uses infrared Pupil Centre Corneal Reflection to illuminate the eye and calculate gaze direction in relation to the monitor location. Before the dot-probe task, participants completed a nine-point calibration of the eye tracker during which they were asked to look at specific points at the center and edges of the monitor. Accuracy of the calibration was confirmed by visual inspection of fixations recorded during the calibration procedure. Fixations were defined as gaze allocation in a predefined area of interest lasting at least 100ms. Initial orienting of attention was indexed as the average latency of the first saccade from the fixation cross to the emotional versus neutral face for each trial type (measured in milliseconds). Sustained attention was indexed as the amount of time children spent looking at each emotional versus neutral faces across the full 1,000ms trial for each trial type (measured in milliseconds). In addition, we also examine reaction times (RTs) to the appearance of the probe.

2.3. Procedure

Potential participants were recruited from the community through a variety of means (e.g., Facebook and television ads). Parents responding to the recruitment advertisements were initially screened over the phone to determine potential eligibility. Upon arrival at the laboratory, parents were asked to provide informed consent and children were asked to provide assent to be in the study. Next, the child completed the dot-probe task. During this time, the K-SADS-PL was administered to the parent by a trained interviewer. Following this, the same interviewer who had administered the K-SADS-PL to the parent also administered it to the child. Finally, an interviewer assisted children with the completion of

self-report questionnaires. The Institutional Review Board approved all procedures. Families were compensated a total of \$90 for their participation in the study.

3. Results

3.1. Data Analytic Plan

Our primary hypothesis in this study was that children with a history of SI, compared to children with no history of SI, would exhibit attentional biases for fearful, but not sad or happy, faces. We examined the three indices of attention bias (initial orienting of attention, sustained attention, reaction time bias score) in separate analyses. For the eye-tracking indices, we conducted two 2 (group: child SI, no child SI) \times 3 (emotion: fearful, happy, sad) \times 2 (face type: emotional, neutral) repeated measures ANOVAs, with children's mean latency of first fixation (initial orienting of attention) or mean gaze duration (sustained attention) to each face type serving as dependent variable. Next, focusing on the RT indices of attention bias, we conducted a 2 (group: child SI, no child SI) \times 3 (emotion: fearful, happy, sad) \times 2 (probe location: following emotional face, following neutral face) repeated measures ANOVA with children's RT to the probe following each face type serving as the dependent variable. Significant interactions were probed to determine the pattern of the findings. Finally, we conducted exploratory analyses to determine whether any of the findings were moderated by children's age or sex.

3.2. Data Analyses

Focusing first on children's initial orienting of attention toward emotional faces, we conducted a 2 (group: child SI, no child SI) \times 3 (emotion: fearful, happy, sad) \times 2 (face type: emotional, neutral) repeated measures ANOVA with children's mean first fixation latency serving as the dependent variable. None of the main effects or interactions were significant (lowest $p = .06$).

Next, we examined children's sustained attention toward emotional faces. Specifically, we conducted a 2 (group: child SI, no child SI) \times 3 (emotion: fearful, happy, sad) \times 2 (face type: emotional, neutral) repeated measures ANOVA with children's mean gaze duration serving as the dependent variable. We found a significant main effect of face type, $F(1, 86) = 208.23$, $p < .001$, $\eta_p^2 = .71$, as well as significant emotion \times face type, $F(2, 172) = 31.07$, $p < .001$, $\eta_p^2 = .27$, and group \times emotion \times face type, $F(2, 172) = 5.17$, $p = .007$, $\eta_p^2 = .06$, interactions. Examining the form of this three-way interaction, we found a significant group \times face type interaction for fearful, $F(1, 86) = 5.12$, $p = .03$, $\eta_p^2 = .06$, but not for happy, $F(1, 86) = .94$, $p = .33$, $\eta_p^2 = .01$, or sad, $F(1, 86) = 2.29$, $p = .13$, $\eta_p^2 = .03$, faces. To examine the form of the significant group \times face type interaction for fearful faces, we created a difference score by subtracting children's gaze duration to neutral faces within fearful-neutral trials from their gaze duration to fearful faces in these trials. Positive values for this difference score reflect greater gaze duration to fearful than neutral faces and negative scores reflect greater gaze duration to neutral than fearful faces. We found a significant SI group difference in this gaze bias score, $F(1, 86) = 5.12$, $p = .03$, $\eta_p^2 = .06$, with children with SI history exhibiting significantly greater attention toward fearful faces than children with no history of SI.

Third, focusing on the RT indices of attention bias, the only significant effect was an emotion \times probe location interaction, $F(2, 172) = 5.82, p < .001, \eta_p^2 = .06$ (all other p s $> .05$). However, none of the follow-up tests examining the form of this interaction was significant (lowest $p = .72$).

Finally, we conducted exploratory analyses to determine whether the SI findings were moderated by children's age or sex. None of these analyses was significant (lowest $p = .51$).

4. Discussion

The primary goal of this study was to examine the presence and nature of attentional biases for interpersonal stimuli (i.e., facial expressions of emotion) in children with and without a history of suicidal ideation. We found that children with a history of SI, compared to children with no SI history, exhibited significantly greater sustained attention (gaze duration) toward fearful faces. Consistent with our hypothesis, the group difference was specific to fearful faces and was not observed for happy or sad faces. In addition, the difference was specific to our eye tracking measure of children's sustained attention and was not observed for children's initial orienting of attention or the RT indices of attention bias. Importantly, because our sample was matched on a broad range of demographic and clinical variables, the findings suggest that they may be due specifically to children's history of SI. The present study extends previous research that has focused primarily on preferential processing of suicide-related information in individuals with STBs (e.g., Nock & Banaji, 2007; Nock et al., 2010) by providing initial behavioral (eye tracking) evidence of specific attentional biases for interpersonal stimuli (i.e., increased sustained attention to fearful faces) in children with a history of SI. These findings are in line with the theories and research pointing to the salience of signals of social threat in relation to suicide risk (e.g., Joiner, 2005; Jollant et al., 2008; Jollant et al., 2011; O'Connor, 2011; Olie et al., 2015). Indeed, in line with these theories, research demonstrating that fear conditioning can be successfully achieved by using interpersonal conflict as a stimulus (Tada et al., 2015) suggests that perceived interpersonal conflict might serve as a potential mechanism through which this attentional bias might develop. Interestingly, the nature of the attentional bias uncovered in our study (i.e., towards fearful faces) is similar to that found in a sample of adolescent and young adults with borderline personality features (Jovev et al., 2012), suggesting that it might represent an early marker of risk for borderline personality in children with a history of SI.

The present study had a number of strengths and constitutes an important addition to the literature on the presence and nature of attentional biases in children with a history of suicidal thinking. Specifically, it is the first study to examine attentional biases for interpersonally-relevant emotional stimuli in children with a history of SI, which might contribute to suicide research and prevention as well as facilitate comparisons and integration with the large depression and anxiety literatures on attentional biases. Another key strength is the use of eye tracking to directly measure children's patterns of attentional allocation. Third, we used interviewer-administered measures of children's history of SI, depression, and anxiety disorders and a sample matched on a broad range of demographic and clinical variables to establish specificity of the findings to children's history of SI.

Despite these strengths, there were also limitations that provide directions for future research. First, due to the cross-sectional nature of the study, no conclusions can be drawn about the temporal relations between the observed bias in sustained attention to fearful faces and suicidal thinking in children. Future research is needed, therefore, to determine whether this attentional bias increases children's risk for SI in the future. Second, because this study focused exclusively on children's history of SI, additional research is needed to determine whether a similar bias would be observed in children with a history of other self-harming thoughts and behaviors, such as nonsuicidal self-injury and suicide attempts. Third, because our sample was predominately Caucasian and focused on children, the findings might not generalize to more diverse groups of children or to other age groups, such as adolescents or adults. Fourth, it will be important for future studies to examine how additional, potentially relevant variables (e.g., IQ, psychotic symptoms, the presence of Attention Deficit Disorder/Attention Deficit and Hyperactivity Disorder) might influence our findings. Finally, although our study assumes that attention biases in children are stable over time, future studies are needed to empirically test this assumption.

In summary, the current results suggest that children with a history of suicidal thinking exhibit biases in sustained attention toward socially-threatening facial expressions (i.e., fearful faces). These results are consistent with theories and prior research (e.g., Joiner, 2005; Jollant et al., 2008; Jollant et al., 2011; O'Connor, 2011; Olie et al., 2015) highlighting the importance of social influences on suicide risk. To the extent that the current findings are replicated and these biases are shown to predict risk for future STBs, it may represent a new avenue of suicide risk assessment, prediction, and intervention. Indeed, because the field's ability to predict risk for suicide has not improved in the past 50 years (for a meta-analysis, see Franklin et al., 2017), largely due to homogenous risk factors and approaches used to examine them, specific attention biases observed in suicidal individuals might be used in machine learning algorithms, along with other novel risk factors, to more accurately assess and predict suicide risk (Franklin et al., 2017). In addition, pending replications of our findings, current attention bias modification protocols (see MacLeod & Clarke, 2015) could be modified to directly target attentional biases relevant to suicide risk.

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Highlights

- Used eye tracking to assess attentional biases to interpersonal stimuli in children
- Children with suicidal ideation had greater gaze duration toward fearful faces
- Results independent of children's history and symptoms of depression and anxiety
- Uncovered specific bias that might constitute a potential suicide prevention target

Table 1

Descriptive statistics for children in the two SI groups

	Children with SI (<i>n</i> = 44)	Children without SI (<i>n</i> = 44)	<i>r</i> effect size
Age	9.19 (1.43)	9.33 (1.39)	-.05
Sex (% female)	43.2%	45.5%	-.02
Race (% Caucasian)	65.9%	68.2%	-.02
Household Income (median)	25,001–30,000	20,001–25,000	.01
Lifetime MDD dx	11.4%	4.5%	.13
Lifetime anxiety dx	11.4%	4.5%	.13
CDI	9.61 (7.60)	10.12 (4.57)	-.11
MASC	52.25 (17.63)	51.87 (12.90)	-.001

Note. SI = Suicidal ideation. MDD = Major Depressive Disorder. Dx = Diagnosis. CDI = Children's Depression Inventory. MASC = Multidimensional Anxiety Scale for Children.

* $p < .05$.

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