Predicting Nonsuicidal Self-Injury Using a Variant of the Implicit Association Test

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Author note

This project was preregistered on the Open Science Framework prior to data collection (https://osf.io/wnbfc/registrations). All data files, materials, study and analytic scripts are publicly available on the Open Science Framework at https://osf.io/wnbfc/. The authors declare that they have no competing interest. The ethical committee of the Faculty of Psychology and Educational Sciences at Ghent University approved this project (approval number 2020/72 Femke Cathelyn). The research was carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki. Informed consent was obtained from all participants included in the studies. This manuscript is supported by Ghent University grant BOF16/MET_V/002 to JDH and by grant FWO19/PDS/041 of the Scientific Research Foundation Flanders to PVD. All authors contributed to the study concept and study design. F.C. performed data collection and data analyses. F.C. drafted the manuscript. PVD and JDH provided critical revisions. All authors approved the final version of the paper for submission. Correspondence concerning this article should be addressed to Femke Cathelyn, Department of Experimental-Clinical and Health Psychology, Ghent University, H. Dunantlaan 2, 9000 Ghent, Belgium. Email: Femke.Cathelyn@UGent.be.

Abstract

Objective. Nonsuicidal self-injury (NSSI) is a severe problem, and its prevalence is increasing. To aid prevention and treatment, there is an urgent need for evidence-based measures to identify individuals at risk for NSSI. Measures that probe past NSSI are most promising, but people are often motivated to conceal NSSI behavior. This problem can be overcome by using implicit measures which do not require individuals to self-report on their behavior. Yet, prior research typically found weak predictive utility of implicit measures. Based on a new perspective on implicit measures and recent findings in NSSI research, we developed an Implicit Association Test that probes past NSSI (the P-NSSI-IAT). **Method.** We report two preregistered studies (N = 83; N = 372) in which we tested the utility of the P-NSSI-IAT to detect past NSSI and predict NSSI one month later. **Results.** P-NSSI-IAT scores (a) differentiated injury groups from non-injury groups and (b) prospectively predicted NSSI and improved prediction above and beyond risk factors of NSSI. **Conclusions.** These initial findings suggest that the P-NSSI-IAT is a promising tool for NSSI risk assessment. Future studies should further examine the predictive utility of this newly developed measure for NSSI behavior.

Keywords: nonsuicidal self-injury, prediction, implicit measures

Predicting Nonsuicidal Self-Injury Using a Variant of the Implicit Association Test

Nonsuicidal self-injury (NSSI), defined as the direct and deliberate destruction of one's own body tissue in the absence of lethal intent (Nock, 2010, p. 340), is highly prevalent in adolescents and young adults (McManus et al., 2019). Evidence suggests that prevalence rates have increased over the past years (e.g., Wester et al., 2018) and there are great concerns about NSSI rates having further increased in light of the COVID-19 pandemic (Plener, 2021). In addition to being physically harmful, NSSI has shown to be a strong predictor of suicidal behavior (e.g., Asarnow et al., 2011; Kiekens et al., 2018). Given the increased prevalence rates and the severity of NSSI, there is an urgent need for empirically-based tools to identify which individuals are at risk for ongoing NSSI behavior to prevent and treat this and related behavior.

In clinical practice, healthcare practitioners often rely on self-reports of self-harm behavior (both NSSI and self-harm behavior with suicidal intent), such as patients' own behavioral forecasts and/or (often non-validated) risk scales, to estimate the risk of future self-harm (e.g., Janis & Nock, 2008; Quinlivan et al., 2014). Importantly, however, it is well-established that patients in clinical settings often conceal self-harm behavior because they fear negative consequences, such as feelings of shame, negative reactions from others, hospital admission, or loss of control (MacDonald et al., 2020). Therefore, practitioners could benefit from also using measures that are less sensitive to self-report bias.

Reliance on self-report measures to detect and predict sensitive behavior is a problem that clinicians have been aware of for a long time. To overcome this problem, researchers developed alternative measurement procedures, which are referred to as implicit measures (see Gawronski et al., 2020). Because of their procedural format implicit measures do not require individuals to self-report on their thoughts, feelings, or behavior. Instead, they provide indices of these constructs based on behavioral performance. Over the past years, however, it

has become clear that the predictive utility of these measures has shown to be below par (Van Dessel et al., 2020).

Perhaps, the most notable exception is found in research investigating the utility of implicit measures for predicting self-harm-related outcomes. One of the most prominently used implicit measures is the self-injury implicit association test (SI-IAT; Nock & Banaji, 2007a). This measure uses an IAT procedure which involves the speeded categorization of certain target stimuli together with certain attribute stimuli. During the SI-IAT, participants categorize self- or other-related words (e.g., “me” and “others”) together with NSSI imagery (pictures of skin that has or has not been cut) as fast as possible, using one of two computer keys. It has been found that participants with a history of NSSI show faster reaction times during trials in which self-related words and pictures of cut skin share the same response key (Nock & Banaji, 2007a).

This measure has also been applied to predict NSSI, but studies have produced contradicting results. For instance, two studies have shown that SI-IAT scores prospectively predict NSSI (Cha et al., 2016a; Glenn et al., 2016), while other studies failed to find such effects (e.g., Cha et al., 2016a; Franklin et al., 2014; Glenn & Klonsky, 2011; Powers et al., 2021). A possible reason for these mixed findings is that the SI-IAT was not developed to predict NSSI. Instead, it aims to target mental constructs (e.g., cognitive associations between “self-injury” and “self”) that are assumed to allow prediction of a conglomerate of self-harm related outcomes, such as suicide ideation, suicide attempts, prior engagement in NSSI, and NSSI persistence (e.g., Glenn et al., 2017; Nock & Banaji, 2007b).

Recent studies have shown that the predictive validity of implicit measures strongly improves when the probed construct corresponds highly with the to-be-predicted behavior (Irving & Smith, 2020). To improve the predictive utility of implicit measures these measures might therefore target the validation of statements about actual behavior that corresponds with

the to-be-predicted behavior, rather than the activation of mental constructs (Van Dessel et al., 2020). In accordance with these guidelines, we developed a new implicit measure to specifically predict future NSSI behavior. Similar to the SI-IAT, the past nonsuicidal self-injury implicit association test (P-NSSI-IAT) probes speeded categorization of stimuli. However, the stimuli of the P-NSSI-IAT contain sentences, rather than single words or pictures. During the P-NSSI-IAT, participants classify statements regarding past NSSI or past non-NSSI behavior (e.g., “I have carved my skin on purpose” or “I have carved my skin not once”) together with statements that are logically true or false (e.g., “I’m doing a psychology experiment” or “I’m climbing a mountain”). In line with previous research that investigated the predictive utility of implicit measures including statements regarding past behavior (see Sartori et al., 2008), it can be expected that individuals who have engaged in NSSI will respond faster to the combination of statements that are logically true and statements regarding past NSSI behavior.

Besides the fact that statements regarding NSSI behavior strongly correspond with future NSSI behavior, past NSSI has often shown to be the strongest predictor of future NSSI. A study by Tuisku and colleagues (2014), for example, showed that the only significant predictor after an eight-year follow-up was past NSSI. Also, several studies have shown that past NSSI outperforms other predictors when forecasting NSSI (e.g., Chapman et al., 2009; Janis & Nock, 2008). By indirectly probing this behavior, this new measure deals with the issue that patients tend to conceal such behavior (MacDonald et al., 2020).

Another important advantage of this new measure is that the stimuli are past behavior statements rather than pictures of cut skin. Repeatedly exposing vulnerable individuals to self-harm images might come with iatrogenic risks. Indeed, growing evidence shows that exposure to self-harm-related content, such as pictures of self-harm on social media, might trigger NSSI urges and result in increased NSSI behavior (e.g., Arendt et al., 2019; Memon et al., 2018).

Moreover, a study by Cha and colleagues (2016b) found that, after completing an SI-IAT, participants reported an increased desire to die and a decline in mood. Because previous research shows that being presented with questions regarding past NSSI behavior does not result in iatrogenic effects (e.g., Muehlenkamp et al., 2015) the P-NSSI-IAT likely comes with fewer iatrogenic risks.

We report two preregistered studies that tested the predictive utility of the P-NSSI-IAT for NSSI in online samples. The aim of Study 1 was to validate the P-NSSI-IAT by assessing its ability to detect prior NSSI behavior. The aim of Study 2 was to test whether results from Study 1 could be replicated while at the same time investigating the ability of the P-NSSI-IAT to prospectively predict NSSI behavior.

Study 1

We predicted that P-NSSI-IAT scores would (a) allow distinguishing between participants with and without a history of NSSI both over a shorter (i.e., past month) and longer term (i.e., past year), (b) predict self-reported past NSSI behavior and future likelihood of NSSI behavior, and (c) improve prediction of these outcomes above and beyond known risk factors. Specifically, we examined added prediction compared to psychiatric disorders that are typically related to NSSI (e.g., eating disorders), gender, age (e.g., Klonsky & Muehlenkamp, 2007), past NSSI frequency, hopelessness, and frequency of prior suicidal thoughts (e.g., Fox et al., 2015).

Method

Participants

Participants were recruited via Prolific Academic (a platform for online participant recruitment) and participated in return for a monetary reward. To recruit a sufficient number of participants with a history of NSSI, we invited participants who were at higher risk of NSSI

(i.e., participants who were between the age of 18 and 24 and had a diagnosed mental health condition: Klonsky & Muehlenkamp, 2007) to first answer several questions regarding their past NSSI behavior. Only participants whose answers indicated that they had either (a) never engaged in any form of NSSI (n = 68) or (b) had intentionally cut or carved their skin during the past year (n = 52) were invited to participate in the main study.

Ninety-eight of the 120 invited participants started the main study. Previous studies comparing SI-IAT scores between self-injury groups and non-injury groups showed medium to large effect sizes in two samples *t*-tests (e.g., Cha et al., 2016a). Therefore, we planned to recruit enough participants to have 90% power to detect a medium effect size (d = 0.70, alpha = .05) in a between-groups *t*-test. In line with our data analysis plan, from those 98 participants who started the study, we excluded the data of those who (a) did not provide complete data (i.e., 10 participants with an incomplete number of P-NSSI-IAT trials or who did not complete all measures) or (b) met the exclusion criteria of the IAT D4-scoring procedure (i.e., four participants with response latencies less than 300 ms on 10% or more of the critical trials, error rates above 30% for all of the critical blocks, and/or error rates above 40% for any of the critical blocks). Finally, one participant indicated to have engaged in NSSI in the past month but not in the past year. The data of this participant were excluded because we could not determine whether the participant belonged to the NSSI or no history of NSSI group. Results did not change when excluding this participant's data. The final sample size consisted of 83 participants (56.63% women, 1.20% other identity, $Mage$ = 21.54, SD = 1.95). The sample included 43 participants without a history of NSSI and 40 participants who indicated having injured themselves in the past year, providing 88% power to detect a medium effect size (d = 0.70, alpha = .05) in the crucial *t*-test.

Materials

P-NSSI-IAT. The P-NSSI-IAT followed the standard procedure of the IAT (Greenwald et al., 1998). On each trial of the P-NSSI-IAT, a statement appeared in the middle of the screen. Participants were instructed to categorize those stimuli as fast as possible by pressing the "E" or "I" keys on the keyboard. Category labels were presented in the top left and right corners to aid categorization. If the response was correct, the stimulus disappeared, and the next stimulus was presented 400ms later. If the response was incorrect, a red cross replaced the stimulus for 200ms, and the next stimulus appeared 400ms after the red cross appeared. During the first block, participants practiced categorizing statements regarding past NSSI behavior (e.g., "I have carved my skin on purpose") and past non-NSSI behavior (e.g., "I have carved my skin not once"). During the second block, participants practiced categorizing statements that were logically true (e.g., "I'm doing a psychology experiment") and statements that were logically false (e.g., "I'm climbing a mountain"). Both practice blocks consisted of 24 trials. Subsequently, participants completed 48 critical trials during which statements from all four categories were categorized. During these trials, statements regarding past NSSI behavior and statements that were logically true shared one response key, whereas statements regarding past non-NSSI behavior and statements that were logically false shared the other response key. Then, participants practiced sorting statements regarding past NSSI behavior and statements regarding past non-NSSI behavior with the response key assignment reversed, for 24 trials. Finally, participants completed 48 trials during which statements from all four categories were categorized using the new response key assignment.

Scores for the P-NSSI-IAT were calculated using the D4 scoring algorithm (Greenwald et al., 2003). Reaction times on trials of the first critical block were subtracted from reaction times on trials of the second critical block, such that higher scores indicated faster responding during critical blocks in which statements regarding past NSSI behavior and

statements that were logically true shared the same response key (Spearman-Brown corrected split-half reliability = .73).

Self-Report Measures of NSSI Behavior. To probe NSSI history, we asked participants how many times they had intentionally cut or carved their skin (without intending to kill themselves) in the past month and the past year. To answer these questions, participants could insert any number. Note that we limited the prediction of NSSI to cutting and carving of the skin because, as discussed in the introduction, we wanted the probed behavior to highly correspond with the to be predicted behavior. We chose to assess cutting and carving of the skin because it is one of the most common methods of NSSI (Klonsky & Muehlenkamp, 2007). The questions that were used were based on questions from the deliberate self-harm inventory (DSHI; Gratz, 2001) and the Self-Injuries Thoughts and Behavior Interview (SITBI; Nock et al., 2007). We also asked participants how likely they were to cut their skin in the future. Responses to this question were provided on a scale that ranged from zero (*low/little*) to four (*very much/severe)*. This question was adopted from the SITBI.

Measures of Risk Factors. To measure hopelessness, we used the Beck Hopelessness Scale (BHS; Beck et al., 1974). The BHS assesses positive and negative beliefs about the future and consists of 20 statements (e.g., “My future seems dark to me”) that are evaluated as true or false (Cronbach's Alpha = .93). We probed suicidal thoughts by asking participants how many separate times in their lives they had thought of killing themselves. This question was adopted from the SITBI. To answer this question, participants could insert any number. To assess prior psychiatric disorders, participants were asked to answer “yes” or “no” to the following question: “Have you (ever) been diagnosed with one or more of the following mental health conditions? Mood disorder (e.g., depression, bipolar); anxiety disorder (e.g., panic, anxiety, phobias, generalized anxiety, obsessive-compulsive disorder); eating disorders (e.g., bulimia nervosa, anorexia nervosa); substance abuse (e.g., alcohol, drugs).”

Procedure

First, participants indicated their age and gender. Afterward, participants completed the P-NSSI-IAT and answered the questions regarding past NSSI and future likelihood of NSSI. Before the NSSI questions, we reminded participants about the anonymous nature of the study to ensure that participants would be less inclined to be dishonest. After the NSSI questions, participants completed the BHS and answered the questions regarding past suicidal thoughts and diagnosed psychiatric disorders. At the end of the study, we debriefed participants about our study goals and referred them to websites containing several help sources. Other than Prolific identification codes, no identifying information was collected. Data were anonymized by removing the Prolific identification codes.

Data Analysis

For the analyses regarding the prediction of past NSSI behavior, participants were grouped as follows (based on the questions regarding past NSSI frequency): (1) participants without a history of NSSI (n = 43), (2) participants who had engaged in NSSI behavior in the past year (n = 40; this group also included participants who had engaged in NSSI in the past month), and (3) participants who had engaged in NSS in the past month (n = 13). First, to test whether the P-NSSI-IAT can distinguish between participants with and without a history of NSSI, we compared P-NSSI-IAT scores of these groups using independent samples *t-tests*. Second, to determine *how well* P-NSSI-IAT scores discriminate between these groups, we conducted receiver-operating-characteristic (ROC) analyses and we tested different cut-off points of the P-NSSI-IAT to probe maximum sensitivity (true positive rate) and specificity (true negative rate). Third, to test the ability of the P-NSSI-IAT to independently predict NSSI-status and self-rated future likelihood of NSSI, we used separate logistic analyses[1]. For

[1] Because of an oversight, these analyses deviate from what we originally preregistered. We used logistic, rather than linear regression analyses to predict past NSSI because we were primarily interested in testing the P-NSSI-

analyses regarding the prediction of self-rated future likelihood of NSSI, participants were grouped as (1) participants who indicated low future likelihood of NSSI (n = 68; 0-2 score on the future likelihood question) and (2) participants who indicated high future likelihood of NSSI (n = 15; 3-4 score on the future likelihood question). Note that these groups included both participants with and without a history of NSSI.

Finally, to determine whether P-NSSI-IAT scores improved prediction of NSSI-status and self-rated future likelihood of NSSI beyond known risk factors, we conducted separate hierarchical logistic regression analyses for each of these outcomes (using the same grouping of participants as indicated above). Significant risk factors were added in the first step and P-NSSI-IAT scores were entered in the second step. Logarithm transformation (log[x+1] transformation) was applied to the frequency risk variables (i.e., frequency of NSS in the past year, frequency of NSSI in the past month, and frequency of past suicidal thoughts) prior to conducting the analyses. This was done because the distributions of these variables were highly positively skewed (because participants without a history of NSSI were included in the analyses) and contained several outliers which led to inflated estimates.

Results

Ability of the P-NSSI-IAT to Distinguish Between Groups

Analyses revealed statistically significant differences in P-NSSI-IAT scores between the non-injury group (n = 43, M = 0.24, SD = 0.40) and both the past year self-injury group (n = 40, M = 0.55, SD = 0.36), $t(80.87) = 3.77$, d = 0.82, $p < .001$, and the past month self-injury group (n = 13, M = 0.71, SD = 0.40), $t(20.04) = 3.76$, d = 1.18, p = .002. In both cases, P-NSSI-IAT scores were highest in the self-injury groups.

IAT's ability to predict group status (NSSI or no NSSI), rather than frequency (severity) of NSSI behavior. Also, for the prediction of self-rated future likelihood of NSSI (rated on a Likert scale), logistic rather than linear regression was used because not all of the assumptions for linear regression were met.

The overall ability of the P-NSSI-IAT to correctly classify participants, measured as the area under the curve (AUC), was .72 (95% CI = 0.61, 0.83) for past year NSSI and .79 (95% CI = 0.65, 0.94) for past month NSSI, which is well above chance level (.50)[2]. Using 0 as the cut-off score for the P-NSSI-IAT, which is often considered theoretically relevant, produced poor specificity (26%) and strong sensitivity (92-93%). The threshold to maximize sensitivity and retain fair specificity (0.16) produced 90-92% sensitivity and 42% specificity. The threshold to maximize specificity (0.65) and retain fair sensitivity produced 84% specificity and 40-54% sensitivity.

Ability of the P-NSSI-IAT to Independently Predict NSSI

Analyses revealed that higher P-NSSI-IAT scores were significantly associated with past year NSSI, Odds Ratio (OR) = 9.34, 95% CI = [2.66, 40.34], p = .001, and past month NSSI, OR = 25.41, 95% CI = [3.83, 311.06], p = .003. P-NSSI-IAT scores were not significantly associated with self-rated future likelihood of NSSI, OR = 1.58, 95% CI = [0.39, 6.86], p = 0.527.

Ability of the P-NSSI-IAT to Incrementally Predict NSSI

Significant risk factors for each outcome (see Table 1) were statistically controlled for in subsequent analyses. Results revealed that P-NSSI-IAT scores predicted past year NSSI (see Table 2) and past month NSSI (see Table 3) above and beyond known risk factors of NSSI. P-NSSI-IAT scores did not increase predictive ability for self-rated future likelihood of NSSI beyond known risk factors of NSSI (see Table 4).

Discussion

[2] We also calculated cross-validated AUCs using ten-fold cross validation as the resampling method. The cross-validated AUCs closely resembled the in-sample AUCs and can be found on the Open Science Framework page for this project at https://osf.io/wnbfc/.

Overall, results of Study 1 indicate predictive value of the P-NSSI-IAT. First, participants with a history of NSSI exhibited higher IAT scores than participants without a history of NSSI. Second, P-NSSI-IAT scores were significantly associated with past NSSI behavior and improved prediction of both outcomes (i.e., NSSI in the past year and NSSI in the past month) above and beyond known risk factors of NSSI. P-NSSI-IAT scores were not significantly associated with self-rated future likelihood of NSSI.

Study 2

Study 2 had two important aims. The first aim was to test whether the results from Study 1 could be replicated. Therefore, we tested the same hypotheses as in Study 1. The second aim of Study 2 was to probe short-term predictive validity of the P-NSSI-IAT for NSSI behavior. Participants completed the P-NSSI-IAT at baseline and, 30 days later, were invited to report on their NSSI behavior over the past 30-day period. We examined whether (a) the P-NSSI-IAT was able to distinguish between participants who injured themselves between baseline and follow-up, (b) whether P-NSSI-IAT scores independently predicted NSSI behavior at follow-up, and (c) whether P-NSSI-IAT scores improved prospective prediction of NSSI above and beyond known risk factors.

Method

Participants

The sampling procedure was identical to Study 1 with one exception. We invited participants who either (a) indicated no history of NSSI behavior (n = 263), (b) indicated having injured themselves in the past year (n = 183), and (c) indicated having injured themselves in the past month (n = 102). We included the latter group to allow sufficient NSSI behavior-rates in the 30 days between baseline and follow-up.

Four hundred and seventy-nine participants started the study at baseline. We planned to have a sufficient number of participants to have sufficient power (90%) to detect a medium effect size (d = 0.70, alpha = .05) in the between-subjects t-test comparing P-NSSI-IAT scores between self-injury and non-injury groups at follow-up. We estimated that 479 participants would allow sufficient power, taking into account possible drop out from baseline to follow-up (estimated at 75%) and taking into account that we would need a sufficient number of participants in the prior NSSI history group to have performed NSSI behavior in the 30-day period (estimated at 35%).

We excluded participants from baseline analyses who (a) did not provide complete data (n = 72) or (b) met exclusion criteria of the IAT D4-scoring procedure (n = 33). Two participants indicated to have engaged in NSSI in the past month but not in the past year. The data of these participants were excluded because we could not determine whether the participants belonged to the NSSI or no history of NSSI group. Results did not change when excluding these participants' data. The final sample size at baseline consisted of 372 participants (65.05% women, 4.30% other identity, M_{age} = 21.35, SD = 1.89).

For the follow-up analyses, the final sample size consisted of 290 participants (21.93% drop-out, 63.79% women, 4.48% other identity, M_{age} = 21.39, SD = 1.89). This sample included 226 participants who did not injure themselves between baseline and follow-up and 64 participants who injured themselves between baseline and follow-up. We achieved 99% power to detect medium effect sizes (d = 0.70, alpha = .05, two-tailed).

Materials and Procedure

The materials and procedure at baseline were identical to Study 1. At follow-up, we asked participants how many times they intentionally cut or carved their skin over the 30-day period.

Data Analysis

To test whether results from Study 1 were replicable and to answer our research questions regarding prospective predictive validity of the P-NSSI-IAT, we used the same analyses as in Study 1. For the analyses regarding the prediction of past NSSI status and self-rated future likelihood of NSSI, participants were grouped in the same manner as in Study 1. The no history of NSSI group consisted of 176 participants, the past year NSSI group consisted of 196 participants, and the past month NSSI group consisted of 88 participants. Two hundred and eighty participants indicated low future likelihood of NSSI and 92 participants indicated high future likelihood of NSSI. For the analyses regarding the prediction of prospective NSSI, participants were grouped as (1) participants who did not engage in NSSI during follow-up (n = 226; regardless of NSSI history) and (2) participant who did engage in NSSI during follow-up (n = 64; regardless of NSSI history). We used the same cut-off scores for the P-NSSI-IAT to maximize sensitivity or specificity as in Study 1 to examine whether these thresholds remained meaningful in a different sample.

Results

Ability of the P-NSSI-IAT to Distinguish Between Groups

Analyses revealed statistically significant differences in P-NSSI-IAT scores between the non-injury group (n = 176, M = 0.33, SD = 0.35) and both the past year self-injury group (n = 196 , M = 0.56, SD = 0.30), t(346.99) = 6.49, d = 0.68, p < .001, and the past month self-injury group (n = 88, M = 0.58, SD = 0.30), t(200.60) = 5.84, d = 0.72, p < .001. We also found significant differences in P-NSSI-IAT scores between participants who did not injure themselves between baseline and follow-up (n = 226, M = 0.42, SD = 0.35) and participants who injured themselves between baseline and follow-up (n = 64, M = 0.59, SD = 0.30), t(116.96) = 3.82, d = 0.49, p < .001.

The AUC was .69 (95% CI= 0.63, 0.74) for past year NSSI, .70 (95% CI= 0.64, 0.77) for past month NSSI, and .64 (95% CI= 0.57, 0.71) for NSSI at follow-up[3]. Using 0 as the cut-off score for the P-NSSI-IAT, produced poor specificity (19%) and strong sensitivity (96 - 98%) to detect past NSSI and poor specificity (13%) and strong sensitivity (98%) to detect NSSI at follow-up. Using .16 as the threshold score produced strong sensitivity (90%) and fair specificity (32%) for detecting past NSSI and strong sensitivity (92%) and poor specificity (23%) to detect NSSI at follow-up. Using .65 as the threshold produced strong specificity (82%) and fair sensitivity (40-43%) to detect past NSSI and strong specificity (73%) and fair sensitivity (45%) to detect NSSI at follow-up.

Ability of the P-NSSI-IAT to Independently Predict NSSI

Analyses revealed that higher P-NSSI-IAT scores were significantly associated with past year NSSI, OR = 7.78, 95% CI= [4.02, 15.69], $p < .001$, past month NSSI, OR = 8.82, 95% CI= [3.86, 21.48], $p < .001$, and self-rated future likelihood of NSSI, OR = 4.48, 95% CI = [2.16, 9.62], $p < .001$. Results also showed that higher P-NSSI-IAT scores were significantly associated with NSSI at follow-up, OR = 4.58, 95% CI= [1.93, 11.50], $p < .001$.

Ability of the P-NSSI-IAT to Incrementally Predict NSSI

Significant risk factors for each outcome (see Table 5) were statistically controlled for in subsequent analyses. Hierarchical logistic regression analyses showed that P-NSSI-IAT scores predicted past year NSSI (see Table 6) and past month NSSI (see Table 7) above and beyond known risk factors of NSSI, but did not improve prediction of self-rated future likelihood of NSSI (see Table 8). However, P-NSSI-IAT scores did improve prediction of NSSI at follow-up above and beyond known risk factors of NSSI (see Table 9).

[3] We also calculated cross-validated AUCs using ten-fold cross validation as the resampling method. The cross-validated AUCs closely resembled the in-sample AUCs and can be found on the Open Science Framework page for this project at https://osf.io/wnbfc/.

Discussion

Results of Study 2 were in line with those of Study 1. As opposed to the results of Study 1, the results of Study 2 showed that higher P-NSSI-IAT scores were also significantly associated with self-rated future likelihood of NSSI. A plausible explanation for this difference is that the sample sizes in Study 2 provided more power to detect (smaller) effects (280 controls and 92 cases) than those in Study 1 (68 controls and 15 cases).

We also found significant differences in P-NSSI-IAT scores between participants who injured themselves and participants who did not injure themselves between baseline and follow-up. The overall ability of the P-NSSI-IAT to correctly classify participants at follow-up was weak. When the cut-off point of the P-NSSI-IAT was set at zero or .16, sensitivity of the measure to detect prospective NSSI was very strong. P-NSSI-IAT scores independently predicted NSSI at follow-up and improved prediction beyond known risk factors of NSSI.

General Discussion

The current studies provided an initial test of the predictive utility of the P-NSSI-IAT for NSSI behavior. Results from Study 1 provided evidence for the validity of the P-NSSI-IAT and showed that P-NSSI-IAT scores differentiated between participants who previously engaged in NSSI behavior and participants who did not. Results from Study 2 showed that results from Study 1 were reproducible and provided evidence for the ability of the P-NSSI-IAT to prospectively predict NSSI behavior (above and beyond known risk factors of NSSI).

Implications

Until now, evidence for the added utility of implicit measures for predicting behavior has been disappointingly limited (Oswald et al., 2013). In part, this might have been due to the fact that implicit measures were often developed to probe specific mental constructs without taking into account the level of correspondence with the specific behavior one wishes

to predict. In accordance with new perspectives on implicit measures (Irving & Smith, 2020; Van Dessel et al., 2020), results of the current studies provide evidence that implicit measures can have applied predictive value when probing the validation of statements about (past) behavior that is known to strongly relate to the to-be-predicted behavior.

These results also have practical implications. Specifically, the use of the P-NSSI-IAT in clinical contexts could be beneficial for several reasons. First, the P-NSSI-IAT probes responses to statements regarding past NSSI behavior, a risk factor that has consistently shown to be one of the strongest predictors of future NSSI behavior. Importantly, the P-NSSI-IAT does not require self-reporting of this behavior and therefore overcomes problems that are typically related to self-reporting in clinical contexts. It is of note that the P-NSSI-IAT could probably not be used to predict the onset of NSSI behavior, given that its predictions rely on the occurrence of past NSSI behavior.

Second, as opposed to the SI-IAT, the P-NSSI-IAT does not require categorization of NSSI imagery stimuli. Therefore, the use of the P-NSSI-IAT in clinical contexts might be more ethically appropriate. Notably, the prospective predictive utility of the P-NSSI-IAT was observed over a short period of time and in a heterogeneous sample including individuals with and without a history of NSSI. This observation is clinically relevant because it implies that the P-NSSI-IAT could, for example, be used in emergency units or general psychiatric wards to identify which individuals are at risk of NSSI during their hospital stay.

Further, the overall performance of the P-NSSI-IAT to correctly classify participants at baseline was relatively strong. Previous studies that examined the predictive utility of the IAT for self-harm behavior produced similar AUCs (e.g., Glenn et al., 2017; Nock & Banaji, 2007b). The overall accuracy of the P-NSSI-IAT to correctly identify participants who injured themselves at follow-up was lower. It is of note that the AUC provides an aggregated measure of test performance across all possible thresholds of the test. From a practical point of view, it

is often critical to minimize one type of classification error (i.e., false positive or false negative rate) by setting a specific threshold. A test that is highly sensitive (i.e., produces a low false negative rate), for instance, could be used for screening purposes because it would facilitate early diagnosis, intervention and/or prevention. Rather than exclusively testing the zero-threshold of the P-NSSI-IAT, which is often considered theoretically relevant, we also tested other thresholds to either maximize sensitivity or specificity of the test. In doing so, we determined thresholds that are of practical importance and can be tailored to the specific needs of the clinical setting in question.

Finally, while the P-NSSI-IAT did not show incremental validity for the prediction of self-rated future likelihood of NSSI, the P-NSSI-IAT did show incremental validity for the prediction of NSSI history and NSSI at follow-up. This latter observation is of higher importance since participants' own behavioral forecasts of future NSSI behavior are likely less valid than their reporting on actual NSSI behavior (e.g., Janis & Nock, 2008). The observation that P-NSSI-IAT scores improved (prospective) prediction of NSSI behavior above and beyond known risk factors of NSSI suggests that the P-NSSI-IAT could be a promising tool for risk assessment in combination with other measures. As established in recent studies, the prediction of NSSI can be strongly improved when assessing multiple risk factors (e.g., Fox et al., 2019; Kiekens et al., 2019). Because of its benefits (i.e., overcoming self-report bias), the P-NSSI-IAT could be a valuable addition to such a test battery.

Limitations and Future Directions

The current study is not without its limitations. First, we relied on self-report measures to verify the predictive utility of the P-NSSI-IAT. As previously discussed, the use of self-reports to assess NSSI could be problematic because of confidence issues. However, it is important to note that the use of self-reports to assess NSSI is likely less problematic in the current study than in real-world clinical settings because participants had less motivation to

conceal their behavior (i.e., they did not need to be dishonest to avoid negative consequences). Moreover, the online nature of our study might have improved the trustworthiness of the self-report measures. A study by Shapiro and colleagues (2013), for example, showed that participants felt more comfortable sharing mental health information online than in person because of visual anonymity. Of course, it is still possible that some participants concealed their NSSI behavior. Thus, future research should also test more objective measures of NSSI to further verify the predictive utility of the P-NSSI-IAT.

Second, we limited prediction of NSSI to cutting and carving of the skin because it is one of the most common methods of NSSI (Klonsky & Muehlenkamp, 2007). However, future studies should examine whether the current version of the P-NSSI-IAT is sensitive to other kinds of NSSI methods. At the same time, a benefit of the P-NSSI-IAT is that it is relatively easy to adjust its stimuli. Future studies could test new versions of the P-NSSI-IAT that probe other kinds of NSSI methods.

A third limitation of the current studies is that the number of risk factors that we examined was limited. Relatedly, the presence of mental disorders was assessed using a single question rather than a validated scale or diagnostic interview. Future research should test the incremental validity of the P-NSSI-IAT above and beyond (other) sources of information that are available in clinical practice (such as diagnostic interviews or clinical judgment) to examine whether the P-NSSI-IAT could be a useful addition to test batteries.

Finally, we verified the validity of the P-NSSI-IAT in an online sample. Despite only preselecting participants who indicated to have been diagnosed with a mental health condition, future studies need to verify the predictive utility of the P-NSSI-IAT within psychiatric samples.

Conclusion

These initial studies show that implicit measures can have applied predictive value and that the P-NSSI-IAT is a promising tool for NSSI risk assessment in clinical settings. This newly developed measure has several benefits over other (implicit and self-report) measures of NSSI. Future studies should examine the clinical utility of the P-NSSI-IAT.

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Tables

Table 1

Risk Factors for Nonsuicidal Self-Injury (Study 1)

Variable	Past year NSSI OR (95% CI)	Past month NSSI OR (95% CI)	Self-rated future likelihood NSSI OR (95% CI)
Gender (male)	0.20*** (0.07, 0.50)	0.29 (0.07, 1.04)	0.62 (0.18, 1.94)
Age	0.77* (0.60, 0.97)	0.79 (0.57, 1.08)	0.95 (0.71, 1.27)
Psychiatric disorder (yes)	3.64* (1.24, 12.34)	2.95 (0.67, 20.68)	2.39 (0.58, 16.23)
Hopelessness	1.18*** (1.09, 1.29)	1.30*** (1.14, 1.55)	1.28*** (1.13, 1.50)
Frequency prior suicidal thoughts	3.17*** (1.95, 5.95)	2.67** (1.56, 5.37)	1.23 (0.97, 1.61)
Frequency past year NSSI	-	-	3.38*** (1.89, 7.10)
Frequency past month NSSI	-	-	21.65*** (4.36, 162.89)

Note. NSSI = nonsuicidal self-injury; OR = odds ratio; CI = confidence interval.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 2

Hierarchical Logistic Regression Predicting Past Year Nonsuicidal Self-Injury (Study 1)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(5) = 42.60$***	.54
Gender (male)	-1.17	0.67	3.00	0.31 (0.08, 1.13)		
Age	-0.20	0.16	1.60	0.82 (0.59, 1.12)		
Psychiatric disorder (yes)	0.04	0.77	0.00	1.05 (0.22, 4.89)		
Hopelessness	0.09	0.05	2.70	1.09 (0.98, 1.21)		
Frequency prior suicidal thoughts	0.80	0.30	7.20	2.24** (1.34, 4.42)		
Step 2					$\chi^2(1) = 8.23$**	.62
P-NSSI-IAT scores	2.34	0.89	6.80	10.37** (2.02, 70.34)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

** $p < .01$. *** $p < .001$.

Only one participant indicated to not identify as male or female (i.e., other identity), which resulted in an inadequate sample size to fit the logistic regression models (i.e., one cell of the contingency table contained only one observation). The data from this participant were excluded prior to fitting these models. $N = 82$. The reference group consisted of participants without a history of NSSI ($n = 43$)

Table 3

Hierarchical Logistic Regression Predicting Past Month Nonsuicidal Self-Injury (Study 1)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(2) = 22.75$***	0.50
Hopelessness	0.20	0.08	5.70	1.22* (1.05, 1.47)		
Frequency prior suicidal thoughts	0.53	0.30	3.10	1.70 (0.99, 3.43)		
Step 2					$\chi^2(1) = 7.15$**	0.63
P-NSSI-IAT scores	2.86	1.28	4.90	17.42* (1.97, 363.02)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

* $p < .05$. ** $p < .01$. *** $p < .001$.

$N = 56$. The reference group consisted of participants without a history of NSSI ($n = 43$)

Table 4

Hierarchical Logistic Regression Predicting Self-Rated Future Likelihood of Nonsuicidal Self-Injury (Study 1)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(3) = 31.09$***	0.51
Hopelessness	0.17	0.82	4.40	1.19* (1.02, 1.41)		
Frequency past year NSSI	0.56	0.40	1.90	1.75 (0.78, 3.99)		
Frequency past month NSSI	1.88	0.98	3.70	6.57* (1.11, 54.65)		
Step 2					$\chi^2(1) = 2.18$	0.54
P-NSSI-IAT scores	-1.45	1.01	2.10	0.23 (0.03, 1.60)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

* $p < .05$. *** $p < .001$.

Only one participant indicated to not identify as male or female (i.e., other identity), which resulted in an inadequate sample size to fit the logistic regression models (i.e., one cell of the contingency table contained only one observation). The data from this participant were excluded prior to fitting these models. $N = 82$. The reference group consisted of participants who indicated low future likelihood of NSSI ($n = 67$)

Table 5

Risk Factors for Nonsuicidal Self-Injury (Study 2)

Variable	Past year NSSI OR (95% CI)	Past month NSSI OR (95% CI)	Self-rated future likelihood NSSI OR (95% CI)	NSSI at follow-up OR (95% CI)
Gender (male)	0.48** (0.30, 0.76)	0.48* (0.26, 0.86)	0.59 (0.33, 1.01)	0.80 (0.42, 1.74)
Gender (other identity)	11.50* (2.27, 209.54)	10.16* (1.68, 194.28)	0.87 (0.24, 2.60)	3.01 (0.92, 9.55)
Age	0.88* (0.79, 0.98)	0.83** (0.72, 0.95)	0.86* (0.75, 0.97)	0.94 (0.80, 1.08)
Psychiatric disorder (yes)	3.54*** (1.81, 7.36)	2.03 (0.96, 4.70)	1.60 (0.75, 3.82)	1.20 (0.55, 2.92)
Hopelessness	1.20*** (1.15, 1.26)	1.27*** (1.20, 1.35)	1.22*** (1.17, 1.28)	1.13*** (1.07, 1.18)
Frequency prior suicidal thoughts	2.21*** (1.85, 2.71)	1.96*** (1.64, 2.39)	1.65*** (1.45, 1.90)	1.50*** (1.31, 1.74)
Frequency past year NSSI	-	-	6.95*** (4.71, 10.89)	2.72*** (2.04, 3.72)
Frequency past month NSSI	-	-	18.78*** (9.91, 37.87)	5.81*** (3.35, 10.74)

Note. NSSI = nonsuicidal self-injury; OR = odds ratio; CI = confidence interval.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 6

Hierarchical Logistic Regression Predicting Past Year Nonsuicidal Self-Injury (Study 2)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(5) = 187.06$***	0.53
Gender (male)	-1.50	0.34	19.80	0.22*** (0.11, 0.42)		
Gender (other identity)	2.24	1.13	19.80	9.36* (1.49, 186.87)		
Age	-0.14	0.08	3.90	0.87 (0.75, 1.01)		
Psychiatric disorder (yes)	0.63	0.49	3.30	1.88 (0.74, 5.13)		
Hopelessness	0.16	0.03	1.70	1.17*** (1.12, 1.24)		
Frequency prior suicidal thoughts	0.61	0.10	34.70	1.83*** (1.53, 2.25)		
Step 2					$\chi^2(1) = 22.65$***	0.58
P-NSSI-IAT scores	2.00	0.45	32.10	7.37*** (3.14, 18.34)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

* $p < .05$. *** $p < .001$.

$N = 372$. The reference group consisted of participants without a history of NSSI ($n = 176$)

Table 7

Hierarchical Logistic Regression Predicting Past Month Nonsuicidal Self-Injury (Study 2)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(4) = 139.09$***	0.57
Gender (male)	-1.38	0.42	10.80	0.25** (0.11, 0.56)		
Gender (other identity)	2.30	1.44	10.80	9.94 (0.76, 283.96)		
Age	-0.23	0.10	2.50	0.78* (0.65, 0.97)		
Hopelessness	0.21	0.04	5.20	1.24*** (1.16, 1.33)		
Frequency prior suicidal thoughts	0.49	0.11	36.90	1.63*** (1.34, 2.02)		
Step 2					$\chi^2(1) = 13.62$***	0.61
P-NSSI-IAT scores	1.93	0.56	21.00	6.91*** (2.40, 21.97)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

* $p < .05$. ** $p < .01$. *** $p < .001$.

$N = 264$. The reference group consisted of participants without a history of NSSI ($n = 176$)

Table 8

Hierarchical Logistic Regression Predicting Self-Rated Future Likelihood of Nonsuicidal Self-Injury (Study 2)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(5) = 210.05$***	0.64
Age	-0.04	0.10	0.15	0.96 (0.79, 1.17)		
Hopelessness	0.10	0.03	9.00	1.10** (1.04, 1.18)		
Frequency prior suicidal thoughts	0.21	0.10	4.80	1.23* (1.02, 1.50)		
Frequency past year NSSI	1.27	0.25	26.60	3.54*** (2.24, 5.88)		
Frequency past month NSSI	1.47	0.41	12.90	4.36*** (1.99, 9.99)		
Step 2					$\chi^2(1) = 2.36$	0.65
P-NSSI-IAT scores	0.89	0.58	2.30	2.42 (0.78, 7.70)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

* $p < .05$. ** $p < .01$. *** $p < .001$.

$N = 372$. The reference group consisted of participants who indicated low future likelihood of NSSI ($n = 280$)

Table 9

Hierarchical Logistic Regression Predicting Nonsuicidal Self-Injury at Follow-Up (Study 2)

Variable	*B*	*SE*	Wald	OR (95% CI)	χ^2	Nagelkerke R^2
Step 1					$\chi^2(4) = 75.28$***	.35
Hopelessness	0.01	0.03	0.16	1.01 (0.95, 1.08)		
Frequency prior suicidal thoughts	0.24	0.08	7.90	1.27** (1.08, 1.50)		
Frequency past year NSSI	0.49	0.20	6.10	1.63* (1.11, 2.44)		
Frequency past month NSSI	0.90	0.36	6.40	2.47* (1.26, 5.12)		
Step 2					$\chi^2(1) = 4.52$*	.37
P-NSSI-IAT scores	1.13	0.54	4.30	3.09* (1.09, 9.22)		

Note. P-NSSI-IAT = past nonsuicidal self-injury implicit association test; OR = odds ratio; CI = confidence interval.

* $p < .05$. ** $p < .01$. *** $p < .001$.

$N = 290$. The reference group consisted of participants who did not injure themselves between Time 1 and Time 2 ($n = 226$)