INTERNATIONAL JOURNAL OF COMPARATIVE PSYCHOLOGY

2017, 30
Catherine Plowright
Special Issue Editor
Peer-reviewed

Categorization of Emotional Facial Expressions in Humans with a History of Non-suicidal Self-injury

Laura Ziebell, Charles Collin, Madyson Weippert, and Misha Sokolov

University of Ottawa, Ottawa, Ontario, Canada

In social animals, such as humans, accurate emotion expression categorization is important for appropriate social functioning. Inaccuracy in emotion categorization can lead to inadequate social behavior, commonly seen in various psychiatric disorders. Non-suicidal self-injury (NSSI) is a psychiatric symptom involving deliberate self-inflicted injury of one's body, without intent to die. NSSI has been regarded as a dysfunctional coping strategy for managing intensely difficult feelings. Difficulties in social interactions have been reported by individuals who engage in NSSI, which may be related to their emotion categorization performance. Participants (17-25 yrs) with a history of NSSI and healthy controls viewed videos of faces changing over 10 s from neutral to a prototypical expression of sadness, disgust, surprise, fear, anger or happiness. They were instructed to stop each video as soon as they felt they recognized the emotion presented, thus indicating the minimum intensity of expression needed for categorization. They were then asked to categorize the expression. Minimum facial expression intensity, accuracy of categorization, and reaction time were the behavioral dependent variables of interest. NSSI participants showed significant advantages compared to controls in their ability to categorize negative emotion expressions, specifically fear, anger, disgust, and sadness. They also were able to recognize the ambiguous emotion of surprise at a lower stimulus intensity. To date, treatments for NSSI have high drop-out rates. Results from this research could be used to inform further development of therapies for the alleviation or prevention of NSSI.

In social animals such as humans, accurate categorization of facial expressions of emotion is essential for appropriate social functioning, because recognizing the internal states of others from external cues can help to establish empathy, trust, and prosocial behavior. Moreover, the accurate decoding of others' facial expressions is of great importance for guiding one's own behavior and regulating or managing one's own emotional state in various social contexts (Marsh, Kozak, & Ambady, 2007; Mayer, Salovey, Caruso, & Sitarenios, 2001). If facial expressions of emotion are not recognized, or recognized incorrectly, this can affect an individual's emotion regulation (Yoo, Matsumoto, & LeRoux, 2006). Emotion regulation is described as the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions (Gross, 1998). For example, the ability to control the behavioral expression of one's negative emotions evoked during times of conflict or stress can be adaptive in many social contexts.

Inaccurate recognition and categorization of emotion expression can lead to emotion dysregulation and in turn can result in emotional disturbances, inadequate social behavior, poor social skills, less adaptive social problem-solving skills, and impaired social functioning, as seen in a variety of psychiatric disorders (Claes, Houben, Vandereycken, Bijttebier, & Muehlenkamp, 2010; Daros, 2012; Daros, Zakzanis, & Ruocco, 2013; Nock & Mendes, 2008). Indeed, emotion dysregulation appears to be involved in many psychiatric disorders. Examples include the failed regulation of anxiety in anxiety disorders (Cole, Michel, & Teti, 1994) or severe emotional dysregulation resulting in significant fear of abandonment and pervasive interpersonal problems in Borderline Personality Disorder (BPD; Lieb, Zanarini, Schmahl, Linehan, & Bohus, 2004).

Please send correspondence to Laura Ziebell, University of Ottawa / Université d'Ottawa,136 Jean Jacques Lussier, Rm 3091, Vanier Hall, Ottawa, ON, K1N 6N5. (Email: lzieb079@uottawa.ca) https://doi.org/10.46867/ijcp.2017.30.01.07

Additionally, evidence for inaccurate emotion categorization has also been found for BPD, Social Anxiety Disorder, Major Depressive Disorder and Eating Disorders (Aldinger et al., 2013; Daros et al., 2013; Fenske et al., 2015; Foa, Gilboa-Schechtman, Amir, & Freshman, 2000; Harrison, Sullivan, Tchanturia, & Treasure, 2009, 2010; Kucharska-Pietura, Nikolaou, Masiak, & Treasure, 2004). Depending on the disorder, research has found either impairments in emotion recognition or sensitivities to facial expressions of emotion. Emotion regulation deficits in these populations are frequently thought to be central to the development and maintenance of psychological problems, and profoundly linked to emotion recognition capabilities.

Non-suicidal Self-injury

Non-suicidal Self-injury (NSSI) is intentional, self-inflicted damage to the surface of one's body without suicidal intent; it does not include forms of socially sanctioned self-injury, such as tattoos, ritual scarification, or piercings (American Psychiatric Association, 2013; Lloyd-Richardson, Perrine, Dierker, & Kelley, 2007). NSSI is a significant problem worldwide with lifetime prevalence estimates at 17.2% among adolescents, 13.4% among young adults (mean age 18 and 24 years) and 5.5% among adults (mean age over 25 years; Swannell, Martin, Page, Hasking, & St. John, 2014). NSSI behaviors include, but are not limited to, cutting, scratching, burning, stabbing, and/or self-hitting without suicidal intent. In past issues of the Diagnostic and Statistical Manual of Mental Disorders (DSM), NSSI has been limited to a symptom of Borderline Personality Disorder (BPD; American Psychiatric Association, 1994). However, suggestions have been made that NSSI should be considered a separate syndrome (Favazza & Rosenthal, 1990, 1993; Herpertz, 1995; Kahan & Pattison, 1984; Muehlenkamp, 2005; Pattison & Kahan, 1983), and recent research demonstrates that NSSI frequently occurs in individuals who do not meet diagnostic criteria for BPD (Selby, Bender, Gordon, Nock, & Joiner, 2012). This supports the idea that there is utility in understanding NSSI as its own diagnostic category. As such, Non-suicidal self-injury disorder now appears in the DSM-5 criteria as a condition for further study. Indeed, considerable research supports the classification of NSSI as a distinct entity that can occur independently of BPD and suicide, yet carries clinical significance (Glenn & Klonsky, 2013; Muehlenkamp, 2005; Nock, Joiner, Gordon, Lloyd-Richardson, & Prinstein, 2006; Zetterqvist, 2015). The focus of the present research study was to examine the emotion categorization capabilities of individuals with a history of NSSI, but no diagnosis of BPD.

NSSI and Emotion Recognition

The role of emotion dysregulation in NSSI behaviors is centrally linked to Linehan's (1993) biosocial theory. According to Linehan's theory, individuals engaging in NSSI behavior have significant difficulty with emotion regulation due to a biological predisposition for high emotional reactivity, as well as a social learning history of emotional invalidation from their families. An emotionally invalidating environment occurs when an individual's emotional experiences are not responded to appropriately or consistently (Linehan, 1993; In-Albon, Bürli, Ruf, & Schmid, 2013). This type of environment does not allow an individual to learn how to adaptively regulate intense emotions. Thus, these individuals rely on impulsive, short-term strategies, such as NSSI, to regulate emotions (In-Albon et al., 2013). Anger, anxiety, and frustration often precede engagement in NSSI, followed by temporary relief and calm, but ultimately result in sadness, guilt, anger, disgust and anxiety in the long term (Klonsky, 2007).

Emotion regulation is intricately linked with emotion perception (Gross, 2013, 2015). If facial expressions of emotion are not recognized correctly, emotion regulation and subsequent emotion recognition

can be influenced. Several studies examining patients who engage in NSSI have found that these individuals are not able to perceive their own feelings at all, or sometimes the opposite, they perceive their feeling too strongly and aversively (Stiglmayr et al., 2005; Nock & Mendes, 2008). According to the biosocial theory (Linehan, 1993), greater sensitivity to emotion stimuli is a direct consequence of the emotion dysregulation characterized by NSSI. Thus we would expect individuals with a history of NSSI to be more sensitive to emotion signals, especially those of a negative nature.

In individuals with BPD (of which NSSI is a frequent symptom), emotion dysregulation has been linked to dysregulation across cognitive processes, neurochemistry and physiology, facial and muscle reactions, and emotion-linked actions (Crowell, Beauchaine, & Linehan, 2009). These individuals display greater emotional sensitivity, greater emotional reactivity, and longer duration of emotional responses (Jovev et al., 2011). However, studies on emotion recognition in adolescents and adults with BPD have shown inconsistent results. A study conducted by Jovev and colleagues (2011) predicted increased emotion sensitivity in adolescents with BPD based on Linehan's (1993) theoretical framework by hypothesizing earlier response times to an emotion recognition task and more accurate recognition responses on the task compared to controls (Jovev et al., 2011). Contrary to their predictions, the BPD group exhibited somewhat longer response latencies for the recognition of fear and disgust. They also observed that the BPD group rated disgust and happiness as less positive than the control group, suggesting a possible negative bias in appraising social cues (Meyer, Pilkonis, & Beevers, 2004). Robin et al. (2012), who also investigated adolescents with BPD, found that they were less sensitive to facial expressions of anger and happiness (i.e., they required more intense facial expressions to correctly identify these emotions than control participants), and that they showed impairments when recognizing fully expressed emotions. In adults with BPD, Lynch et al. (2006) reported a heightened sensitivity to facial expressions, whereas Domes et al. (2008) reported a comparable emotion detection threshold in BPD and non-clinical controls. A recent review of 25 studies of emotion recognition in BPD concluded that despite differences in methodology, there were no significant recognition impairments for any negative emotions between BPD and healthy controls; however, there was consistent evidence supporting a negative response bias to neutral and ambiguous facial expressions (Mitchell, Dickens, & Picchioni, 2014).

To date, there are two studies examining facial emotion recognition capabilities in individuals exhibiting NSSI, both in an adolescent inpatient population. In-Albon, Ruf, and Schmid (2015) hypothesized that female adolescents engaging in NSSI would have more difficulty recognizing facial expressions, as measured by the intensity of expression at which they could accurately identify an emotion. They also predicted a decline in emotion recognition, mean emotion intensity before first correct response, and accuracy following a sad mood induction compared to a neutral mood. Contrary to their predictions, adolescents engaging in NSSI showed no general deficits accurately recognizing facial expressions of emotion, and no significant differences in intensity of emotion required for accurate identification between adolescents with NSSI disorder, clinical controls without NSSI, and nonclinical controls. All groups correctly recognized emotions at similar stages of emotional expressivity, and mood induction did not affect recognition or accuracy. However, adolescents with NSSI disorder did rate the valence and arousal of emotions as significantly more unpleasant for neutral and happy expression and significantly more arousing for angry, sad, and happy expressions compared to the non-clinical control group.

Most recently, Seymour et al. (2016) examined facial emotion expression recognition in three groups: (1) inpatient adolescents engaging in NSSI, (2) inpatient adolescents who attempted suicide, and (3) typically developing controls. Facial emotion recognition ability was assessed using DANVA-2, a computer-based behavioral task in which participants are asked to identify 2-second static photographs of child and adult faces expressing happiness, sadness, anger, or fear at high and low intensities. Their results showed that adolescents

with NSSI made more errors on child fearful and adult sad face recognition compared to the typically developing controls. They concluded that adolescent inpatients engaged in NSSI showed greater deficits in facial emotion expression recognition compared to controls, but not when compared to inpatient adolescents who attempted suicide.

In summary, there is a divergence between the predictions derived from Linehan's biosocial theory of the etiology of BPD and the findings in the literature; the former predicts greater sensitivity to emotion and thus better performance in categorizing facial expressions, but the latter has generally shown this not to be the case. It is thus unclear what to expect with individuals who have a history of NSSI in the absence of BPD. Based on Linehan's theory, one is led to hypothesize that individuals with a history of NSSI will show superior performance at emotion categorization. Conversely, based on comparisons with the literature on the related condition of BPD and NSSI, one is led to expect the opposite, or perhaps no difference between groups.

One reason why previous literature might have failed to find differences in emotion categorization performance between participants with BPD and controls is that the former may be more impulsive (Jovev et al., 2011). This would lead them to have higher rates of error across all emotion categories as responses are given too quickly. That is, their greater sensitivity might have been cancelled out by their poorer impulse control. For this reason, in the present study we used a measure of emotion categorization ability that allowed us to detect impulsivity effects. Specifically, we presented participants with stimuli consisting of videos of faces that gradually varied (morphed) over 10 seconds from a neutral to an emotional expression and asked them to press a button to stop the video as soon as they felt they could recognize the emotion. They were then to immediately categorize the emotion as happy, sad, angry, fearful, disgusted or surprised. Participants who are more impulsive would be expected to stop the video too soon, yielding a lower emotion intensity but higher error rates. Subjects that are genuinely more effective at categorizing emotions should demonstrate either: (1) Lower required emotion intensity without reduced accuracy, (2) Superior accuracy without a higher required emotion intensity, or (3) Superior accuracy and a lower required emotion intensity. For instance, if participants with a history of NSSI are more impulsive, then they would tend to choose an emotion intensity that is too low for them to make an accurate assessment. Conversely, if such individuals can make equally accurate categorizations at lower intensity levels than controls, then this would provide evidence compatible with the idea that Linehan's biosocial model is correct with regards to the etiology of NSSI.

Given the small amount of previous literature on NSSI, and the divergent results in studies on BPD, we have chosen to base our hypotheses on Linehan's bioosocial theory. We therefore predict that a community sample of individuals with a history of NSSI will be more sensitive to emotion signals than controls, and that they will exhibit superior performance in emotion categorization. To guard against confounds due to impulsive responses we assess emotion categorization ability in terms of both the minimum facial expression intensity required to perform the categorization and the accuracy of categorization. In addition, we examine the reaction time for choosing a category label, and the frequency of use of the various category labels in order to probe for any other response biases that might account for our results.

Method

Participants

The study sample is composed of young adults recruited through an undergraduate subject pool at the University of Ottawa. Participants were drawn from a pool of students enrolled in the introductory psychology courses. The University of Ottawa Ethics Review Board approved this research study. After the purpose and procedure of the study were explained to participants, informed

written consent was obtained. A total of 38 participants with a history of engaging in NSSI and 48 control participants were recruited through this method. All NSSI participants reported having engaged in intentional self-inflicted injury to the surface their body at least 5 times or more within their lifetime. The majority of participants self-injured over 6 months ago, 50% (n = 19). However, within the last 6 months, 44.7% (n = 17) reported thinking about self-injuring 1 to 5 times and 36% (n = 14) engaged in the behavior, while 15.8% (n = 6) reported thinking about self-injuring monthly or weekly 13.2% (n = 5), and 13.2% (n = 5) engaged in the behavior. Demographic data regarding our sample are shown in Table 1.

Table 1
Participant Demographics

Variable	NSSI group (n = 38)	Control group (n = 48)
Age: years	18.68 ± 1.33	18.75± 1.12
Sex: male	8% (3)	6% (3)
Ethnicity: Caucasian	68% (26)	62% (30)
Comorbid Diagnosis:		
Depression	21% (8)	-
Generalized Anxiety Disorder	28% (11)	-
PTSD	5% (2)	-
OCD	3% (1)	-
Other	8% (3)	-
None	57% (22)	100% (48)

Inclusion/Exclusion Criteria. Eligible participants were between 17 to 24 years of age. For inclusion in the NSSI group, a participant had to report having engaged in intentional self-inflicted injury to the surface of his or her body at least 5 times within their lifetime, with the expectation that the injury would lead to only minor or moderate physical harm (i.e., no suicidal intent). These participants were identified through subject pool pre-screening questions. The pre-screening question read, "Have you ever intentionally self-inflicted damage to the surface of your body to cause bleeding, bruising, or pain (e.g., cutting, burning, stabbing, and/or hitting), without the intent to kill yourself? Please note that this does not include ear piercing, tattooing, circumcision, or cultural healing rituals." Potential responses included Never; Once; 2-4 times; 5 or more times. Only individuals who responded "Never" or "5 or more times" were screened in to participate as controls or NSSI respectively. Exclusion criteria for both the NSSI and control groups included a self-reported diagnosis of Borderline Personality Disorder. The pre-screening question read, "Have you ever been diagnosed with Borderline Personality Disorder? Yes/No." Additionally, individuals who reported to have engaged in NSSI "5 or more times" on the pre-screening question, but failed to report NSSI behavior in either of the administered NSSI questionnaires were also excluded from the study. Refer to Table 1 for demographic characteristics of the sample by group.

Measures

Socio-Demographic Questionnaire. This demographic questionnaire collected standard participant information such as age, gender, primary language, ethnicity, education, and current or past mental health diagnoses. This information was used to describe the demographics of the NSSI and control groups.

The Ottawa Self Injury Inventory (OSI - Functions 1.1). This questionnaire assessed self-injurious behaviors and their functions. The OSI - Functions 1.1 is a 33-item self-report measure designed to identify the psychosocial functions of NSSI. It addresses cognitive, affective, behavioral, and environmental aspects of self-injury and requires approximately 20 minutes to complete. Example questions include "why do you think you started and if you continue, why do you still self-injure?" and example responses include "to release unbearable tension" or "to punish myself." Answers were provided on a 5-point scale (0 = never a reason, 2 = sometimes a reason, 4 = always a reason). This scale provided cumulative scores for the subscales of internal emotional regulation (0 to 32), external emotional regulation (0 to 12), social influence (0 to 36), and sensation seeking (0 to 12). Test–retest reliability has previously been demonstrated over a two-week time span for this scale (r between 0.52 - 0.74 across domains; Cloutier & Nixon, 2003).

The Inventory of Statements About Self-Injury (ISAS). Section II of this questionnaire was administered. It is a 39-item self-report measure that assessed an individual's reasons for engaging in self-injurious behaviors on a scale from 0 ("not relevant") to 2 ("very relevant"). Based on previous research (Klonsky & Glenn, 2009), 13 functions of NSSI have been identified. The questionnaire states "when I self-harm, I am…" and example responses include "causing pain so I will stop feeling numb" or "creating a physical sign that I feel awful." The score on these 13 functions can be summed (ranging from 0 to 6) to create separate factors that index interpersonal functions of NSSI (i.e., autonomy, interpersonal boundaries, interpersonal influence, peer-bonding, self-care, revenge, sensation seeking, toughness; Cronbach's alpha = 0.94) and Intrapersonal Functions of NSSI (i.e., affect-regulation, anti-dissociation, anti-suicide, marking distress, self-punishment; Cronbach's alpha = 0.84). The interpersonal functions and intrapersonal functions factors correlated moderately ($r = 0.40$).

Procedure

Study participation included a computer-based task (emotion recognition) at the Integrated Neurocognitive and Social Psychophysiology Interdisciplinary Research Environment (INSPIRE) lab at the University of Ottawa. Prior to the computerized tasks, and after having the study described to them verbally, participants signed an informed consent document. All participants completed the socio-demographic questionnaire**.** Two additional questionnaires, the Ottawa Self Injury Inventory (OSI) and the Inventory of Statements About Self-Injury (ISAS), were completed by individuals in the NSSI group. Participants that reported suicidal ideation or severe harm on the OSI underwent a suicide protocol that assessed their level of risk.

Emotion recognition task. This task involved identifying the emotion expressions of a series of morphing facial images presented on a computer screen. On each trial, a 10-second video was presented wherein a face image changed smoothly from a neutral expression until 100% expression intensity was reached (see Figure 1). By pressing a button, participants signaled at what point along the morphing progression they were able to identify the emotion expression. This provided an index of the minimum emotion intensity subjects felt they needed in order to categorize the expression shown. Immediately following the button press, participants were provided a forced-choice task to identify the emotion presented; each of the six basic emotions described by Ekman (1993; happiness, sadness, anger, fear, disgust and surprise) was presented across 24 identities (equal numbers of Caucasian male (12) and female (12) color images). Thus, a total of 144 trials (24 identities x 6 emotions) were presented. These were shown in random order. On each trial, image number and response time were electronically recorded, providing an index of the emotion intensity threshold.

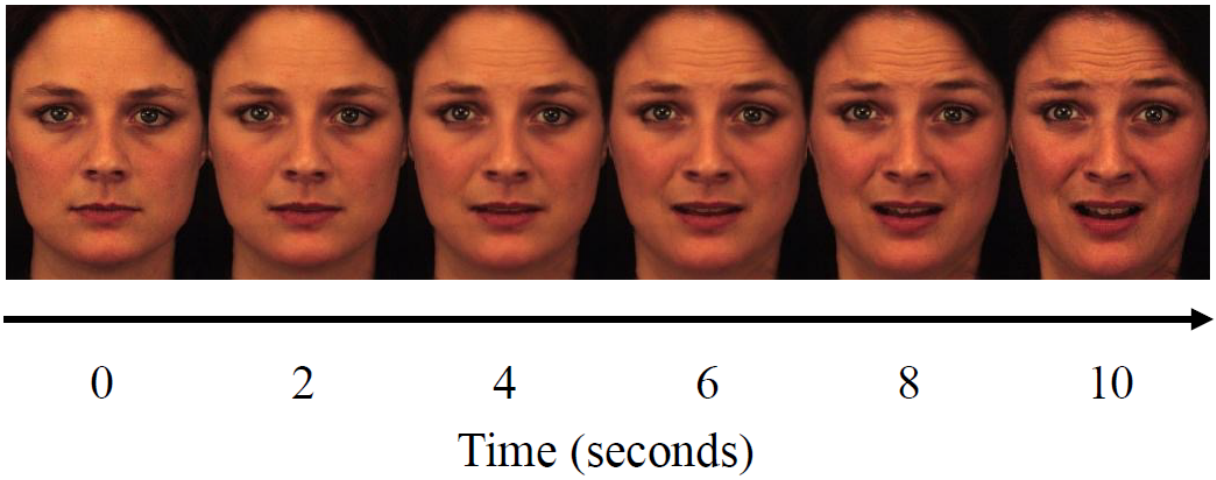

Figure 1. **An example of the stimuli presented for the emotion of fear**. Images were presented in succession as 10-second video wherein the face image transformed smoothly from a neutral expression to 100% expression intensity.

The morphing stimuli were created using Morpheus Photo Morpher® v3.17 (Morpheus Software, LLC) such that 150 images were created to produce a video of an emotion expression seamlessly progressing from 0 (neutral) to 100% (prototypic expression) in 10 seconds. Face images were obtained from the Karolinska Directed Emotional Faces (Lundqvist, Flykt, & Öhman, 1998) database. This image database includes 70 individuals (35 females and 35 males) each displaying 7 different emotion expressions (including a neutral facial expression). Images are of amateur actors aged 20 to 30 years old with no beards, mustaches, earrings, or eyeglasses, and no visible makeup. A total of 48 individuals were selected for the study based on image quality. Stimuli were pre-processed by MATLAB image processing toolbox to have equal overall lightness and color composition.

Results

Mean accuracy results for each emotion category are shown in Figure 2. To analyze between-groups differences in performance, we conducted a series of planned contrasts (Rosenthal & Rosnow, 1985). The error term for these analyses was taken from a mixed 2 x 6 ANOVA (see the Appendix for the ANOVA table). These analyses showed that participants with a history of NSSI are generally equally accurate in categorizing emotion expressions when compared to control participants. However, with regards to the expression of fear, we found that the NSSI group was significantly superior to control participants, $F(1, 84) = 4.75$, $p = 0.03$. There was no difference between groups in accuracy for categorizing happy face stimuli, however these may be subject to a ceiling effect.

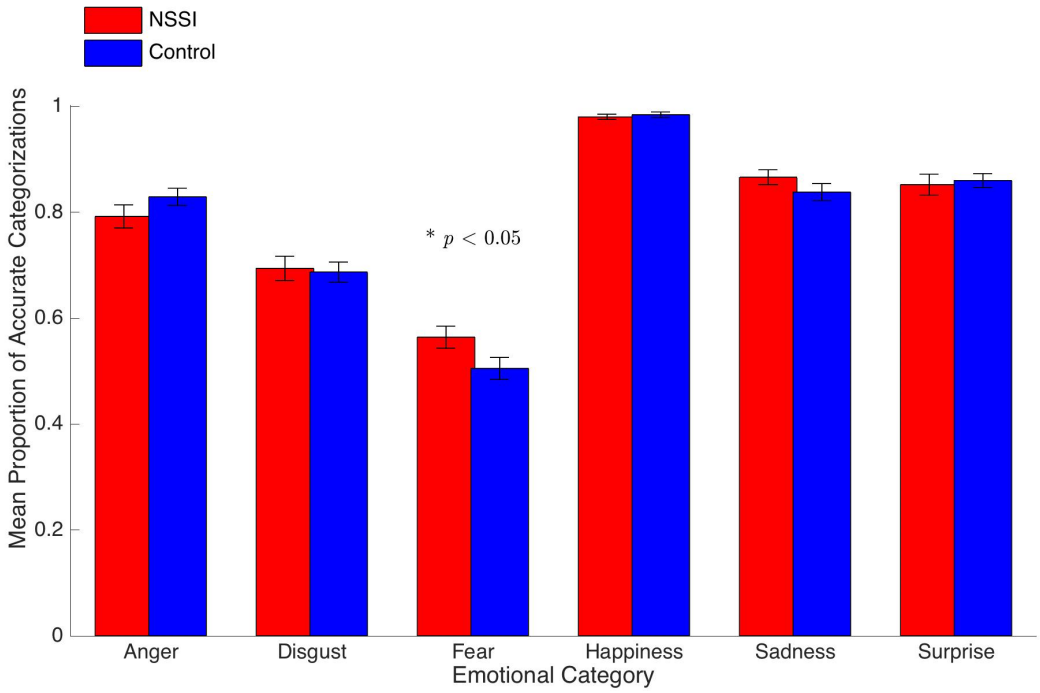

Figure 2. **Mean proportion of accurate categorization for each emotion category.** Participants with a history of NSSI were significantly more accurate in recognizing fear. Error bars represent one standard error of the mean.

Mean emotion intensity data for each emotion category are shown in Figure 3. We again conducted a series of planned contrasts to assess whether there were any group differences in this measure (see Appendix for mixed factorial ANOVA results). These analyses showed that participants with a history of NSSI were superior at recognizing the emotion of disgust, in that they could recognize it at a lower emotion intensity, $F(1, 84) = 23.3$, $p < 0.01$, despite showing no differences in accuracy. Similarly, the analyses revealed that the NSSI group was able to recognize angry, $F(1, 84) = 5.8$, $p = 0.01$, and sad expressions, $F(1, 84) = 6.7$, $p = 0.01$, at a lower intensity levels than controls. As with disgust, this was not simply a speed-accuracy trade-off, as there was no difference in accuracy between the groups. The lack of difference between groups in terms of the intensity of fear expressions likewise supports the idea that the accuracy difference shown in Figure 2 is a genuine difference in behavioral performance. Thus, for four negative emotions—anger, disgust, fear and sadness—there is evidence of superior sensitivity in individuals with a history of NSSI. This finding is compatible with Linehan's model suggesting a greater sensitivity to negative emotions in the related condition of BPD. This is the first evidence of such differences in a population defined by a history of NSSI in the absence of a diagnosis of BPD.

Finally, analyses also revealed that the NSSI group was able to recognize surprise expressions at a lower intensity level, $F(1, 84) = 16.8$, $p < 0.01$, than controls. Surprise has ambiguous valence, in that it can be both negative and positive, so this finding does not clearly fit with the prediction of superior sensitivity to negative emotions.

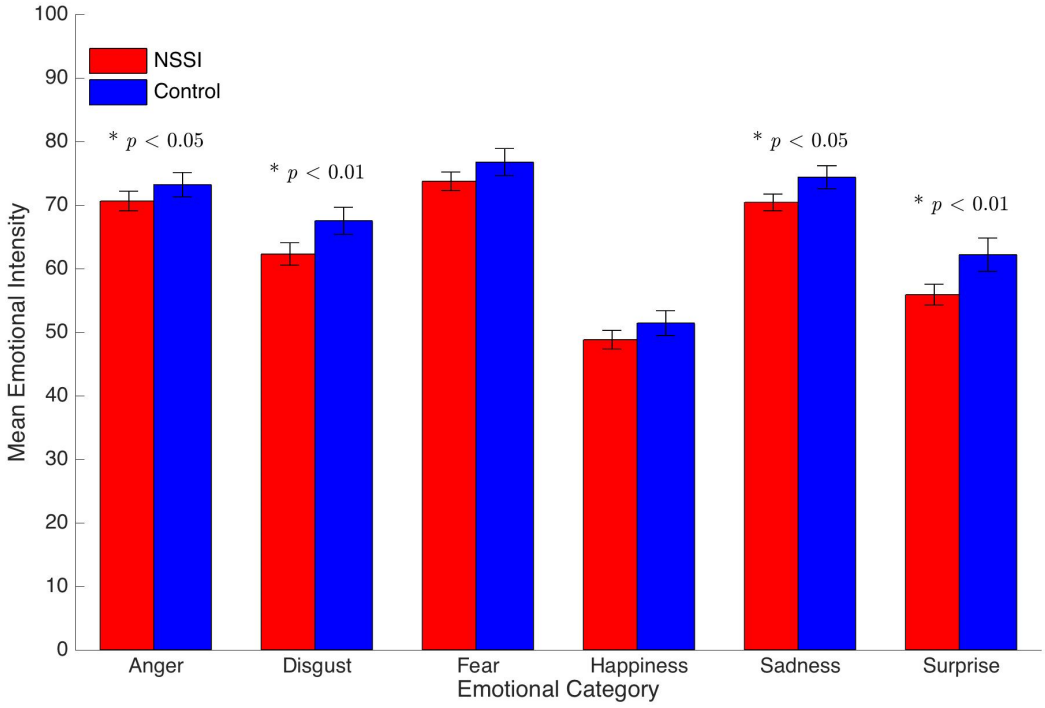

Figure 3. **Mean emotion intensity percentage**. Zero indicates a neutral facial expression, and 100 indicates a full-intensity expression. Participants with a history of NSSI were able to recognize disgust, sadness and surprise at a significantly lower emotion intensity. Error bars represent one standard error of the mean.

In addition to analyzing accuracy and emotion intensity data, we also examined reaction times. That is, we examined the amount of time it took participants to categorize the stimulus's emotion after they had stopped the morph video to indicate that they recognized it. Differences in reaction times might cast doubt on the interpretability of differences in accuracy or emotion intensity, suggesting that they are due to speed-accuracy trade-offs. To check for this, a series of planned comparison *t*-tests were carried out. None of these showed any significant inter-group differences.

Finally, we examined another potential confounding factor in our results, which is response bias. That is, participants with a history of NSSI may have achieved superior performance in certain emotion categories by using particular responses more often. To test for this, we conducted a series of planned comparison *t*-tests, one for each emotion category. These found no differences between groups in response frequency for any of the emotion categories.

Discussion

This study sought to determine whether individuals with a history of NSSI exhibit enhanced sensitivity to negative facial expressions as compared to controls. This was assessed via three behavioral measures: Accuracy of categorization, minimum expression intensity at which categorization could be made, and reaction time to choose an emotion category. Our data show a pattern of differences supporting the hypothesis that individuals with a history of NSSI exhibit superior performance at emotion categorization for negative emotions. Specifically, they demonstrated superior accuracy when categorizing fear, and were able to categorize anger, disgust and sad expressions at a lower intensity. Reaction time data showed no differences between groups, assuaging concerns about possible speed-accuracy trade-offs. This latter point is especially important in this population, as they may be prone to impulsivity (Hamza, Willoughby, & Heffer, 2015). For this reason, the present study used the measures of accuracy and reaction time for emotion categorization to allow us to detect impulsivity effects. One would expect that greater impulsivity would lead to lower emotion intensity, but also higher error rates. Additionally, if the participants with a history of NSSI were indeed more impulsive, this would result in higher error rates across all emotion categories, as responses for all emotions would be given too quickly. This was not found in the current study. Furthermore, our data also showed no evidence of a bias towards either group using any response categories more than the other.

Participants with a history of NSSI also showed an ability to categorize surprise at a lower intensity level. In this study, surprise had an ambiguous valence, in that participants could interpret it as either positive or negative. This finding does not clearly fit with our prediction; however, it may reflect a more general sensitivity to emotions that are potentially negative. Compatible with this is the fact that we found no suggestions of inter-group differences in the categorization of happy faces on any of our measures. This result from the history of NSSI population may correspond with the evidence found in BPD by Daros et al. (2013) and Mitchell et al. (2014), supporting a negative response bias to neutral and ambiguous facial expressions. The emotion of surprise can have any valence such as neutral, pleasant, unpleasant, positive, or negative. Whether participants with a history of NSSI interpreted the surprise emotion presented in this study as negative is a question that requires further investigation.

Our findings are compatible with Linehan's biosocial theory of the etiology of NSSI, which suggests that this behavior arises from poor emotion regulation. These results fit a model in which individuals with NSSI are hypersensitive to others' emotions, especially negative ones, and therefore experience poorer emotional interactions and poorer social outcomes. While higher sensitivity apparently led to better

performance in our task, this does not mean that it is an asset in real-world interactions. According to Linehan's model, one reason for this is that individuals with high sensitivity also exhibit high reactivity. That is, they over-react to others' emotions, interpreting them as higher in valence than they are. If this were the case, we would expect individuals with a history of NSSI to exhibit a greater degree of physiological response to emotive faces. Subsequent research should focus on investigating the bio-behavioral correlates of emotion face processing including any differences in physiological responses to emotions.

Comparing our results regarding NSSI to the previous literature on BPD suggests a divergence between these two conditions. Most studies on individuals with BPD have found no evidence that they have superior emotion sensitivity, and some have even found evidence suggesting poorer sensitivity in this population as compared to controls. In contrast, we find evidence of superior performance on several negative emotions. This may provide further evidence that NSSI and BPD are separate clinical entities, with different underlying emotional processes, etiologies and symptomatologies, as others have previously argued (Favazza & Rosenthal, 1990, 1993; Herpertz, 1995; Kahan & Pattison, 1984; Muehlenkamp, 2005; Pattison & Kahan, 1983; Selby et al., 2012).

Unlike the study conducted by Seymour et al. (2016), where inpatient adolescents engaged in NSSI made more recognition errors for child fearful faces and adult sad faces compared to controls, our sample of NSSI participants drawn from a non-psychiatric population were found to be superior at recognizing these emotions compared to typically developing controls. It is likely that their sample was composed of participants with more severe cases of NSSI as compared to our sample, as demonstrated by their need for hospitalization, and as suggested by the authors, may have been subject to Berkson's bias. Additionally, the design of Seymour et al.'s study permitted participants to view a static, 2-second image of a facial emotion instead of viewing a morphing progression. Interestingly, when assessing NSSI participants with a similar morphing paradigm to the current study, In-Albon et al. (2015) found no general deficits in accurately recognizing facial expressions of emotion. However, compatible with the present findings, they did show that the NSSI group, relative to controls, rated neutral and happy expressions as more unpleasant, whereas angry, sad, and happy expressions were rated as more arousing.

The fact that we find superior performance in the NSSI participants only for negative facial expressions suggests that this group is mainly hyper-sensitive to emotions that may signal social rejection or threat. Unlike Von Ceumern-Lindenstjerna et al.'s (2007) findings in individuals with BPD, we find no suggestion that those with a history of NSSI view happy faces more negatively. Neither minimum expression intensity nor accuracy differed between groups in our study when happy expressions were being judged. This may again suggest a distinction between BPD and NSSI. If an individual who engages in NSSI is hyper-sensitive to the social the cues of those around them, particularly fearful, angry, sad or disgusted faces as our data suggest, they may overreact in their own emotional responses to those around them, leading to rejection or isolation. This could serve to maintain a perpetuating cycle of NSSI behaviors. Additionally, since theoretical models of NSSI have postulated that individuals engage in this behavior as a means of gaining attention or influencing others' behavior, it is possible that individuals engaged in NSSI might be extremely attentive to negative social cues signaling lack of belonging.

Limitations

There are a few limitations that must be taken into account when interpreting the results of the present study. First, we relied on participants to self-report a diagnosis of borderline personality disorder, which does

not yield as reliable results as implementing a scale to assess borderline characteristics. Future studies should employ a scale such as the Personality Assessment Inventory to better assess for characteristics of borderline personality disorder. This would allow for a continuous measure of borderline characteristics rather than relying on a simple dichotomous self-reported diagnosis. Additionally, administration of all questionnaires occurred approximately 40 minutes prior to the test administration and every attempt was made by the researchers to discuss only neutral topics with participants while preparing for the emotion recognition task to avoid priming. However, is it possible that completing questionnaires about self-injury induced more negative emotions for the history of NSSI participants compared to the control participants. A possible increased emotional state could have influenced the performance of the history of NSSI group on in the emotion categorization task and may provide an alternative explanation for our pattern of findings. However, the finding that there were no differences in the frequency of responses between groups somewhat assuages this concern.

Conclusions

Results from this study show that individuals with a history of NSSI exhibited a pattern of differences that suggest superior performance of emotion categorization for negative emotions. They performed slightly better than controls when accurately categorizing fear, and they required a lower stimulus intensity to correctly categorize anger, disgust, sad and surprise expressions. The history of NSSI participants were able to categorize these emotions without displaying different reaction times compared to controls, thus decreasing concerns regarding speed-accuracy trade-offs.

Our findings add to the limited research on NSSI and point to the need for more studies on this condition. There is currently very little guidance for clinicians treating NSSI because it is considered a symptom of other disorders such as BPD, rather than as a distinct condition. Moreover, the drop-out rates for therapies aimed at NSSI are quite high (Burns, Dudley, Hazell, & Patton, 2005; Mitchell, 2015; Wester & Trepal, 2016). Our data support the contention that NSSI is distinct from BPD, suggesting that therapies should be tailored specifically for it. This may lead to more effective interventions with higher retention rates. Further research is needed to verify our findings, and to examine whether the apparent greater sensitivity of those with a history of NSSI is in fact linked to greater emotional reactivity and poorer outcomes.

References

Aldinger, M., Stopsack, M., Barnow, S., Rambau, S., Spitzer, C., Schnell, K., & Ulrich, I. (2013). The association between depressive symptoms and emotion recognition is moderated by emotion regulation. *Psychiatry Research*, *205,* 59–66.

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: American Psychiatric Publishing.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Burns, J., Dudley, M., Hazell, P., & Patton, G. (2005). Clinical management of deliberate self-harm in young people: the need for evidence-based approaches to reduce repetition. *Australia and New Zealand Journal of Psychiatry, 39,* 121–128.

Claes, L., Houben, A., Vandereycken, W., Bijttebier, P., & Muehlenkamp, J. (2010). Brief report: The association between non-suicidal self-injury, self-concept and acquaintance with self-injurious peers in a sample of adolescents. *Journal of Adolescence*, *33,* 775–778.

Cloutier, P. F., & Nixon, M. K. (2003). The Ottawa self-injury inventory: A preliminary evaluation. Abstracts to the 12th International Congress European Society for Child and Adolescent Psychiatry. *European Child & Adolescent Psychiatry*, *12*(Suppl. 1), 1–94.

Cole, P. M., Michel, M. K., & Teti, L. O. D. (1994). The development of emotion regulation and dysregulation: A clinical perspective. *Monographs of the society for research in child development*, *59*, 73–102.

Crowell, S. E., Beauchaine, T. P., & Linehan, M. M. (2009). A biosocial developmental model of borderline personality: Elaborating and extending Linehan's theory. *Psychological Bulletin*, *135,* 495–510.

Daros, A. (2012). *Emotion Perception in Borderline Personality Disorder* (Master's Thesis).Retreived from ProQuest Dissertation and Theses Global. (Accession Order No. AAT MR92890)

Daros, A. R., Zakzanis, K. K., & Ruocco, A. C. (2013). Facial emotion recognition in borderline personality disorder. *Psychological Medicine*, *43,* 1953–1963.

Domes, G., Czieschnek, D., Weidler, F., Berger, C., Fast, K., & Herpertz, S. C. (2008). Recognition of facial affect in Borderline Personality Disorder. *Journal of Personality Disorders, 22,* 135–147.

Ekman, P. (1993). Facial expression and emotion. *American Psychologist, 48*, 384–392.

Favazza, A. R., & Rosenthal, R. J. (1990). Varieties of pathological self-mutilation. *Behavioral Neurology*, *3,* 77–85.

Favazza, A. R., & Rosenthal, R. J. (1993). Diagnostic issues in self-mutilation. *Psychiatric Services*, *44,* 134–140.

Fenske, S., Lis, S., Liebke, L., Niedtfeld, I., Kirsch, P., & Mier, D. (2015). Emotion recognition in borderline personality disorder: effects of emotional information on negative bias. *Borderline Personality Disorder and Emotion Dysregulation*, *2,* 1–12.

Foa, E. B., Gilboa-Schechtman, E., Amir, N., & Freshman, M. (2000). Memory bias in generalized social phobia: remembering negative emotional expressions. *Journal of Anxiety Disorders, 14*, 501–519.

Glenn, C. R., & Klonsky, E. D. (2013). Nonsuicidal self-injury disorder: An empirical investigation in adolescent psychiatric patients. *Journal of Clinical Child & Adolescent Psychology, 42*, 496–507.

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, *2*, 271–299.

Gross, J. J. (2013). Emotion regulation: Taking stock and moving forward. *Emotion*, *13,* 359–365.

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry, 26*, 1–26.

Hamza, C. A., Willoughby, T., & Heffer, T. (2015). Impulsivity and nonsuicidal self-injury: A review and meta-analysis. *Clinical Psychology Review*, *38*, 13–24.

Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2009). Emotion recognition and regulation in anorexia nervosa. *Clinical Psychology & Psychotherapy*, *16,* 348–356.

Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2010). Emotional functioning in eating disorders: attentional bias, emotion recognition and emotion regulation. *Psychological Medicine, 40,* 1887–1897.

Herpertz, S. (1995). Self-injurious behavior Psychopathological and nosological characteristics in subtypes of self-injurers. *Acta Psychiatrica Scandinavica*, *91,* 57–68.

In-Albon, T., Bürli, M., Ruf, C., & Schmid, M. (2013). Non-suicidal self-injury and emotion regulation: a review on facial emotion recognition and facial mimicry. *Child and Adolescent Psychiatry and Mental Health*, *7,* 1-11.

In-Albon, T., Ruf, C., & Schmid, M. (2015). Facial emotion recognition in adolescents with nonsuicidal self-injury. *Psychiatry Research*, *228,* 332–339.

Jovev, M., Chanen, A., Green, M., Cotton, S., Proffitt, T., Coltheart, M., & Jackson, H. (2011). Emotional sensitivity in youth with borderline personality pathology. *Psychiatry Research, 187*, 234–240.

Kahan, J., & Pattison, E. M. (1984). Proposal for a distinctive diagnosis: The Deliberate Self-Harm syndrome (DSH). *Suicide and Life-Threatening Behavior*, *14,* 17–35.

Klonsky, E. D. (2007). The functions of deliberate self-injury: A review of the evidence. *Clinical Psychology Review*, *27,* 226–239.

Klonsky, E. D., & Glenn, C. R. (2009). Assessing the functions of non-suicidal self-injury: Psychometric properties of the Inventory of Statements About Self-injury (ISAS). *Journal of Psychopathology and Behavioral Assessment*, *31*, 215-219.

Kucharska-Pietura, K., Nikolaou, V., Masiak, M., & Treasure, J. (2004). The recognition of emotion in the faces and voice of anorexia nervosa. *International Journal of Eating Disorders, 35,* 42–47.

Lieb, K., Zanarini, M. C., Schmahl, C., Linehan, M. M., & Bohus, M. (2004). Borderline personality disorder. *Lancet, 364,* 453–461.

Linehan, M. (1993). *Cognitive-behavioral treatment of borderline personality disorder*. New York, NY: Guilford Press.
Lloyd-Richardson, E. E., Perrine, N., Dierker, L., & Kelley, M. L. (2007). Characteristics and functions of non-suicidal self-injury in a community sample of adolescents. *Psychological Medicine, 37,* 1183–1192.
Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska directed emotional faces - KDEF [CD ROM]. Stockholm, Sweden: Karolinska Institutet. Available from http://www.facialstimuli.com
Lynch, T. R., Rosenthal, M. Z., Kosson, D. S., Cheavens, J. S., Lejuez, C. W., & Blair, R. J. (2006). Heightened sensitivity to facial expressions of emotion in borderline personality disorder. *Emotion, 6,* 647–655.
Marsh, A. A., Kozak, M. N., & Ambady, N. (2007). Accurate identification of fear facial expressions predicts prosocial behavior. *Emotion, 7,* 239–251.
Mayer, J. D., Salovey, P., Caruso, D. R., & Sitarenios, G. (2001). Emotional intelligence as a standard intelligence. *Emotion, 3*, 232–242.
Meyer, B. R., Pilkonis, P. A., & Beevers, C. G., (2004). What's in a (neutral) face? Personality disorders, attachment styles, and the appraisal of ambiguous social cues. *Journal of Personality Disorders, 18*, 320–336.
Mitchell, A. E., Dickens, G. L., & Picchioni, M. M. (2014). Facial emotion processing in borderline personality disorder: A systematic review and meta-analysis. *Neuropsychology Review*, *24,* 166—184.
Mitchell, D. A. (2015). *Use of Multi-Informants in Predicting Adolescent Treatment Dropout.* (Doctoral Dissertation). Retreived from Loma Linda University Electronic Theses & Dissertations. (Order No, 272)
Muehlenkamp, J. J. (2005). Self-injurious behavior as a separate clinical syndrome. *American Journal of Orthopsychiatry*, *75,* 324–333.
Nock, M. K., Joiner, T. E., Gordon, K. H., Lloyd-Richardson, E., & Prinstein, M. J. (2006). Nonsuicidal self-injury among adolescents: Diagnostic correlates and relation to suicide attempts. *Psychiatry Research, 144*, 65–72.
Nock, M. K., & Mendes, W. B. (2008). Physiological arousal, distress tolerance, and social problem-solving deficits among adolescent self-injurers. *Journal of Consulting and Clinical Psychology*, *76,* 28–38.
Pattison, E. M., & Kahan, J. (1983). The deliberate self-harm syndrome. *American Journal of Psychiatry*, *140,* 867–872.
Robin, M., Pham-Scottez, A., Curt, F., Dugre-Le Bigre, C., Speranza, M., Sapinho, D., Corcos, M., Berthoz, S., & Kedia, G. (2012). Decreased sensitivity to facial emotions in adolescents with Borderline Personality Disorder. *Psychiatry Research*, *200,* 417–421.
Rosenthal, R., & Rosnow, R. L. (1985). *Contrast analysis: Focused comparisons in the analysis of variance*. New York, NY: Cambridge University Press.
Selby, E. A., Bender, T. W., Gordon, K. H., Nock, M. K., & Joiner Jr, T. E. (2012). Non-suicidal self-injury (NSSI) disorder: a preliminary study. *Personality Disorders: Theory, Research, and Treatment*, *3,* 167–175.
Seymour, K. E., Jones, R. N., Cushman, G. K., Galvan, T., Puzia, M. E., Kim, K. L., Spirito, A., & Dickstein, D. P. (2016). Emotional face recognition in adolescent suicide attempters and adolescents engaging in non-suicidal self-injury. *European Child & Adolescent Psychiatry*, *25,* 247–259.
Stiglmayr, C. E., Grathwol, T., Linehan, M. M., Ihorst, G., Fahrenberg, J., & Bohus, M. (2005). Aversive tension in patients with borderline personality disorder: A computer-based controlled field study. *Acta Psychiatrica Scandinavica, 111*, 372–379.
Swannell, S. V., Martin, G. E., Page, A., Hasking, P., & St John, N. J. (2014). Prevalence of nonsuicidal self-injury in nonclinical samples: Systematic review, meta-analysis and meta-regression. *Suicide and Life-Threatening Behavior*, *44,* 273–303.
Von Ceumern-Lindenstjerna, I. A., Brunner, R., Parzer, P., Frey, M., Fiedler, P., & Resch, F. (2007). Wahrnehmung und Bewertung von emotionalen Gesichtsausdrücken bei weiblichen Jugendlichen mit einer Borderline-Persönlichkeitsstörung. *Zeitschrift fur Kinder und Jugendpsychiatrie und Psychotherapie, 35*, 333–340.
Wester, K. L., & Trepal, H. C. (2017). *Non-suicidal self-injury: Wellness perspectives on behaviors, symptoms, and diagnosis*. New York, NY: Routledge.
Yoo, S. H., Matsumoto, D., & LeRoux, J. A. (2006). The influence of emotion recognition and emotion regulation on intercultural adjustment. *International Journal of Intercultural Relations*, *30,* 345–363.
Zetterqvist, M. (2015). The DSM-5 diagnosis of nonsuicidal self-injury disorder: a review of the empirical literature. *Child and Adolescent Psychiatry and Mental Health*, *9,* 31-43

Appendix

In order to obtain the error terms for our planned comparisons (Rosenthal & Rosnow, 1985), we conducted separate 2 (Group: NSSI or Control) × 6 (Emotion: sadness, disgust, surprise, fear, anger or happiness) mixed factorial ANOVAs on accuracy and emotion intensity data. For accuracy, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(14) = 80.43$, $p < 0.001$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.83$).

Table 2
Results of Mixed Factorial ANOVA for Accuracy

Source	*df*	*MS*	*F*	η^2_p	*p*
Group	1	0.008	.551	0.007	0.460
Error	84	0.014			
Emotion	4.13	2.49	163.54	0.661	<0.001
Emotion x Group	4.13	0.027	1.79	0.021	0.128
Error	346.7	0.015			

For emotion intensity, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(14) = 95.80$, $p < 0.001$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.70$).

Table 3
Results of Mixed Factorial ANOVA for Emotion Intensity

Source	*df*	*MS*	*F*	η^2_p	*p*
Group	1	1990.42	2.47	0.029	0.120
Error	84	806.42			
Emotion	3.48	11281.51	226.12	0.729	<0.001
Emotion x Group	3.48	70.93	1.42	0.017	0.232
Error	292.12	49.89			

Financial conflict of interest: No stated conflicts.
Conflict of interest: No stated conflicts.

Submitted: *October 20th, 2016*
Resubmitted: *January 18th, 2017*
Accepted: *January 28th, 2017*