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Emotional face recognition in adolescent suicide attempters and adolescents engaging in non-suicidal self-injury

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Abstract

Little is known about the bio-behavioral mechanisms underlying and differentiating suicide attempts from non-suicidal self-injury (NSSI) in adolescents. Adolescents who attempt suicide or engage in NSSI often report significant interpersonal and social difficulties. Emotional face recognition ability is a fundamental skill required for successful social interactions, and deficits in this ability may provide insight into the unique brain-behavior interactions underlying suicide attempts versus NSSI in adolescents. Therefore, we examined emotional face recognition ability among three mutually exclusive groups: (1) inpatient adolescents who attempted suicide (SA, $n = 30$); (2) inpatient adolescents engaged in NSSI (NSSI, $n = 30$); and (3) typically developing controls (TDC, $n = 30$) without psychiatric illness. Participants included adolescents aged 13–17 years, matched on age, gender and full-scale IQ. Emotional face recognition was evaluated using the diagnostic assessment of nonverbal accuracy (DANVA-2). Compared to TDC youth, adolescents with NSSI made more errors on child fearful and adult sad face recognition while controlling for psychopathology and medication status ($ps < 0.05$). No differences were found on emotional face recognition between NSSI and SA groups. Secondary analyses showed that compared to inpatients without major depression, those with major depression made fewer errors on adult sad face recognition even when controlling for group status ($p < 0.05$). Further, compared to inpatients without generalized anxiety, those with generalized anxiety made fewer recognition errors on adult happy faces even when controlling for group status ($p < 0.05$). Adolescent inpatients engaged in NSSI showed greater deficits in emotional face recognition than TDC, but not inpatient adolescents who attempted suicide. Further results suggest the importance of psychopathology in emotional face recognition. Replication of these preliminary results and examination of the role of context-dependent emotional processing are needed moving forward.

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Keywords

Suicide; Non-suicidal self-injury; Self-injurious behavior; Emotional face processing; Emotions; Adolescent

Introduction

Globally, suicide is the second leading cause of death among youth of 15–19 years, and is the third-leading cause of death of youth aged 15–24 years in the United States (US) making suicide a significant public health concern [1–4]. In fact, worldwide at least 100,000 youth kill themselves each year [5]. According to the Centers for Disease Control Youth Risk Study (2011), 7.8 % of US high school students report at least one suicide attempt in the past 12 months, and approximately 16 % have seriously considered suicide in the past year [1]. Numerous risk factors have been associated with a suicide attempt (SA)—defined as an act of self-injury with at least an inferred intent to die—in adolescents, including female gender, increased age, socioeconomic disadvantage, exposure to trauma or stressful life events, previous SAs, and the presence of major depressive disorder (MDD), anxiety disorders and substance/alcohol use [6–13].

However, SA reflects only one type of self-injurious behavior (SIB) in adolescents. Another form of SIB is non-suicidal self-injury (NSSI)—defined as the direct, deliberate infliction of pain and tissue damage by an individual on his or her own body in the absence of suicidal intent [14]. The most common form of NSSI is self-cutting generally on the arms, legs and stomach [14, 15]. NSSI is even more common than SA, with studies of community-based adolescents in the US reporting rates ranging from 13 to 45 % with rates rising to 40–80 % in psychiatrically hospitalized adolescents [16–19]. Similarly, results from the Child and Adolescent Self-harm in Europe (CASE) study showed that 13.5 % of females and 4.3 % of males of ages 14–17 years reported engaging in deliberate self-harm [20]. Several risk factors have been associated with NSSI in adolescence including: a history of childhood abuse, negative attributional style, parent–child difficulties, peers who engage in NSSI, a previous history of NSSI, and the presence of psychopathology [13, 14, 21–24].

Despite the significance of adolescent SA and NSSI, little research has focused on clarifying the unique versus overlapping mechanisms involved in SA versus NSSI. In particular, research examining emotional disturbances (e.g., emotional valence disturbances, disturbances in emotional intensity and regulation and emotional disconnectedness) have been shown to predict the correlates and course of psychopathology above use of traditional diagnostic categories suggesting the importance of understanding specific forms of emotional disturbances more clearly [25]. One form of emotional disturbance that may be particularly important in SA and NSSI is emotional face recognition ability as individuals who attempt suicide as well as those who engage in NSSI report significant interpersonal impairments and social communication difficulties [16, 26–28]. Interpersonal theories of self-injury suggest that self-injurious behavior can in fact act as a form of communication for certain individuals, particularly when more traditional forms of communication appear ineffective, there-fore, emphasizing the importance of better understanding emotional face

recognition an important aspect of social communication in this population [29–31]. Emotional face recognition—the ability to correctly identify another person’s emotional facial expression (i.e., social cognition)—is one of the most fundamental skills required for human social interactions [32–34]. As such, emotional face recognition provides a window into the other person’s internal (i.e., emotional) state, and subsequently informs how we should act with that individual. Disturbances in emotional face recognition can therefore contribute to poor social cognition including social skills deficits and impaired social interactions [35, 36]. From a neurobiological perspective, emotional face recognition involves both top-down cortical regulation of attention and processing of visual stimuli plus bottom-up evaluation of emotionally evocative stimuli [37, 38]. Therefore, studying emotional face recognition allows for the examination of brain–behavior interactions underlying social cognition as well as alterations in these processes associated with psychiatric disorders and symptoms such as SA and NSSI [39–41]. Yet to date, no research has examined emotional face recognition ability in youth with either SA or NSSI.

A significant body of literature has shown aberrant emotional face recognition in children and adolescents with psychiatric disorders including MDD and generalized anxiety disorder (GAD) [42–45]. For example, both boys with MDD and boys at-risk for MDD (i.e., have a parent with MDD) identify sad faces at lower levels of intensity on a multi-morph task, in which the intensity of emotional face intensity is varied from neutral to 100 %, compared to boys at low familial risk for MDD [45]. Similar results are shown for girls at-risk for depression who demonstrate a bias towards negative facial expressions compared to either girls at low familial risk or typically developing control (TDC) girls [46]. Furthermore, compared to males with a history of MDD without a suicide attempt and TDCs, males with a history of MDD and suicide attempt show aberrant neural activity to angry and happy faces suggesting an increased sensitivity to disapproval and reduced attention to positive emotional stimuli [26]. Regarding anxiety, an attentional bias toward threatening stimuli such as angry or fearful faces is demonstrated by individuals with diagnosed anxiety disorders or high levels of trait anxiety [42, 47–50]. For example, adults with high levels of self-rated trait anxiety showed better recognition of fearful face expressions than those with low levels of trait anxiety [47, 48]. Similarly, Roy et al. found that children with anxiety disorders showed a greater attentional bias towards angry, but not happy, faces compared to healthy controls [50]. When examining emotional face recognition ability, children with anxiety make more total recognition errors on adult faces compared to children without anxiety [42, 49]. Taken together, these studies indicate the importance of further probing emotional face processing in relation to psychopathology, including NSSI and SA, especially in the context of mood or anxiety disorders.

To address these gaps in the literature, we examined emotional face recognition ability among three mutually exclusive groups of adolescents: (1) psychiatric inpatients who attempted suicide (SA group); (2) psychiatric inpatients who engage in NSSI (NSSI group); and (3) typically developing controls without psychiatric illness (TDC group). We focused on adolescence because it has been identified as a developmental period of critical risk for the development of NSSI [14]. Furthermore, we recruited both patient groups from an inpatient setting to minimize potential recruitment bias that would be inherent if groups were

recruited from different levels of care (i.e., if SA participants were inpatients but NSSI participants were outpatients).

In the absence of previous studies comparing emotional face processing ability among adolescents engaged in either SA or NSSI behaviors, but not both, we hypothesized that the SA group would have greater impairments in emotional face recognition (i.e., more errors) than the NSSI group for the following reasons. First, studies suggest that SA is a more severe form of SIB associated with greater levels of impairment, including deficits in emotional face processing [51, 52]. Second, triggers of SA are often of the social nature (e.g., difficulty with a close friend or partner or loss of social status, etc.) suggesting that response to the social environment, including interpreting emotional faces, may be particularly salient in understanding SA [26]. Third, compared to healthy controls, adult SAs demonstrate aberrant neural activation when processing negative emotional faces [53].

Given high rates of both MDD and GAD in our sample and prior literature demonstrating aberrant emotional face processing in these populations, as a secondary aim we examined the role of MDD and GAD on emotional face recognition ability. We hypothesized that adolescent inpatients with MDD would demonstrate greater deficits in emotional face recognition, including a bias for sad face identification compared to those without MDD. Additionally, we hypothesized that inpatients with GAD would make fewer errors on fearful faces than those without GAD, given prior literature suggesting that anxious children and adults selectively attend to threatening stimuli [49, 50].

Methods and materials

Participants

Three mutually exclusive groups of participants aged 13–17 years were enrolled in an Institutional Review Board approved research study conducted at Bradley Hospital: (1) psychiatric inpatients who attempted suicide; (2) psychiatric inpatients who engaged in NSSI and (3) community-based TDCs. Adolescents in the SA or NSSI groups were admitted for inpatient psychiatric care at Bradley Hospital, a free-standing child and adolescent psychiatric hospital in Rhode Island. Recruitment procedures involved daily chart reviews of new psychiatric inpatients, and if eligible participants were identified, research staff presented the protocol to adolescents and their guardian(s). TDC participants were recruited from the community through advertisements distributed to physicians' offices or posted online and in local businesses.

This research study was approved by both the Bradley Hospital Institutional Review Board (IRB) and the Brown University IRB. After the purpose and procedures of the study were explained to participants and their parent/guardians, informed written consent was obtained from the parents/legal guardians and written assent was obtained from all participants.

For all groups, inclusion criteria were: (1) age between 13 and 17 years; (2) English fluency; and (3) a consenting parent/guardian. Exclusion criteria were: (1) Wechsler Abbreviated Scale of Intelligence Full-scale IQ (WASI FSIQ) ≥ 70 ; (2) Autism Spectrum Disorders or

primary psychosis due to concerns about ability to complete behavioral testing; and (3) any history of significant head trauma or neurological deficit [54].

SA group ($n = 30$) inclusion criteria were: (1) having made at least 1 suicide attempt within the past 30 days. A suicide attempt was defined as an action, regardless of lethality, completed with intent to die [55]. SA participants were excluded for any lifetime history of NSSI (defined below). The majority of SA participants attempted suicide via overdose ($n = 27$); however, alternative methods included hanging ($n = 1$), suffocation ($n = 1$), entering traffic ($n = 1$) or a combination of these methods ($n = 3$).

NSSI group ($n = 30$) inclusion criteria were consistent with Diagnostics and Statistics Manual 5th version (DSM-5) criteria for NSSI: (1) having engaged in at least one instance of NSSI—defined as the purposeful destruction of one's body without the intent to die—within the past 30 days and (2) a minimum of 5 days of NSSI within the past year [23, 56, 57]. NSSI participants were excluded for any lifetime history of SA. Within the NSSI group, all participants ($n = 30$) reported primarily engaging in self-cutting behaviors; however, secondary forms of NSSI, including burning or erasing skin (i.e., using an eraser to rub skin creating a burn mark), hitting or biting oneself, pulling one's hair out, and wound/skin picking, were reported by 93 % ($n = 28$) of the NSSI sample.

TDC group ($n = 30$) inclusion criteria were: (1) absence of current or lifetime psychiatric illness or substance abuse/dependence; (2) absence of current or lifetime history of NSSI; and (3) absence of first-degree relatives with a diagnosed psychiatric illness.

Groups were age, gender and IQ-matched (to within 1 SD = 15 points) to avoid potential confounds in computerized emotional face recognition. Demographic characteristics of the sample by group can be seen in Table 1.

Measures

Psychiatric diagnoses and symptoms—Participants were evaluated for categorical psychopathology using the Child Schedule for Affective Disorders and Schizophrenia, Present and Lifetime Version (KSADS-PL), a semi-structured diagnostic interview administered by either a board-certified child/adolescent psychiatrist (DPD) or licensed clinical psychologist (KLK; $\kappa > 0.85$) [58]. Parental assessment of adolescent psychopathology and functioning was obtained via the child behavior checklist (CBCL) due to logistical constraints of using the KSADS-PL with an inpatient population (e.g., shorter lengths of stay, relatively limited access to other family members) [59].

SIB characteristics—Participants in both the SA and NSSI group were interviewed using the Self-Injurious Thoughts and Behaviors Interview (SITBI), a structured interview to assess the presence, frequency and severity of NSSI, SA and suicidal ideation [60].

DANVA-2 emotional face recognition task

Emotional face recognition ability was assessed using the diagnostic analysis of nonverbal accuracy (DANVA-2) [61, 62]. The DANVA-2 is a computer-based behavioral task in which participants are asked to identify, via forced-choice [happy, sad, angry, or fearful], the facial

emotion being expressed on the computer screen by either a child or adult actor. The DANVA-2 comprised two subtests one with child faces (24 stimuli), and the other with adult faces (24 stimuli). Each subtest includes 24 standardized, static photographs of models (12 male, 12 female) displaying one of four facial emotions (happy, sad, angry, fearful) at one of two levels of intensity (high and low). Therefore, in each subtest (child; adult) there are 6 representations of each of the 4 emotions. Faces were presented for 2 s, and participants were instructed to choose which of the four emotions listed was expressed in the photograph. Both DANVA-2 subtests have been standardized and demonstrate adequate construct validity, internal reliability (Cronbach $\alpha = 0.64\text{--}0.81$), and test–retest reliability [61, 62]. Outcome variables for each subtest include: errors on happy, sad, angry and fearful faces, and errors at each intensity level (e.g., child face low-intensity errors).

Data analytic plan

IBM Statistical Package for Social Sciences (version 21.0.) [63] was used for examination of variable normality and participant characteristics. Examination of dependent variables (e.g., child total face errors, child face errors by emotion type, adult total face errors and adult face errors by emotion type) demonstrated that variables were non-normally distributed according to Shapiro–Wilk statistics. Therefore, given this skew, which is typical of summed scores, we scored performance on the DANVA-2 subscales using Rasch measurement methods. Prior studies utilizing behavioral tasks to examine emotional processes have employed Rasch models for non-normally distributed data [64]. Rasch measurement assumes a continuous latent construct underlies observed item responses, and provides a method for estimating an individual's level on those constructs. As such, a latent trait score was derived for each subscale of the eight DANVA-2 (e.g., [happy, sad, angry fearful] $\times$ [child, adult]).

For Rasch modeling, MPlus software [65] was used to generate the latent trait estimates, and Rasch measurement models were approximated by imposing a single factor measurement model to child versus adult $\times$ emotional response items (i.e., 8 models, 8 subscale scores). Fit of the single factor model was evaluated using a multivariate probit weighted least squares estimator, and latent trait estimates were generated via a multivariate logit maximum likelihood estimator. Goodness of fit for each model was assessed using the comparative fit index (CFI) in which values range from 0 to 1 and values greater than 0.95 are considered good, and the root mean squared error of approximation (RMSEA) fit index in which the RMSEA value of less than 0.06 indicates good fit with values closer to zero indicating improvement in fit [66, 67]. Five of eight measurement models had good fit statistics (CFI >0.94 , RMSEA <0.06): child happy, child angry, adult angry, adult sad, and adult fear. Although, child happy had a poor fit by RMSEA probably due to an extreme floor effect. The other scales did not fit well (child sad, child fear, and adult happy).

Group comparisons were conducted using linear regressions with the Rasch scores for each subscale used as the dependent variable and group as the independent variable. Given high rates of comorbid psychopathology (MDD, GAD) and psychotropic medication use, these variables were included as covariates. Secondary and exploratory analyses also utilized logistic regression using Rasch scores. For all analyses significance was set at $p < 0.05$, and

effect size statistics are expressed as Cohen's d in which values between 0.2 and 0.5 are small, 0.5–0.8 are medium, and effects greater than 0.8 are large [68].

Results

Preliminary analyses

As groups were matched on age, gender and FSIQ, no group differences were found on these variables (Table 1).

Psychiatric diagnoses and symptomatology—SA and NSSI groups were compared on current (past 6 months) KSADS psychiatric diagnoses, and results showed that adolescents in the NSSI group had higher rates of major depressive disorder [$\chi^2(1, N = 60) = 4.32, p < 0.05$], but groups did not differ in terms of rates of other diagnoses (Table 1). According to parent-report on the CBCL, NSSI participants had significantly higher t-scores on the Internalizing [$F(1, 57) = 9.36, p = 0.003$], Total Problems [$F(1, 57) = 6.28, p = 0.02$], Anxious/Depressed [$F(1, 57) = 5.62, p = 0.02$] and Withdrawn/Depressed [$F(1, 57) = 10.03, p = 0.002$] subscales compared to SA participants. No group differences were found on the CBCL Externalizing problems subscale [$F(1, 57) = 0.72, p = \text{ns}$] (Table 1).

Psychotropic medication—Adolescents in the NSSI group were more likely to be taking medication than those in the SA group [$\chi^2(1, N = 60) = 5.46, p < 0.05$] with selective serotonin reuptake inhibitors (SSRIs) being the most commonly prescribed class of medication (Table 1).

Primary analyses

Comparison of SA, NSSI and TDC groups on emotional face recognition controlling for Co-morbid MDD, GAD and medication status—Group comparisons for child and adult emotional face recognition variables are presented in Table 2.

Examination of child emotional faces showed a significant group difference such that adolescents in the NSSI group made more recognition errors for child fearful faces than TDC youth ($d = 0.22, p < 0.05$). NSSI and SA groups did not differ on child fearful face identification nor did the SA versus the TDC group (Fig. 1). No group differences were shown for child happy, sad or angry face recognition.

Examination of adult emotional face recognition showed a significant group difference between the NSSI and TDC group on adult sad faces in which adolescents in the NSSI group made significantly more recognition errors for adult sad faces than TDC adolescents ($d = 0.28, p = 0.02$) (Fig. 2). NSSI and SA groups did not differ on adult sad face recognition. SA and TDC groups did not differ on adult sad face recognition errors. No group differences were shown for adult happy, angry or fearful faces.

To probe the effect of emotional face intensity (high-versus low-intensity face stimuli) on group comparisons, we conducted logistic regressions to examine differences in the probability of incorrect responses given high versus low-intensity faces. We found that relative to controls, the SA group was less likely to make errors on high-intensity face items

(OR 0.6, 95 % CI 0.3–0.9; $p = 0.02$). No differences were found comparing the NSSI and TDC ($p = 0.09$) groups or SA and NSSI groups ($p = 0.33$) on high-intensity face items.

Given the prior literature showing aberrant emotional face processing in children with mood and anxiety disorders, and the high rates of MDD and GAD within our inpatient sample (i.e., combined NSSI and SA groups), we conducted secondary analyses to examine the role of MDD and GAD on emotional face recognition within our sample.

Secondary analyses evaluating inpatients with and without MDD—Of our SA and NSSI groups, 83 % ($n = 50$) met criteria for MDD while 17 % ($n = 10$) did not. Inpatients with and without MDD did not differ on age [$F(1,58) = 0.80$, $p = 0.37$], gender ($p = 0.71$) or FSIQ [$F(1,58) = 3.75$, $p = 0.06$].

No significant group differences were found on child happy, angry, sad or fearful faces. On adult faces, results showed that adolescents with MDD made significantly fewer recognition errors on adult sad faces than adolescents without MDD ($d = -0.71$, $p = 0.04$). No group differences were found on adult happy, angry and fearful adult faces (Table 3).

Secondary analyses evaluating inpatients with and without GAD—Of the SA and NSSI groups, 70 % ($n = 50$) met criteria for GAD while 30 % ($n = 18$) did not. Inpatients with and without GAD did not differ on age [$F(1,58) = 0.02$, $p = 0.90$], or gender ($p = 0.76$); however, inpatients with GAD had higher FSIQ scores than those without GAD (GAD = 107.78 ± 9.34 ; without GAD = 101.60 ± 10.03), [$F(1,58) = 3.75$, $p = 0.06$].

No significant group differences were found for child happy, sad, angry or fearful face recognition.

On adult faces variables, a significant group difference was found for errors on adult happy faces ($d = -0.76$, $p = 0.02$). Specifically, adolescents with GAD made fewer recognition errors on adult happy faces than adolescents without GAD.

Discussion

To the best of our knowledge, our study is the first to evaluate emotional face recognition in adolescent psychiatric inpatients who either attempted suicide or engaged in NSSI. Our primary finding is that inpatient adolescents engaged in NSSI make more emotional face recognition errors for child fearful faces and adult sad faces compared to TDC youth. However, there is no difference in emotional face recognition ability between inpatient adolescents engaged in NSSI versus those who attempt suicide. Consistent with previous research, our secondary analyses showed the importance of categorical diagnoses, including MDD and GAD, on emotional face recognition [42, 46, 48, 69–71]. Further work is required to determine if our lack of between-group differences in emotional face recognition in adolescents engaged in SA vs. NSSI represents a true null finding, or if they suggest the importance of context-dependent emotional states (e.g., psychiatric hospitalization vs. real-world settings). Furthermore, in addition to behavioral findings, there is a need to examine the neural underpinnings behind emotional face recognition in adolescents engaged in SA or NSSI.

Our primary analyses revealed significant differences in emotional face recognition between inpatient adolescents engaged in NSSI compared to TDC youth, but not inpatient adolescents who have attempted suicide. While there have been no studies of emotional face recognition in individuals who engage in NSSI, our results are consistent with the broader theoretical and empirical literature about NSSI in adolescents. Specifically, theoretical models of NSSI have posited, among other reasons, that individuals engage in NSSI as a means of social communication—a way to gain attention or influence another’s behavior [72, 73]. Further, empirical studies have shown that individuals who engage in NSSI display deficits in social communication skills including impaired social problem-solving, poor verbal skills, and alexithymia [27, 29, 74]. Therefore, it is not surprising that individuals engaged NSSI also demonstrate deficits in emotional face recognition, a critical social communication skill. Interestingly, NSSI often begins between the ages of 12 and 14 years, a period of intense social development [75]. It may be that adolescents with social communication deficits, including difficulties with emotional face recognition, engage in NSSI behaviors as an alternative means of communication. Additional research is needed to better understand the relationship between impairments in emotional face recognition and broader social communication deficits in individuals with NSSI.

In a similar vein, our results can be interpreted within the context of Joiner’s (2005) [30] interpersonal theory of suicide which proposes that an individual will not die by suicide unless he/she has both the desire to die by suicide and the ability to do so. Specifically, in order to commit suicide an individual must have the “acquired capacity for suicide” which includes the ability to overcome the pain and fear associated with suicidal behaviors. Joiner has suggested that engagement in NSSI behaviors may increase this acquired capacity by desensitizing an individual to the fear and pain associated with suicidal self-harm behaviors which has been supported with empirical evidence [76]. Moreover, Joiner suggests that suicidal desires increase when an individual feels a sense of “thwarted belongingness”—the psychologically painful mental state that results from a fundamental need for connectedness [77, 78]. Our results showing that compared to TDC participants NSSI participants display deficits in emotional face identification could suggest a mechanism by which feelings of social isolation and thwarted belongingness develop. That is, if an individual who engages in NSSI misinterprets the social cues of people around him/her, particularly angry or fearful faces as our data suggest, then he/she may attribute incorrect emotional responses to those around him/her leading to feelings of isolation or lack of belonging. In turn, this sense of thwarted belongingness could increase his/her risk for attempting suicide. Of course, this hypothesis requires empirical testing, and in our study we did not specifically measure thwarted belongingness (e.g., Interpersonal Needs Questionnaire [79]), but such a study could provide a means by which some individuals who engage in NSSI go on to attempt suicide.

While our results showed emotional face recognition differences between the NSSI and TDC groups, no differences were found between the NSSI and SA groups. To the best of our knowledge, only Pan et al. have evaluated brain/behavior interactions underlying emotional face recognition in relation to SA [43]. Comparing depressed adolescents with and without a history of SA, Pan et al. did not find differences in behavioral performance using a face morphing task. However, their results showed that depressed adolescents with a history of

SA had significantly greater activation in the dorsolateral prefrontal cortex, dorsal anterior cingulate gyrus, bilateral primary sensory cortices and middle temporal gyrus when viewing angry faces at 50 % intensity compared to depressed adolescents without a history of SA [43]. These results suggest there may be differential neural efficiency between adolescents with and without a history of SA when processing emotional stimuli. Since neither this study, nor others, have examined the neural correlates of emotional face processing in NSSI, studies are needed to address this gap in the literature and to compare neural activation during emotional face processing in adolescents with NSSI compared to SA.

Given our well-matched groups, our data may suggest a true null finding, but it is also possible that our results represent type II error. Although our sample size may be relatively large compared to other studies of SA and NSSI adolescents, the overall sample size is small and our failure to find a clear signal to find group differences is likely a reflection of type II error. That is to say, we were powered to detect only large effects as statistically significant ($d = 0.73$). In many cases we observe effects as large or larger, but due to non-normality and skew in outcomes and covariates, are unable to rule out chance as a possible cause of the observed differences. In fact, it may be that there are greater differences in emotional face recognition between the SA and NSSI groups, but they are context-dependent effects. Specifically, is it possible that the brain/behavior underpinnings of emotional face recognition differ between adolescents engaged in SA vs. NSSI when in their typical setting (i.e., home), that have normalized during the course of inpatient hospitalization, when they are removed from stressors and triggers (i.e., peers, parents, school). Along these lines, many have hypothesized that self-injurious behaviors, including NSSI and SA, function as maladaptive emotion regulation strategies used to alleviate or reduce negative emotional experiences [73, 80–82]. Research with depressed youth suggests that high levels of negative affect may occur only in certain contexts [83]. Regarding emotional face processing, the research has shown both state- and context-dependent changes in ability. For example, treatment with antidepressant medication has been shown to attenuate aberrant amygdala responses to negative face emotions in individuals with depression [84–86]. Moreover, in an 8-week treatment study of sertraline in individuals with depression, results showed an enhanced neural response in the pregenual anterior cingulate cortex to happy faces post-treatment suggesting that positive emotional stimuli may become more reinforcing with pharmacological treatment [86]. When we examined the specific effects of SSRIs (vs. psychotropic medication more generally) on emotional face processing (Online Supplement), our results were largely the same. One difference was that controlling for SSRIs ameliorated the group differences originally shown between the NSSI and TDC groups on child fearful faces. Further, a new finding emerged such that adolescents with SA made slightly more adult sad face errors than TDC children. These results may suggest that SSRIs, more so than other psychotropic medications, may help reduce emotional face processing deficits in adolescents struggling with mood difficulties. To date, the specific mechanism by which psychotropic medications, including SSRIs, affect emotional face processing is unknown suggesting that additional studies are warranted. Additionally, numerous studies have documented the reduction in clinical symptoms during psychiatric hospitalization in children implicating the importance of context. For example, prior work by Dickstein et al. has shown that 45 % of children with severe mood dysregulation (SMD),

which is characterized by chronic irritability, made significant clinical improvement during psychiatric hospitalization; therefore, not requiring the addition of medication [87]. Given the importance of context on both emotional face processing and adolescent mood, moving forward, it will be important to examine emotion regulation, including emotional face processing ability, while adolescents are in their typical environment (home/school) rather than during an inpatient hospitalization. Use of ecological momentary assessment as a means of collecting data throughout the day in real time in an individual's natural environment could help advance what is known about variations in emotional face recognition ability in relation to mood, context and treatment.

Secondary analyses revealed that adolescents with MDD made fewer errors on adult sad faces than adolescents without MDD suggesting a possible bias for sad faces in depressed youth. This finding is consistent with prior work which showed that both boys with MDD and boys at elevated risk for MDD (i.e., by virtue of having a parent with MDD) identified sadness in faces at lower levels of intensity compared to boys at low familial risk [45]. In contrast, in a study comparing children with depression (DEP), children with comorbid depression and conduct disorder (DEP/CD), and TDCs, Schepman et al. [88] found that children with depression (in either DEP or DEP/CD groups) did not show an overall deficit in recognizing facial expressions (i.e., no group differences). However, follow-up analyses showed that children with depression, compared to TDCs, were more likely to perceive low-intensity expressions as sad, whereas control participants were more likely to perceive low-intensity expressions as happy, suggesting a negative affective processing bias in the children with depression. Furthermore, using an Emotional Go/NoGo task utilizing emotional faces, Ladouceur et al. found that youth with MDD had significantly faster reaction times to sad faces compared to youth with anxiety disorders or TDCs indicating a disorder-specific attentional bias towards sad stimuli [71]. Despite the robust literature examining emotional face processing in individuals with and without depression, it remains unclear as to whether aberrant processing of emotional faces is a cause, or effect, of depression. Few studies have examined emotional face processing in at-risk samples of individuals with early or attenuated symptoms of depression (e.g., affective temperament characterized by low self-esteem, unhappiness, irritability, etc.) [88]. In a study examining emotional face processing and affective temperament in adults, results showed that individuals with higher scores on the affective temperament dimension had an increased tendency to identify neutral faces as negative emotional expressions compared to individuals with lower affective temperament scores. Yet, there were no group differences (between those with high vs. low affective temperament) in accuracy of identification of specific facial emotions: happy, sad, angry or fearful facial expressions. These results may suggest that biased emotional face processing (e.g., viewing neutral faces as negative) may be one mechanism by which at-risk individuals develop depression. Taken together, these studies suggest that additional work is needed to clarify whether these findings represent a bias towards sad or negative stimuli as a whole or whether these deficits are specific to emotional face processing and identification.

Regarding the role of anxiety, our finding showed that adolescents with GAD made fewer adult happy face recognition errors than adolescents without GAD. This may suggest that adolescents with GAD are more aware of the emotional expressions of adults especially ones that appear reassuring or approving—i.e., happy faces. This is consistent with the

clinical profile of youth with GAD as they often worry about competency, seek reassurance from adults and struggle with uncertainty [89, 90]. It may be that inpatients with significant GAD in addition to either SA or NSSI are more attuned to the emotional facial expressions of adults as a way to avoid negative social interactions and subsequent negative emotions. Clinical features such as high conscientiousness and rule-abiding behavior may actually facilitate the social relations with adults in children with GAD [91, 92]. While our work examining the role of GAD in emotional face processing was consistent with some research, it does contrast with other behavioral studies comparing DANVA performance in adolescents with anxiety disorders vs. TDCs. For example, McClure et al. found no differences in emotional face recognition between children with anxiety compared to TDCs [93]. Additionally, Easter et al. found that adolescent outpatients with social phobia, separation anxiety and/or GAD made significantly more adult face total errors than TDCs with post hoc analyses showing that anxious adolescents were more likely than TDCs to make errors on low-intensity, but not high-intensity, adult faces [42]. Our findings may differ from prior studies due to differences in participant populations (i.e., our sample recruited based on SA and NSSI not anxiety) and levels of impairment (i.e., inpatient vs. outpatient samples). Future studies in youth with anxiety need to examine emotional face recognition ability among different diagnoses of anxiety (e.g., GAD compared to social phobia or obsessive compulsive disorder) and between inpatient and outpatient populations as behavioral markers of emotion regulation among these groups may be different.

Our study had several limitations. First, our sample may have been affected by sampling bias because we sought to enroll inpatient SAs vs. inpatient NSSIs, potentially resulting in NSSI participants being more severe than typical teens engaged in NSSI (as demonstrated by need for hospitalization despite no suicide attempt), and thus inducing Berkson's bias [94]. However, we sought to avoid the more concerning sampling bias that would result from comparing inpatient SAs to outpatient NSSIs, and wanted to enroll both groups in closest temporal proximity to their self-harm behaviors. Second, as discussed previously, our sample examined psychiatrically hospitalized youth, and while that confers the advantage of working with adolescents with clinically significant and impairing problems, it is also a limitation as inpatient responses to emotional stimuli may be more context-dependent as discussed previously. Third, our sample examined "pure attempters" and "pure non-suicidal self-injurers". However, research in clinical samples of adolescents suggest that between 14 and 70 % report histories of both SA and NSSI [9, 23, 95]. Subsequent research should examine the bio-behavioral correlates of emotional face processing including a combined NSSI-SA group. Finally, while unlikely, it is possible that our positive results may be due to chance (type I error). However, correction for multiple comparisons, especially with smaller samples can severely reduce power and result in type II error [96, 97]. As this was a pilot study, replication of our results with a larger sample is needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Eaton DK, Kann L, Kinchen S, Shanklin S, Flint KH et al. (2012) Youth risk behavior surveillance —United States, 2011. *MMWR Surveill Summ* 61:1–162
2. Anderson RN, Smith BL (2005) Deaths: leading causes 2002. National vital statistics report In: Statistics NCfH, editor. National Center for Health Statistics, Hyattsville
3. Wasserman D, Cheng Q, Jiang GX (2005) Global suicide rates among young people aged 15–19. *World Psychiatry* 4:114–120 [PubMed: 16633527]
4. Rutz EM, Wasserman D (2004) Trends in adolescent suicide mortality in the WHO European Region. *Eur Child Adolesc Psychiatry* 13:321–331 [PubMed: 15490280]
5. SUPRE WHO Initiative for the prevention of suicide. In: Organization WH, editor. http://www.who.int/mental_health/management/en/SUPRE_flyer1.pdf
6. Brent D, Baugher M, Bridge J, Chen T, Chiappetta BS (1999) Age- and sex-related risk factors for adolescent suicide. *J Am Acad Child Adolesc Psychiatry* 38:1497–1505 [PubMed: 10596249]
7. Wolitzky-Taylor KB, Ruggiero KJ, McCart MR, Smith DW, Hanson RF et al. (2010) Has adolescent suicidality decreased in the United States? Data from two national samples of adolescents interviewed in 1995 and 2005. *J Clin Child Adolesc Psychol* 39:64–76 [PubMed: 20390799]
8. Posner K, Brown GK, Stanley B, Brent D, Yershova KV et al. (2011) The Columbia-Suicide Severity Rating Scale: initial validity and internal consistency findings from three multisite studies with adolescents and adults. *Am J Psychiatry* 2011:1266–1277
9. Asarnow JR, Porta G, Spirito A, Emslie G, Clarke G et al. (2011) Suicide attempts and nonsuicidal self-injury in the treatment of resistant depression in adolescents: findings from the TORDIA study. *J Am Acad Child Adolesc Psychiatry* 50:772–781 [PubMed: 21784297]
10. Beautrais AL, Joyce PR, Mulder RT (1996) Risk factors for serious suicide attempts among youths aged 13 through 24 years. *J Am Acad Child Adolesc Psychiatry* 35:1174–1182 [PubMed: 8824061]
11. Klonsky ED, May AM, Glenn CR (2013) The relationship between nonsuicidal self-injury and attempted suicide: converging evidence from four samples. *J Abnorm Psychol* 122:231–237 [PubMed: 23067259]
12. Waldrop AE, Hanson RF, Resnick HS, Kilpatrick DG, Naugle AE et al. (2007) Risk factors for suicidal behavior among a national sample of adolescents: implications for prevention. *J Trauma Stress* 20:869–879 [PubMed: 17955525]
13. Wilkinson P, Kelvin R, Roberts C, Dubicka B, Goodyer I (2011) Clinical and psychosocial predictors of suicide attempts and nonsuicidal self-injury in the Adolescent Depression Antidepressants and Psychotherapy Trial (ADAPT). *Am J Psychiatry* 168:495–501 [PubMed: 21285141]
14. Nock MK (2010) Self-injury. *Annu Rev Clin Psychol* 6:339–363 [PubMed: 20192787]
15. Klonsky ED, Muehlenkamp JJ (2007) Self-injury: a research review for the practitioner. *J Clin Psychol* 63:1045–1056 [PubMed: 17932985]
16. Lloyd-Richardson EE, Perrine N, Dierker L, Kelley ML (2007) Characteristics and functions of non-suicidal self-injury in a community sample of adolescents. *Psychol Med* 37:1183–1192 [PubMed: 17349105]
17. Plener PL, Libal G, Keller F, Fegert JM, Muehlenkamp JJ (2009) An international comparison of adolescent non-suicidal self-injury (NSSI) and suicide attempts: Germany and the USA. *Psychol Med* 39:1549–1558 [PubMed: 19171079]
18. Ross S, Heath NL (2003) Two models of adolescent self-mutilation. *Suicide Life Threat Behav* 33:277–287 [PubMed: 14582838]

19. Whitlock J, Muehlenkamp J, Purington A, Eckenrode J, Barreira P et al. (2011) Nonsuicidal self-injury in a college population: general trends and sex differences. *J Am Coll Health* 59:691–698 [PubMed: 21950249]
20. Madge N, Hewitt A, Hawton K, de Wilde EJ, Corcoran P et al. (2008) Deliberate self-harm within an international community sample of young people: comparative findings from the Child & Adolescent Self-harm in Europe (CASE) Study. *J Child Psychol Psychiatry* 49:667–677 [PubMed: 18341543]
21. Hankin BL, Abela JR (2011) Nonsuicidal self-injury in adolescence: prospective rates and risk factors in a 2(1/2) year longitudinal study. *Psychiatry Res* 186:65–70 [PubMed: 20807667]
22. Klonsky ED, Moyer A (2008) Childhood sexual abuse and non-suicidal self-injury: meta-analysis. *Br J Psychiatry* 192:166–170 [PubMed: 18310572]
23. Nock MK, Joiner TE Jr, Gordon KH, Lloyd-Richardson E, Prinstein MJ (2006) Non-suicidal self-injury among adolescents: diagnostic correlates and relation to suicide attempts. *Psychiatry Res* 144:65–72 [PubMed: 16887199]
24. Young R, Sweeting H, West P (2006) Prevalence of deliberate self harm and attempted suicide within contemporary Goth youth subculture: longitudinal cohort study. *BMJ* 332:1058–1061 [PubMed: 16613936]
25. Berenbaum H, Raghavan C, Le H, Vernon LL, Gomez JJ (2003) A taxonomy of emotional disturbances. *Clin Psychol Sci Pract* 10:206–226
26. Jollant F, Lawrence NL, Olie E, Guillaume S, Courtet P (2011) The suicidal mind and brain: a review of neuropsychological and neuroimaging studies. *World J Biol Psychiatry* 12:319–339 [PubMed: 21385016]
27. Jacobson CM, Gould M (2007) The epidemiology and phe-nomenology of non-suicidal self-injurious behavior among adolescents: a critical review of the literature. *Arch Suicide Res* 11:129–147 [PubMed: 17453692]
28. In-Albon T, Burli M, Ruf C, Schmid M (2013) Non-suicidal self-injury and emotion regulation: a review on facial emotion recognition and facial mimicry. *Child Adolesc Psychiatry Ment Health* 7:5 [PubMed: 23421964]
29. Nock MK (2008) Actions speak louder than words: an elaborated theoretical model of the social functions of self-injury and other harmful behaviors. *Appl Prev Psychol* 12:159–168 [PubMed: 19122893]
30. Joiner TE (2005) *Why people die by suicide*. Harvard University Press, Cambridge
31. Hagen EH, Watson PJ, Hammerstein P (2008) Gestures of despair and hope: a view on deliberate self-harm from economics and evolutionary biology. *Biol Theory* 3:123–138
32. Gobbini MI, Haxby JV (2007) Neural systems for recognition of familiar faces. *Neuropsychologia* 45:32–41 [PubMed: 16797608]
33. Gobbini MI, Leibenluft E, Santiago N, Haxby JV (2004) Social and emotional attachment in the neural representation of faces. *Neuroimage* 22:1628–1635 [PubMed: 15275919]
34. Leibenluft E, Gobbini MI, Harrison T, Haxby JV (2004) Mothers' neural activation in response to pictures of their children and other children. *Biol Psychiatry* 56:225–232 [PubMed: 15312809]
35. Keltner D, Kring AM (1998) Emotion, social function and psychopathology. *Rev General Psychiatry* 2:320–342
36. Haxby JV, Hoffman EA, Gobbini MI (2001) Human neural systems for face recognition and social communication. *Biol Psychiatry* 51:59–67
37. Johnson MH, Griffin R, Csibra G, Halit H, Farroni T et al. (2005) The emergence of the social brain network: evidence from typical and atypical development. *Dev Psychopathol* 17:599–619 [PubMed: 16262984]
38. Palermo R, Rhodes G (2007) Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia* 45:75–92
39. Stanley DA, Adolphs R (2013) Toward a neural basis for social behavior. *Neuron* 80:816–826 [PubMed: 24183030]
40. Frith CD, Frith U (2012) Mechanisms of social cognition. *Annu Rev Psychol* 63:287–313 [PubMed: 21838544]

41. de Boer M, Toni I, Willems RM (2013) What drives successful verbal communication? *Front Hum Neurosci* 7:622 [PubMed: 24101898]
42. Easter J, McClure EB, Monk CS, Dhanani M, Hodgdon H et al. (2005) Emotion recognition deficits in pediatric anxiety disorders: implications for amygdala research. *J Child Adolesc Psychopharmacol* 15:563–570 [PubMed: 16190788]
43. Pan LA, Hassel S, Segreti AM, Nau SA, Brent DA et al. (2013) Differential patterns of activity and functional connectivity in emotion processing neural circuitry to angry and happy faces in adolescents with and without suicide attempt. *Psychol Med* 43:2129–2142 [PubMed: 23298821]
44. Demenescu LR, KorteKaas R, den Boer JA, Aleman A (2010) Impaired attribution of emotion to facial expressions in anxiety and major depression. *PLoS One* 5:e15058
45. Lopez-Duran NL, Kuhlman KR, George C, Kovacs M (2013) Facial emotion expression recognition by children at familial risk for depression: high-risk boys are oversensitive to sadness. *J Child Psychol Psychiatry* 54:565–574 [PubMed: 23106941]
46. Joormann J, Gilbert K, Gotlib IH (2010) Emotion identification in girls at high risk for depression. *J Child Psychol Psychiatry* 51:575–582 [PubMed: 19788553]
47. Surcinelli P, Codispoti M, Montebanocci O, Rossi N, Baldaro B (2006) Facial emotion recognition in trait anxiety. *J Anxiety Disord* 20:110–117 [PubMed: 16325118]
48. Cooper RM, Rowe AC, Penton-Voak IS (2008) The role of trait anxiety in the recognition of emotional facial expressions. *J Anxiety Disord* 22:1120–1127 [PubMed: 18226491]
49. Monk CS, Nelson EE, McClure EB, Mogg K, Bradley BP et al. (2006) Ventrolateral prefrontal cortex activation and attentional bias in response to angry faces in adolescents with generalized anxiety disorder. *Am J Psychiatry* 163:1091–1097 [PubMed: 16741211]
50. Roy AK, Vasa RA, Bruck M, Mogg K, Bradley BP et al. (2008) Attention bias toward threat in pediatric anxiety disorders. *J Am Acad Child Adolesc Psychiatry* 47:1189–1196 [PubMed: 18698266]
51. Prinstein MJ, Nock MK, Simon V, Aikins JW, Cheah CS et al. (2008) Longitudinal trajectories and predictors of adolescent suicidal ideation and attempts following inpatient hospitalization. *J Consult Clin Psychol* 76:92–103 [PubMed: 18229987]
52. Nock MK (2009) Why do people hurt themselves? New insights into the nature and functions of self-injury. *Curr Dir Psychol Sci* 18:78–83 [PubMed: 20161092]
53. Jollant F, Lawrence NS, Giampietro V, Brammer MJ, Fullana MA et al. (2008) Orbitofrontal cortex response to angry faces in men with histories of suicide attempts. *Am J Psychiatry* 165:740–748 [PubMed: 18346998]
54. Weschler D (2005) Weschler abbreviated scale of intelligence. The Psychological Corporation, San Antonio
55. Posner K, Oquendo MA, Gould M, Stanley B, Davies M (2007) Columbia classification algorithm of suicide assessment (C-CASA): classification of suicidal events in the FDA's pediatric suicidal risk analysis of antidepressants. *Am J Psychiatry* 164:1035–1043 [PubMed: 17606655]
56. Plener PL, Fegert JM (2012) Non-suicidal self-injury: state of the art perspective of a proposed new syndrome for DSM V. *Child Adolesc Psychiatry Ment Health* 6:9 [PubMed: 22463601]
57. American Psychiatric Association (2013) *Diagnostics and statistics manual of mental disorders (DSM-5)*. American Psychiatric Publishing, Washington, DC
58. Ambrosini PJ (2000) Historical development and present status of the schedule for affective disorders and schizophrenia for school-age children (K-SADS). *J Am Acad Child Adolesc Psychiatry* 39:49–58 [PubMed: 10638067]
59. Achenbach TM, Rescorla LA (2001) *Manual for ASEBA school-age forms and profiles*. Research Center for Children, Youth & Families- University of Vermont, Burlington
60. Nock MK, Holmberg EB, Photos VI, Michel BD (2007) Self-injurious thoughts and behaviors interview: development, reliability, and validity in an adolescent sample. *Psychol Assess* 19:309–317 [PubMed: 17845122]
61. Nowicki S Jr, Duke M (1994) Individual differences in the non-verbal communication of affect: the Diagnostic Analysis of Non-verbal Accuracy Scale. *J Nonverbal Behav* 18:9–35
62. Nowicki S Jr (2012) *Manual for the receptive tests of diagnostic accuracy 2 (DANVA 2)*. Atlanta, GA

63. Corporation I (2012) IBM SPSS Statistics for Windows. 21.0 ed. Armonk, NY: IBM Corporation
64. Schlegel K, Grandjean D, Scherer KR (2013) Introducing the Geneva emotion recognition test: An example of rasch-based test development. *Psychol Assess* 26:666–672 [PubMed: 24295238]
65. Muthen LK, Muthen BO (2007) Mplus user's guide Muthen & Muthen, Los Angeles
66. Hu L, Bentler PM (1999) Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equ Model* 6:1–55
67. Yu CY (2002) Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes
68. Cohen JD (1988) Statistical power analysis for behavioral sciences. Erlbaum, Hillsdale
69. Stuhmann A, Suslow T, Dannowski U (2011) Facial emotion processing in major depression: a systematic review of neuroimaging findings. *Biol Mood Anxiety Disord* 1:10 [PubMed: 22738433]
70. Waters AM, Mogg K, Bradley BP, Pine DS (2008) Attentional bias for emotional faces in children with generalized anxiety disorder. *J Am Acad Child Adolesc Psychiatry* 47:435–442 [PubMed: 18388762]
71. Ladouceur CD, Dahl RE, Williamson DE, Birmaher B, Axelson DA et al. (2006) Processing emotional facial expressions influences performance on a Go/NoGo task in pediatric anxiety and depression. *J Child Psychol Psychiatry* 47:1107–1115 [PubMed: 17076749]
72. Nock MK, Prinstein MJ (2005) Contextual features and behavioral functions of self-mutilation among adolescents. *J Abnorm Psychol* 114:140–146 [PubMed: 15709820]
73. Nock MK, Prinstein MJ (2004) A functional approach to the assessment of self-mutilative behavior. *J Consult Clin Psychol* 72:885–890 [PubMed: 15482046]
74. Nock MK, Mendes WB (2008) Physiological arousal, distress tolerance, and social problem-solving deficits among adolescent self-injurers. *J Consult Clin Psychol* 76:28–38 [PubMed: 18229980]
75. Nock MK (ed) (2009) Understanding non-suicidal self-injury: origins, assessment, and treatment. American Psychological Association, Washington, DC
76. Hamza CA, Stewart SL, Willoughby T (2012) Examining the link between nonsuicidal self-injury and suicidal behavior: a review of the literature and an integrated model. *Clin Psychol Rev* 32:482–495 [PubMed: 22717336]
77. Franklin JC, Hessel ET, Prinstein MJ (2011) Clarifying the role of pain tolerance in suicidal capability. *Psychiatry Res* 189:362–367 [PubMed: 21868104]
78. Baumeister RF, Leary MR (1995) The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychol Bull* 117:497–529 [PubMed: 7777651]
79. Joiner TE Jr, Van Orden KA, Witte TK, Selby EA, Ribeiro JD et al. (2009) Main predictions of the interpersonal-psychological theory of suicidal behavior: empirical tests in two samples of young adults. *J Abnorm Psychol* 118:634–646 [PubMed: 19685959]
80. Chapman AL, Gratz KL, Brown MZ (2006) Solving the puzzle of deliberate self-harm: the experiential avoidance model. *Behav Res Ther* 44:371–394 [PubMed: 16446150]
81. Linehan MM (1987) Dialectical behavior therapy for borderline personality disorder. Theory and method. *Bull Menninger Clin* 51:261–276 [PubMed: 3580661]
82. Suyemoto KL (1998) The functions of self-mutilation. *Clin Psychol Rev* 18:531–554 [PubMed: 9740977]
83. Mor N, Doane LD, Adam EK, Mineka S, Zinbarg RE et al. (2010) Within person variations in self-focused attention and negative affect in depression and anxiety: an anxiety study. *Cogn Emot* 24:48–62
84. Arnone D, McKie S, Elliott R, Thomas EJ, Downey D et al. (2012) Increased amygdala responses to sad but not fearful faces in major depression: relation to mood state and pharmacological treatment. *Am J Psychiatry* 169:841–850 [PubMed: 22854930]
85. Sheline YI, Barch DM, Donnelly JM, Ollinger JM, Snyder AZ et al. (2001) Increased amygdala response to masked emotional faces in depressed subjects resolves with antidepressant treatment: an fMRI study. *Biol Psychiatry* 50:651–658 [PubMed: 11704071]

86. Victor TA, Furey ML, Fromm SJ, Ohman A, Drevets WC (2013) Changes in the neural correlates of implicit emotional face processing during antidepressant treatment in major depressive disorder. *Int J Neuropsychopharmacol* 16:2195–2208 [PubMed: 23809145]
87. Dickstein DP, Towbin KE, Van Der Veen JW, Rich BA, Brotman MA et al. (2009) Randomized double-blind placebo-controlled trial of lithium in youths with severe mood dysregulation. *J Child Adolesc Psychopharmacol* 19:61–73 [PubMed: 19232024]
88. Schepman K, Taylor E, Collishaw S, Fombonne E (2012) Face emotion processing in depressed children and adolescents with and without comorbid conduct disorder. *J Abnorm Child Psychol* 40:583–593 [PubMed: 22068712]
89. Masi G, Millepiedi S, Mucci M, Poli P, Bertini N et al. (2004) Generalized anxiety disorder in referred children and adolescents. *J Am Acad Child Adolesc Psychiatry* 43:752–760 [PubMed: 15167092]
90. Dugas MJ, Ladouceur R, Leger E, Freeston MH, Langlois F et al. (2003) Group cognitive-behavioral therapy for generalized anxiety disorder: treatment outcome and long-term follow-up. *J Consult Clin Psychol* 71:821–825 [PubMed: 12924687]
91. American Psychiatric Association (2000) *Diagnostics and statistics manual of mental disorders –4th edition-text revision (DSM-IV-TR)*. American Psychiatric Publishing, Washington DC
92. Scharfstein L, Alfano C, Beidel D, Wong N (2011) Children with generalized anxiety disorder do not have peer problems, just fewer friends. *Child Psychiatry Hum Dev* 42:712–723 [PubMed: 21739298]
93. McClure EB, Pope K, Hoberman AJ, Pine DS, Leibenluft E (2003) Facial expression recognition in adolescents with mood and anxiety disorders. *Am J Psychiatry* 160:1172–1174 [PubMed: 12777278]
94. Westreich D (2012) Berkson’s bias, selection bias, and missing data. *Epidemiology* 23:159–164 [PubMed: 22081062]
95. Esposito-Smythers C, Goldstein T, Birmaher B, Goldstein B, Hunt J et al. (2010) Clinical and psychosocial correlates of non-suicidal self-injury within a sample of children and adolescents with bipolar disorder. *J Affect Disord* 125:89–97 [PubMed: 20089313]
96. Gelman A, Hill J, Yajima M (2012) Why we (usually) don’t have to worry about multiple comparisons. *J Res Educ Eff* 5:189–211
97. Nakagawa S (2004) A farewell to Bonferroni: the problems of low statistical power and publication bias. *Behav Ecol* 15:1044–1045

Fig. 1.
Child face recognition errors by group

Fig. 2.
Adult face recognition errors by group

Table 1

Participant demographic and clinical characteristics

Variable	SA group (<i>n</i> = 30)	NSSI group (<i>n</i> = 30)	TDC (<i>n</i> = 30)	Significance
Age (years)	15.47 ± 1.19	15.24 ± 1.06	15.40 ± 1.19	$F(2,87) = 0.32$
Sex: male	30 % (9)	30 % (9)	30 % (9)	$\chi^2(2, N = 90) = 0.00$
Full-Scale IQ ^a	102.70 ± 10.21	104.20 ± 10.23	104.97 ± 9.54	$F(2,87) = 0.40$
Ethnicity: caucasian	74 % (20)	86 % (25)	77 % (23)	$\chi^2(2, N = 90) = 1.40$
KSADS current diagnosis (past 6 months) ^b				
Major depressive disorder	73 % (22)	93 % (28)	–	$\chi^2(1, N = 60) = 4.32^*$
Manic episode	0 % (0)	0 % (0)	–	N/A
Generalized anxiety disorder	20 % (6)	40 % (12)	–	$\chi^2(1, N = 60) = 2.86$
Panic disorder	7 % (2)	20 % (6)	–	$\chi^2(1, N = 60) = 2.31$
Social phobia	20 % (6)	10 % (3)	–	$\chi^2(1, N = 60) = 1.18$
Attention-deficit/hyperactivity disorder	7 % (2)	10 % (3)	–	$\chi^2(1, N = 60) = 0.22$
Oppositional defiant disorder	13 % (4)	17 % (5)	–	$\chi^2(1, N = 60) = 0.13$
Conduct disorder	3 % (1)	13 % (4)	–	$\chi^2(1, N = 60) = 1.96$
Alcohol abuse	0 % (0)	7 % (2)	–	$\chi^2(1, N = 60) = 2.07$
Cannabis abuse	0 % (0)	10 % (3)	–	$\chi^2(1, N = 60) = 3.16$
Currently taking psychotropic medication ^b	60 % (18)	87 % (26)	–	$\chi^2(1, N = 60) = 5.46^*$
Atypical neuroleptic	3 % (1)	7 % (2)	–	
Anti-epileptic	7 % (2)	7 % (2)	–	
SSRI	47 % (14)	73 % (22)	–	
Other anti-depressant	7 % (2)	13 % (4)	–	
Sedative	0 % (0)	7 % (2)	–	
Stimulant ^d	10 % (3)	3 % (1)	–	
Alpha agonist ADHD medication	0 % (0)	3 % (1)	–	

Results = mean ± standard deviation or as *n* (%)

KSADS schedule for affective disorders, NSSI/non-suicidal self-injury, SA suicide attempt, TDC typically developing controls

* *p* 0.05

Full Scale IQ is reported as standard scores on the Wechsler Abbreviated Scale of Intelligence (WASI)
Group comparisons are made between SA and NSSI groups only for these variables

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Group differences in emotional face recognition controlling for comorbid psychopathology (MDD, GAD) and medication status

Table 2

	Groups		Group comparisons (<i>p</i> values)			
	SA (<i>n</i> = 30)	NSSI (<i>n</i> = 30)	TDC (<i>n</i> = 30)	TDC vs NSSI	TDC vs SA	SA vs. NSSI
Child face errors						
Happy	0.02 ± 0.42	-0.10 ± 0.22	0.09 ± 0.56	0.48	0.58	0.15
Angry	-0.07 ± 0.52	0.02 ± 0.55	0.05 ± 0.62	0.38	0.54	0.89
Sad	0.04 ± 0.64	0.00 ± 0.62	-0.03 ± 0.54	0.91	0.53	0.67
Fearful	0.04 ± 0.88	0.06 ± 0.71	-0.10 ± 0.74	0.05	0.34	0.71
Adult face errors						
Happy	-0.03 ± 0.32	0.01 ± 0.30	0.02 ± 0.38	0.95	0.77	0.29
Angry	0.05 ± 0.18	-0.04 ± 0.25	-0.01 ± 0.34	0.76	0.78	0.13
Sad	0.00 ± 0.29	0.04 ± 0.29	-0.04 ± 0.28	0.02	0.15	0.16
Fearful	0.03 ± 0.30	-0.09 ± 0.30	0.05 ± 0.39	0.67	0.22	0.09

Results presented as mean ± standard deviation of Rasch modeling-derived factor scores with higher values indicating greater errors. *p* values refer to the probability of observing a test statistic with an absolute value as or more extreme as estimated for the given contrast. Values less than *p* < 0.05 are presented in bold typeface

GAD generalized anxiety disorder, *MDD* major depressive disorder, *NSSI* non-suicidal self-injury, *SA* suicide attempt, *TDC* typically developing controls

Table 3

Effects of MDD and GAD on emotional face recognition in inpatient adolescents

	Groups		<i>p</i> value	Groups		<i>p</i> value
	MDD (<i>n</i> = 50)	No MDD (<i>n</i> = 10)		GAD (<i>n</i> = 42)	No GAD (<i>n</i> = 18)	
Child face errors						
Happy	-0.05 ± 0.33	-0.02 ± 0.38	0.84	-0.03 ± 0.36	-0.08 ± 0.28	0.62
Angry	-0.01 ± 0.55	-0.08 ± 0.42	0.73	-0.09 ± 0.56	0.14 ± 0.43	0.12
Sad	0.05 ± 0.76	-0.14 ± 0.37	0.37	0.06 ± 0.65	-0.08 ± 0.56	0.44
Fearful	0.05 ± 0.76	0.04 ± 0.95	0.95	0.05 ± 0.84	0.04 ± 0.68	0.95
Adult face errors						
Happy	0.00 ± 0.30	-0.10 ± 0.33	0.30	0.05 ± 0.33	-0.15 ± 0.17	0.02
Angry	0.01 ± 0.23	-0.03 ± 0.20	0.57	0.01 ± 0.23	0.00 ± 0.22	0.89
Sad	-0.02 ± 0.28	0.19 ± 0.30	0.04	0.07 ± 0.30	-0.09 ± 0.24	0.06
Fearful	-0.01 ± 0.31	-0.10 ± 0.26	0.43	0.01 ± 0.31	-0.11 ± 0.28	0.15

Results presented as mean ± standard deviation of Rasch modeling-derived factor scores with higher values indicating greater errors. *p* values refer to the probability of observing a test statistic with an absolute value as or more extreme as estimated for the given contrast. Values less than $p < 0.05$ are presented in bold typeface

GAD generalized anxiety disorder, *MDD* major depressive disorder