

ORIGINAL ARTICLE

Do implicit measures improve suicide risk prediction? An 18-month prospective study using different tasks

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Funding information

This work was supported by a grant from the Bundesministerium für Gesundheit (German Federal Ministry of Health), ZMVI1-2517FSB140.

Abstract

Background: There is accumulating evidence that implicit measures improve the prediction of suicidality within a 6-month follow-up period in psychiatric populations. Building upon these results, we set out to expand the follow-up period and to investigate various implicit methods.

Methods: Seventy-nine inpatients completed the Beck Scale for Suicidal Ideation (BSS) and a range of implicit measures: three implicit association tests (IATs: Death; Self-harm–Me/Others; Self-Harm–Good/Bad) and a subliminal priming task (with separate scores for negative and positive adjectives, each indicating the association between the primes “dying” and “growing”). After 18 months, we reached $n = 52$ patients and reassessed suicidal ideation, plans, and attempts.

Results: In a hierarchical regression, the five implicit task indices were entered after the patient's age, gender, and BSS score at baseline. The implicit scores improved prediction of BSS scores after 18 months compared to prediction based on age, gender, and BSS score at baseline alone. However, none of the implicit measures was associated with suicide plans or attempts during the follow-up period.

Conclusion: Results suggest that implicit measures can be a useful assessment tool for the prediction of suicidal ideation, even beyond the BSS. However, long-term prediction of suicide plans or attempts using implicit measures seems limited.

INTRODUCTION

Every 40 s, someone in the world dies of suicide (WHO, 2014). At least in the industrialized Western world, the majority of individuals who commit suicide had contact with mental health institutions over the course of their lives (Stene-Larsen & Reneflot, 2019). In fact, the majority of psychiatrists have one patient under their care die of suicide during their career (Alexander et al., 2000; Leaune et al., 2019). Unfortunately, no clear clinically useful markers exist indicating the vulnerability of patients to suicide, which could signal the need for intervention or prevention (Carter et al., 2017; Large, 2018;

Woodford et al., 2019). A comprehensive meta-analysis summarized 50 years of research on suicide risk factors and found that research attempts to identify meaningful risk factors have been disappointing (Franklin et al., 2017). Thus, the research field needs novel and innovative methods to identify patients at risk of suicide (Bolton et al., 2015).

One recently discussed idea is the measurement of so-called implicit suicidal cognitions. This is mostly done by a computerized task called the implicit association test (IAT; Greenwald & Farnham, 2000). In the Death IAT (e.g., Nock et al., 2010), for example, participants rapidly sort words into the categories “death” (e.g., “dying” and “suicide”) and “life”

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(e.g., “living” and “breathing”) and—using the same two response keys—sort words into the categories “me” (e.g., “I” and “mine”) and “others” (e.g., “you” and “yours”). If a participant responds faster in trials in which “death” and “me” have the same response key—compared to trials in which “life” and “me” have the same response key—the test result is interpreted as revealing a stronger association between the concepts “death” and “me” compared to “life” and “others.” The question is then whether participants with a stronger association between “death” and “me” have an increased risk for suicide. Three studies (Barnes et al., 2017; Nock et al., 2010; Tello et al., 2020) found that results on the Death IAT improved the prediction of suicide attempt over a 6-month follow-up period above other risk factors (e.g., patient’s prediction). The first study (Nock et al., 2010) investigated patients with a lifetime history of suicide attempt from a psychiatric emergency department; an effect recently replicated directly and independently by Tello et al. (2020). The third study (Barnes et al., 2017) investigated veterans hospitalized due to suicide risk. Yet, given the goal of using implicit measures as a reliable tool in clinical practice, predictive validity needs further improvement, possibly by the use of additional implicit measures. Also, the temporal stability of the predictive validity of implicit measures over longer periods has yet to be explored. Therefore, in the present study, we aimed at extending previous results by using a variety of implicit measures as a predictor for suicidality over an 18-month follow-up period.

All the studies described so far focused on the Death IAT. However, alternative versions of this IAT exist that are also relevant in this context. In the self-harm IAT, for example, participants categorize images of wounds from self-injurious behavior. Cross-sectionally, the self-harm IAT differentiated between people with and without a history of suicide attempts within a large online sample with over 7000 participants (Glenn et al., 2017). Yet, within a diverse psychiatric population, no differences on the self-harm IAT could be found between those with and without a previous suicide attempt (Kene, 2017). In a study among adolescents (Nock & Banaji, 2007), the self-harm IAT differentiated between individuals with a previous suicide attempt and those without. Further, the test predicted suicidal ideation after 6 months above other measures. Hence, these results offer hope that the self-Harm IAT can serve as an additional predictor for suicide to increase predictive validity. Thus, we decided to include two self-harm IATs in our study with a longer follow-up and a different psychiatric population.

Another methodology for measuring implicit attitudes or cognitions beyond the IAT are priming tasks. Researchers from various fields (De Houwer et al., 2009)—including clinical researchers (e.g., Dannlowski et al., 2006; Roefs et al., 2005)—have used priming tasks to test implicit associations. To our knowledge, however, no one has applied (subliminal) priming tasks in the context of suicide prediction, a gap we

aimed to close by adapting the task to relevant cognitions similar to the IATs described above. Following the standard procedure for subliminal priming (Olson & Fazio, 2002), participants were exposed to either a prime associated with life (“growing”) or death (“dying”) for such a short time that it was most likely processed subliminally. Then, participants categorized adjectives, presented afterwards, as either “positive” or “negative.” We presumed that a person with an increased risk for suicide would correctly categorize a positive adjective faster if they were first primed by the word “dying.”

Finally, before clinical implementation of the implicit measures, three additional important questions need to be answered. First, do implicit measures predict suicidality over longer time periods than the previously investigated 6-month follow-up? Second, can implicit measures in addition to the Death IAT be used for the long-term prediction of suicidality? And third, what forms of suicidality can implicit measures predict? To answer these questions, a sample of psychiatric inpatients with a high-risk for suicidality completed a range of implicit measures and reported their suicidality 18 months later. To establish incremental validity, we investigated whether implicit measures predicted suicidal ideation beyond the widely used Beck Scale for Suicidal Ideation (BSS; Beck et al., 1988) and the patients’ age and gender. If implicit measures have a predictive value beyond explicit measures, they could be a valuable tool for clinical practice. If not, classical explicit measures are preferable as they are easier to administer and acceptance and face validity can be low for implicit measures (Howell et al., 2017; Mendonça et al., 2019). Therefore, we additionally reported the association of implicit measures with different forms of suicidality and investigated their specificity exploratorily.

MATERIAL AND METHODS

Participants

We recruited 79 inpatients at the Clinic for Psychiatry and Psychotherapy of the University Medical Center Hamburg-Eppendorf (Germany). All patients gave written informed consent prior to participation. The ethics committee of the local medical board approved the trial (trial number PV5263). We excluded patients if they were below 18 or above 65 years of age, had a lifetime F2 diagnosis, had a neurological disorder (e.g., multiple sclerosis), or if IQ < 70 was estimated by the use of a vocabulary test. Medication was tolerated. Of the included patients, $N = 77$ gave consent to be recontacted again, either by telephone, e-mail, or mail. These 77 patients were recontacted 18 months after baseline assessment (follow-up).

We offered a compensation of 40 Euros for participation in the follow-up. We could not reach nine of the former patients.

Of these nine patients, none was registered as a suicide in the forensics department of the clinic, which conducts autopsy for most suicides in the city. Another 13 of the 77 patients did not want to participate in the follow-up assessment. In total, $n = 55$ patients completed the follow-up assessment at 18 months (response rate = 69.6%). Table 1 depicts sample characteristics at baseline for both the baseline sample and the follow-up sample. There were no significant differences on any sociodemographic or clinical (diagnosis, suicidality, and symptomology) variables, suggesting that the follow-up sample is representative of the entire baseline sample.

Procedure

For the baseline assessment, patients completed the self-report questionnaires and participated in two in-person assessments. In one session, they completed various experimental implicit assessment measures in randomized order and were diagnosed with the Mini-International Neuropsychiatric Interview (M.I.N.I.). We also rated depression with the 17-item version of the Hamilton Depression Rating Scale (HDRS; Hamilton, 1960). In the next assessment, we conducted a comprehensive assessment of suicidality and self-harming behavior

with the German version of the Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock et al., 2007). When patients agreed to participate in the follow-up assessment, we asked them to answer again all self-report questionnaires and conducted the SITBI again during a telephone interview.

Psychometric measures

Self-reported suicidality was measured with the German version of the Beck Scale for Suicidal Ideation (BSS; Beck et al., 1988; German translation: Kliem et al., 2017), which shows good internal consistency (Cronbach's $\alpha = .94$) and construct validity.

Additionally, clinician-assessed suicidality was measured with the German version of the SITBI (Nock et al., 2007; German translation: Fischer et al., 2014), which showed perfect interrater reliability for suicidality ($\kappa = 1.00$) and good construct validity. At baseline, the complete, original interview was used. For the follow-up assessment via telephone, we adapted the interview and only asked for suicide thoughts, plans, and attempts within the time period between baseline and follow-up. Accordingly, we skipped the questions on suicidal behavior over the patient's lifetime, the previous year,

TABLE 1 Characteristics of baseline and follow-up samples at baseline assessment: Mean (standard deviation) or number (percentage)

	Baseline sample ($N = 79$)	Follow-up sample ($n = 55$)	Statistics
Age	41.23 (10.42)	41.67 (10.40)	$t(113.14) = 0.248, p = 0.805$
Female gender	39 (49.37%)	29 (47.27%)	$\chi^2(1) = 0.043, p = 0.836$
IQ (assessed by vocabulary test)	104.70 (9.93) ^a	105.75 (10.47) ^b	$t(95.764) = 0.535, p = 0.594$
Any depressive disorder ^c	68 (86.08%)	46 (83.64%)	$\chi^2(1) = 0.021, p = 0.886$
Number of depressive episodes ^c	5.65 (10.46)	6.71 (12.16)	$t(104.71) = 0.527, p = 0.599$
Lifetime manic or hypomanic episode ^c	11 (13.92%)	9 (16.36%)	$\chi^2(1) = 0.025, p = 0.875$
Any anxiety disorder ^c	29 (36.71%)	25 (45.45%)	$\chi^2(1) = 0.700, p = 0.403$
Posttraumatic stress disorder ^c	7 (8.86%)	5 (9.09%)	$\chi^2(1) < 0.001, p = 1$
Obsessive-compulsive disorder ^c	10 (12.66%)	7 (12.73%)	$\chi^2(1) < 0.001, p = 1$
Any alcohol-use disorder ^c	21 (26.58%)	16 (29.09%)	$\chi^2(1) = 0.015, p = 0.902$
Any substance-use disorder ^c	9 (11.39%)	4 (7.27%)	$\chi^2(1) = 0.236, p = 0.627$
Any eating disorder ^c	3 (3.80%)	1 (1.82%)	$\chi^2(1) = 0.020, p = 0.888$
Duration of illness (in months)	137.44 (150.51)	152.24 (168.81)	$t(107.51) = 0.522, p = 0.603$
Lifetime suicidal thoughts ^d	63 (79.75%)	43 (78.18%)	$\chi^2(1) < 0.001, p = 0.997$
Lifetime suicide attempts ^d	26 (32.91%)	20 (36.36%)	$\chi^2(1) = 0.052, p = 0.819$
Number of suicide attempts ^d	0.99 (4.52)	1.24 (5.40)	$t(102.77) = 0.280, p = 0.780$
BSS	8.77 (10.47)	8.93 (10.45)	$t(116.44) = 0.084, p = 0.933$
HDRS	18.96 (7.15)	18.77 (7.71)	$t(110.62) = 0.139, p = 0.890$

Abbreviations: BSS, Beck Scale for Suicidal Ideation; HDRS, Hamilton Depression Rating Scale.

^a $n = 67$.

^b $n = 47$.

^cBased on Mini-International Neuropsychiatric Interview (M.I.N.I.).

^dBased on Self-Injurious Thoughts and Behaviors Interview (SITBI).

and the previous week. For the number of episodes of suicidal behavior, we additionally asked about the length of each episode and the frequency of suicidal thoughts for each episode, resulting in an estimate of days with suicidal thoughts for the follow-up period.

Implicit predictor variables at baseline

Implicit Association Test

To capture implicit cognitions on self-harm and suicidality, we gave patients three different IATs: two different versions of the Self-Harm IAT and one version of the Death IAT. For all IATs, the procedure followed the standard seven-block procedure (Greenwald et al., 2003). For example, in the Self-Harm–Me/Other IAT, patients first consecutively sorted images of human skin (with cuts or without) into “cutting” or “not cutting” by either pressing the left or the right key on the keyboard. In the next practice block, patients sorted words into the category “me” (e.g., “I” and “mine”) or the category “others” (e.g., “you” and “yours”), using the same two keys as before. In the test blocks, patients sorted both images and words at the same time. For this, each of the two keys was assigned two categories. In one block, for example, the left key was assigned to the categories “cutting” and “me” and the right key to the categories “not cutting” and “others.” For the Self-Harm–Good/Bad test, the procedure was the same except that patients sorted words as “good” (e.g., “joy” and “love”) or “bad” (e.g., “misery” and “horrible”) instead of as “me” and “others.” For the Death IAT, the categories were “me” and “other,” as in the Self-Harm–Me/Other IAT, but instead of images, patients sorted words into either the category “death” (e.g., “dying” and “suicide”) or “life” (e.g., “living” and “breathing”). The allocation and pairings changed between the blocks. The current allocation was displayed on the screen at all times. We instructed patients to respond as fast as possible. It is assumed that patients respond faster in trials in which the categories allocated to the same key are more closely connected in their associative network. Based on this assumption, we calculated a *D*-score according to the algorithm recommended by Greenwald et al. (2003). For all IATs, a higher *D*-score represents a stronger association between self-harm/dying and self/positive (e.g., patients respond faster when “cutting” and “me” are paired than when “not cutting” and “me” are paired), which we expected to be associated with higher suicidality.

Subliminal priming

We designed a subliminal priming task following Olson and Fazio (2002). Each trial started with a prime word, which was either the German word for dying (“*Sterben*”) or for growing

(“*Wachsen*”). The sequence started with a prime word shown for 28 milliseconds, followed by an alphanumeric string for 42 ms to mask the prime and then the display of the actual target word. The target word was either a positive or negative German attribute word. We instructed patients to categorize the word as positive or negative by pressing either the left or right key as quickly and as accurately as possible. Patients could see the key mappings in the upper left and right corners on the screen. The target word stayed on the screen until the patient pressed a key. The experiment started with a practice block with eight trials using a “pseudo” prime. Patients received feedback on the practice block only. The experimental block consisted of 128 trials, where each prime (“dying” and “growing”) was paired twice with each of the 32 adjectives (16 “positive” and 16 “negative”). We subtracted the mean reaction time following the growth prime from the mean reaction time following the death prime separately for the positive and the negative adjectives. Thus, we had one score called Life-Positive, where higher scores meant that the patient reacted faster to positive words after a growth prime than after a dying prime (which we expected to be associated with higher implicit cognitions opposing suicidality). For the Life-Negative score, higher scores meant that the patient reacted faster to negative words after a growth prime than after a dying prime (which we expected to be associated with higher implicit cognitions favoring suicidality).

Reliability of implicit measures

For each test block, we expected similar reaction times for all stimuli, indicating high internal consistency. To test this, we calculated Cronbach's alpha across all stimuli's reaction times (averaged per block, if repeatedly presented). All resulting scores signal adequate reliability (Self-Harm–Good/Bad: $\alpha = .78$ (congruent blocks; Cutting and Good allocated same response key), $\alpha = .79$ (incongruent blocks); Self-Harm–Me/Other IAT: $\alpha = .85$ (congruent blocks), $\alpha = .83$ (incongruent blocks); Death IAT: $\alpha = .81$ (congruent blocks), $\alpha = .85$ (incongruent blocks); Subliminal priming: $\alpha = .80$ (Death prime, positive adjective), $\alpha = .83$ (growth prime, positive adjective), $\alpha = .84$ (Death prime, negative adjectives), $\alpha = .74$ (growth prime, negative adjectives).

Statistical analysis

First, we conducted hierarchical regression models for suicidal ideation. The primary outcome measure was BSS score at follow-up. As the distribution of the BSS score was heavily right-skewed, with 28 (51%) participants with a BSS score of zero at follow-up, we also computed analyses for the subsample of participants who had a BSS sum score above zero at baseline ($n = 31$). Furthermore, we repeated the analysis for

the estimated number of days with suicidal thoughts within the 18-month follow-up period, retrieved from the SITBI telephone interview.

In each model, the procedure for the predictor variables was the same. In step 1, sole predictors were the sociodemographic variables age and gender. For the second model, we added the BSS score at baseline as an outcome predictor. In step 3, we added the implicit measures (*D*-Scores of the IATs Self-Harm–Good/Bad, Self-Harm–Me/Others, and Death as well as the Life-Positive and Life-Negative scores on the subliminal priming task) to the model.

In each step, we analyzed whether adding the predictors improved model fit using analysis of variance (ANOVA). Additionally, we reported Akaike information criterion (AIC) as an indicator of model fit. From the analyses, we excluded three patients due to technical problems (data from one IAT were missing).

Second, we conducted univariate analyses between implicit measures and different outcomes of suicidality. Analogous to hierarchical regression models, we reported Pearson correlation coefficients between the five implicit measure indices and the outcome variable BSS score (entire sample and BSS score above zero at baseline) as well as estimated days with suicidal thoughts within the 18-month follow-up period. Furthermore, we conducted Welch's *t* tests and reported Cohen's *d* as effect sizes for differences in the implicit measure indices between patients with and patients without suicidal thoughts, plans, or attempts within the 18-month follow-up period (retrieved from SITBI telephone interviews).

Additionally, we created a separate scatterplot for each implicit measure. For this, we plotted the distribution of *D*-scores, where each dot represents the score of a patient and the color of the dot codes represents whether the patient had suicidal thoughts, suicide plans, or suicide attempts or none of these over the 18-month follow-up period (for advantages of these plots, see Weissgerber et al., 2019).

RESULTS

Multivariate analysis

Table 2 depicts the results of the hierarchical multiple linear regressions predicting suicidal thoughts. For the three analyses, adding BSS score at baseline in step 2 to the sociodemographic variables of age and gender improved the model fit significantly. Adding the five implicit measure indices (at baseline) in step 3 also significantly improved model fit for the prediction of BSS score at 18-month assessment in the linear models, both for the entire sample (improvement of .080 to $R^2_{\text{adj}} = .589$; $F(43, 5) = 2.871$, $p = .025$) and for the subsample of patients with a BSS score above zero at baseline (improvement of .227 to $R^2_{\text{adj}} = .541$; $F(21, 5) = 3.573$,

$p = .017$). Yet, adding the implicit measures in step 3 did not improve the prediction compared to the BSS score at baseline for the estimated number of days with suicidal thoughts.

Univariate analysis

Table 3 depicts Pearson's correlations between predictors at baseline and outcome measures (BSS) and estimated days of suicidal thoughts at follow-up, as well as effect sizes Cohen's *d* for differences in baseline predictors between those with and without suicidal thoughts, plans, and attempts within the 18-month follow-up period. BSS baseline scores were associated with all outcomes. That is, BSS baseline scores correlated moderately to strongly positive with BSS scores at follow-up (entire sample and subsample with baseline scores above zero) and the estimated days of suicidal thoughts. Further, patients had higher BSS baseline scores if they reported having had suicidal thoughts, plans, or attempts within the follow-up period of 18 months compared to those without. On the other hand, a younger age was associated with lower follow-up BSS scores in the entire sample and was also lower in the group with suicidal thoughts at follow-up. At trend level, in the entire sample, BSS scores at follow-up were positively correlated with the Death IAT and unexpectedly negatively correlated with the Life-Negative score of the subliminal priming task. For the subgroup with a BSS score above zero at baseline, BSS score at follow-up was positively correlated with the Death IAT as well as negatively correlated with the Life-Positive score on the subliminal priming task. No significant group differences in the implicit measures emerged between those with or without suicidal thoughts, plans, or attempts, although the effect sizes were small to medium.

Graphical inspection

Additionally, we descriptively looked at the prediction of each implicit measure. Figure 1 depicts scatterplots with the distribution of *D*-scores derived from the implicit measures at baseline. The dots' colors indicate the patient's suicidal behavior over the 18-month follow-up period, that is, whether the patient reported having a suicide attempt, suicide plan, suicidal thought, or none of these. The four patients with suicide attempts had *D*-scores across the range of implicit scores. More specifically, the percentile rank range for suicide attempts was 32.7–81.8 for IAT Self-Harm–Good/Bad, 24.1–92.6 for IAT Self-Harm–Me/Others, 43.4–98.1 for the Death IAT, and 1.8–60.0 for the Life-Positive and 16.4–92.7 for the Life-Negative subliminal priming tasks. This means that the four cases with a suicide attempt were distributed over at least three quartiles in each implicit measure.

TABLE 2 Hierarchical multiple linear regression for outcomes measured by the Beck Scale for Suicidal Ideation (BSS; Full Sample and Subsample with Baseline Scores above Zero) as well as estimated days of suicidal thoughts

Outcome variable	Full sample			Subsample with Baseline BSS score >0			Full sample		
	BSS	BSS	BSS	BSS	BSS	BSS	Estimated days of suicidal thoughts	Estimated days of suicidal thoughts	Estimated days of suicidal thoughts
	<i>n</i> = 52	<i>n</i> = 52	<i>n</i> = 52	<i>n</i> = 29	<i>n</i> = 29	<i>n</i> = 29	<i>n</i> = 52	<i>n</i> = 52	<i>n</i> = 52
	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Step 1: Demographics									
Age	-.287*	-.100	-.119	-.206	-.132	-.148	-.244 [†]	-.040	-.034
Gender (0 = male, 1 = female)	-.056	-.102	-.161+	.027	-.145	-.397*	-.004	-.078	-.105
Step 2: BSS score at baseline									
BSS	.701***	.662***	.614***	.554**	.627***	.627***	.658***	.627***	.627***
Step 3: Implicit measures									
IAT Self-Harm - Good/Bad	.067	.067	.067	.124	.124	.124	.124	.124	.124
IAT Self-Harm - Me/Others	.070	.070	.070	.261	.261	.261	.166	.166	.166
Death IAT	.181 [†]	.181 [†]	.181 [†]	.332*	.332*	.332*	.009	.009	.009
Life-positive (subliminal priming)	-.246**	-.246**	-.246**	-.232	-.232	-.232	-.010	-.010	-.010
Life-negative (subliminal priming)	-.072	-.072	-.072	.010	.010	.010	-.080	-.080	-.080
Model fit	$R^2_{adj} = .047, F(2, 49) = 2.253, p < .001$	$R^2_{adj} = .509, F(3, 48) = 18.590, p < .001$	$R^2_{adj} = .589, F(8, 43) = 10.130, p < .001$	$R^2_{adj} = -.027, F(2, 27) = 0.619, p = .546$	$R^2_{adj} = .314, F(3, 26) = 5.422, p = .005$	$R^2_{adj} = .541, F(8, 21) = 5.273, p = .001$	$R^2_{adj} = -.020, F(2, 48) = 1.519, p = .229$	$R^2_{adj} = .409, F(3, 47) = 12.53, p < .001$	$R^2_{adj} = .390, F(8, 42) = 4.999, p < .001$
Akaike information criterion	149.99	116.46	111.48	90.78	79.54	71.08	148.59	123.75	129.61
Model comparison									
	$F(1, 48) = 47.042, p < .001$	$F(5, 43) = 2.871, p = .025$	$F(5, 43) = 2.871, p = .025$	$F(1, 26) = 14.415, p < .001$	$F(5, 21) = 3.573, p = .017$	$F(1, 48) = 32.553, p < .001$	$F(1, 48) = 32.553, p < .001$	$F(4, 5) = 0.711, p = .619$	$F(4, 5) = 0.711, p = .619$

[†]*p* < .1
p* < .05; *p* < .01; ****p* < .001.

TABLE 3 Pearson's correlation between predictors at baseline and outcomes measured by the Beck Scale for Suicidal Ideation (BSS) and estimated days of suicidal thoughts at follow-up, as well as group differences (Cohen's *d*) between those with and without suicidal thoughts, plans, and attempts according to answers to the SITBI at 18-month assessment

	BSS (<i>n</i> = 55)	Subsample with Baseline BSS score >0 (<i>n</i> = 29)	Estimated Days of Suicidal Thoughts (<i>n</i> = 55)	Suicidal Thoughts (<i>n</i> = 55; yes =36)	Suicide Plans (<i>n</i> = 55; yes =19)	Suicide Attempts (<i>n</i> = 55; yes =4)
Demographics						
Age	-.28*	-.21	-.24 [†]	-1.23***	-0.33	0.00
Gender (0 = Male, 1 = Female)	-.05	.04	.00			
Self-report measure						
BSS	.72***	.59***	.66***	1.00***	1.34***	1.73*
Implicit measures						
IAT Self-Harm–Good/Bad	.08	-.04	-.11	0.54 [†]	-0.10	0.49
IAT Self-Harm–Me/Others	-.15	.30	.19	-0.12	-0.07	0.59
Death IAT	.27 [†]	.50**	.14	-0.10	0.28	0.56
Life-positive (subliminal priming)	-.22	-.39*	-.06	0.25	0.34	-0.72
Life-negative (subliminal priming)	-.24 [†]	-.29	-.20	-0.02	0.50	0.00
	Pearson's correlations.	Pearson's correlations.	Pearson's correlations.	Cohen's <i>d</i>	Cohen's <i>d</i>	Cohen's <i>d</i>

[†]*p* < .1

p* < .05; *p* < .01; ****p* < .001.

Likewise, patients with suicide plans during the follow-up period had a wide range of *D*-scores at baseline. In sum, descriptive inspection suggests low specificity of the implicit measures in the prediction of suicide attempts or plans.

DISCUSSION

Previous studies showed that the Death IAT can be used to predict suicide attempts in the long term (Barnes et al., 2017; Nock et al., 2010; Tello et al., 2020). In this study, we set out to investigate a longer follow-up period (18 months), test a wider range of implicit methods (three IATs and a subliminal priming task), and report multiple outcomes in regard to suicidality.

Summary of findings

In a sample of psychiatric inpatients, we investigated whether implicit measures predict suicidal ideation after 18 months

better than sociodemographic variables and the Beck Scale for Suicidal Ideation (BSS). For the prediction of suicidal ideation, as measured with the BSS, the implicit measures added incremental validity above the sociodemographic variables and baseline BSS scores. This was also found in a subsample including only patients with suicidal thoughts at baseline. Of the five indices derived from the implicit tasks, the Life-Positive score on the subliminal priming task (in the analysis including all patients) and the *D*-score on the Death IAT (in the analysis of the subsample that included patients with suicidal thoughts at baseline) were significant predictors. However, for predicting the estimated days of suicidal thoughts during the follow-up period, none of the five implicit indices was significant and model fit did not improve after their inclusion.

In the univariate analysis, in the subsample of patients with suicidal thoughts at baseline, the Death IAT correlated positively and the Life-Positive score of the subliminal priming task correlated negatively with suicidal ideation at follow-up (as measured with the BSS); other implicit indices were uncorrelated. In the sample including all patients, no

Individual *D*-Scores for Different Implicit Measures and Suicidality Within 18-Month Follow-Up Period

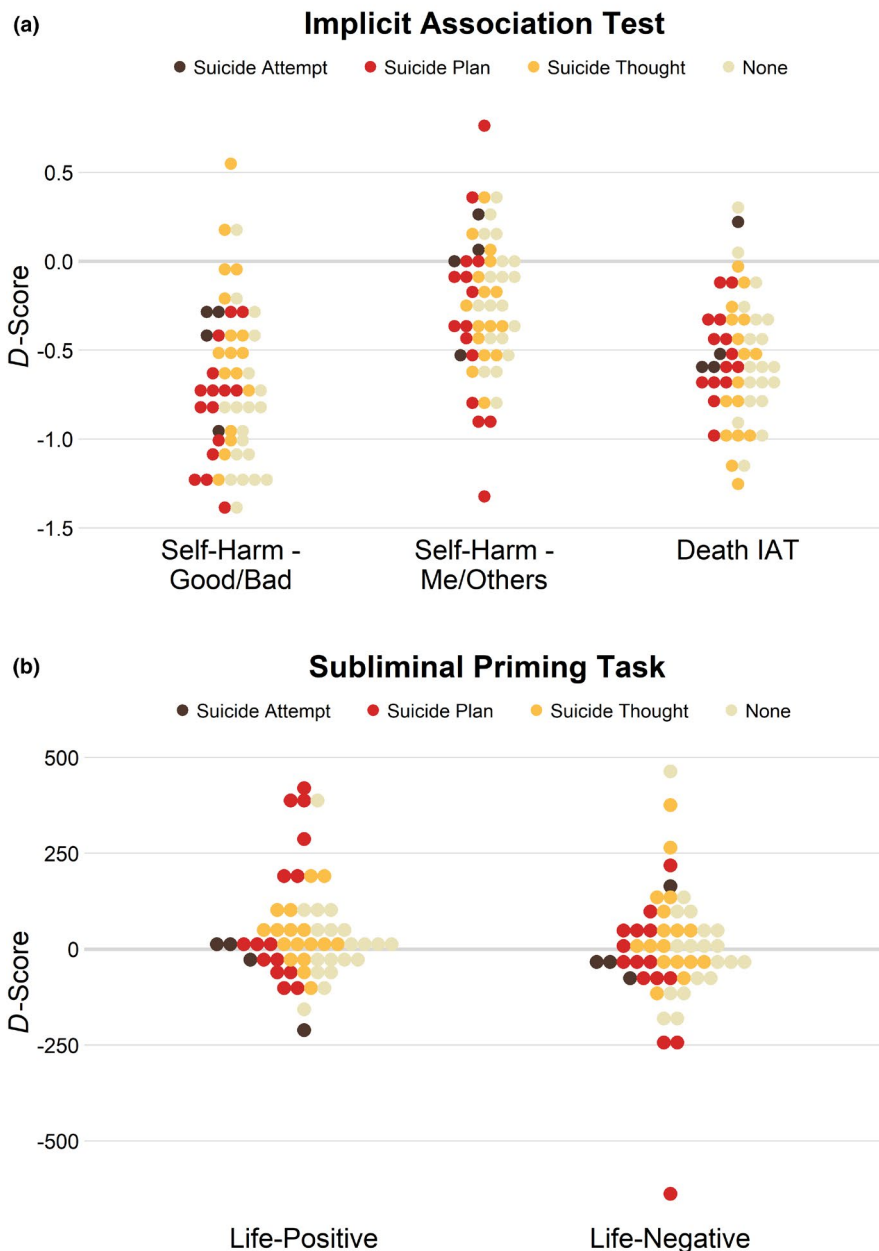


FIGURE 1 The plot displays individual *D*-scores on the different implicit association tests (a) and subliminal priming task (b). The dots' colors indicate whether the patient reported having had a suicide attempt (brown), made a suicide plan (red), had suicidal thoughts (dark yellow), or none of these (beige) during the 18-month follow-up period [Colour figure can be viewed at wileyonlinelibrary.com]

implicit index was correlated with suicidal ideation at follow-up or with the estimated days of suicidal thoughts during the follow-up period. There were no significant group differences between patients with and without suicidal thoughts, plans, or attempts within the 18-month follow-up period. The explicit measure of patients' BSS scores at baseline, however, correlated strongly with their BSS scores at follow-up and showed large effect sizes for the difference between those with and without suicidal thoughts, plans, and attempts.

An additional visual inspection of the indices' distribution showed no distinguishing pattern for suicidality. The four

patients with a suicide attempt during the 18-month follow-up period had scores on implicit measures across the whole range, as did patients with suicide plans or thoughts. This means that our data provided no indication of specificity of the implicit measures.

To summarize, contrary to previous studies (Barnes et al., 2017; Nock et al., 2010; Tello et al., 2020), our results do not suggest that implicit measures predict suicide behavior, whether planning or an actual attempt. Yet, important differences between previous studies and the current study need to be pointed out.

Comparison to previous studies

First, our follow-up period of 18 months is the longest follow-up period reported so far. In fact, this follow-up period was three times as long as those in previous longitudinal studies. It is possible that the IATs have predictive value for 6 months but that for a longer period, the predictive value vanishes. Thus, the predictive interval needs to be established by future research.

Second, while our sample size is typical for predictive studies in suicide research (Franklin et al., 2017), it was lower than previous studies and too low for a robust analysis of the prediction of suicide plans or actual suicide attempts. Thus, we focused on suicidal ideation, making this the first longitudinal study with suicidal ideation as an outcome. Suicidal ideation is highly prevalent in psychiatric practice and requires clinical intervention (Cole-King et al., 2013). Therefore, research should continue to investigate which forms of suicidality the IATs have predictive value for.

Third, the time point of assessment after admission was different than in Nock et al. (2010) and Tello et al. (2020). Nock and Tello investigated all psychiatric patients in an emergency department, not all of whom ended up hospitalized. Yet, all our patients were hospitalized due to severe mental illness and had stayed in hospital for a few days prior to testing (similar to the procedure described in Barnes et al. (2017)). Therefore, it is possible that a therapist's interventions in a single session could have influenced the IAT results as it has been shown that the presentation of suicide awareness material can increase life self-association on the Death IAT in some participants (Arendt et al., 2016). Further, the stay at the hospital possibly influenced the reference group "other" in the IATs through their exposure to patients with worse symptomology (for effects on IAT performance by changes in the reference group, see Karpinski, 2004; Van Ravenzwaaij et al., 2011). In fact, situational factors have large effects on IAT performance (Bertram Gawronski & Sritharan, 2010). Thus, future studies should determine the best time point for assessment.

Open questions

Another open question is the interpretation of the *D*-score. Nock et al. (2010) suggested a cut point of zero as a predictor for suicide attempt, which indicates high specificity. While a cut point of zero seems plausible, others have criticized a cut point of zero in IATs as arbitrary (Blanton et al., 2015). In our sample, only 6% of patients had a *D*-score above zero on the Death IAT (compared to 24% in Nock and colleagues' study) and specificity was low. Additionally, as all values above zero were only marginal, higher *D*-scores in our sample were small in absolute terms. Importantly, possible

confounders, such as task-switching ability as a component of executive function (Klauer et al., 2010) or less idiographic stimuli (Bluemke & Friese, 2012), can also lead to low IAT values. This could mean that if hypothetical patient A has high task-switching ability and the stimuli have little personal meaning, this patient might perform better on the IAT compared to patient B with low task-switching ability for whom the stimuli have—maybe due to a history of psychotherapeutic treatment for suicidal ideation—more personal meaning. Patient A's performance would be better, producing values closer to zero, which in this case would be interpreted as a higher implicit suicidality even though their risk would be lower. Thus, future studies should investigate the conceptual validity of the IAT in the context of suicide. For example, Podlogar et al. (2020) tested several potential moderators for the discrepancy between explicit and implicit suicidality and concluded that poor introspective awareness rather than deception explains the discrepancy between performance on the Death IAT and explicit suicide scales. Furthermore, Harrison et al. (2014) were able to show that the relation between Death IAT and suicidality is mediated by a diminished desire to live rather than an increased desire to die. Likewise, Hussey et al. (2015) compared performance on the Death IAT with performance on the Implicit Relational Assessment Procedure—another implicit measure producing separate scores for different trial types—and suggested that the Death IAT scores might be driven by attitudes toward living rather than by attitudes toward dying. Hence, future studies should refine the methodology to capture implicit cognitions on suicidality and to determine a meaningful cut point indicating increased risk of suicide.

Potential of implicit measures

Although the results seem discouraging for the long-term prediction of suicide behavior on the individual level, the prediction of suicidality on the group level seems much more promising. For a follow-up period as long as 18 months, implicit measures advanced the prediction of suicidal ideation as measured by the BSS—even when controlling for the same scale at baseline. This is in line with reviews from nonclinical fields promoting implicit measures as a tool for studying group effects rather than predicting behavior on the individual level (Payne et al., 2017). In this regard, IATs have large potential (e.g. Greenwald et al., 2015; Teachman et al., 2019). For instance, implicit measures could be used to investigate changes in treatment. As an example, Price et al. (2014) found changes in explicit suicidal ideation but not in the Death IAT after the administration of ketamine. With repeated measures, researchers could, for example, investigate whether changes in implicit cognitions on suicidality align with changes in depression symptoms and whether

these implicit cognitions are precursors or derive from other depression symptoms. For such research questions, measures with lower reliability and specificity are sufficient compared to prerequisites for measures used in a diagnostic setting.

It is a major strength of our study that we did not focus on the Death IAT alone but included other implicit measures. In fact, the Life-Positive score on the subliminal priming task was the strongest implicit predictor of the BSS score at follow-up. Its advantages over the IAT are that the task is easier to understand, it provides two scores, and, as the primes are not processed consciously, the link to suicide remains unclear to the participant. Thus, future studies should consider the subliminal priming task as an additional method to measure implicit cognition of suicidality. Of the three IATs investigated, the Death IAT had the strongest predictive value. The Self-Harm IATs were not predictive in any of the analyses, despite promising previous results (e.g., Glenn et al., 2017; Nock & Banaji, 2007). This is the first longitudinal study that used a range of implicit measures. Future studies should continue this approach to clarify the differences between the IATs used in the literature and to optimize stimuli material.

CONCLUSION

To summarize, we found that on a group level over 18 months, implicit measures added predictive value for suicidal ideation beyond the same explicit scale at baseline, age, and gender. Yet, implicit measures were unsuccessful at predicting suicide plans or attempts in univariate analysis. In this line, predictive value at the individual level was low. To conclude, our results suggest that implicit measures can be used to predict long-term changes in suicidal ideation on the group level, making it a useful tool for research. This is also true for the subliminal priming task, used in our study for the first time. However, our results reduce the hope of using implicit measures in clinical practice for suicide risk assessment on the individual level. As explicit measures seem to have better predictive value, they should be preferred at this point. While our results are limited due to small sample size and low retention rate (but comparable to previous studies; e.g., Tello et al., 2020), they do offer insights due to the long follow-up and the use of multiple implicit instruments and outcomes on suicidality. Next steps might be optimization of the assessment procedure and determination of the predictive interval.

ETHICAL STANDARDS

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and

institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

ACKNOWLEDGEMENTS

We would like to thank Anna Mascherek for providing statistical advice. Further, we would like to thank Marko Stojisavlevic, Birte Jessen, Saija Beck, and Sophie Banasiak for their support with the data collection.

CONFLICTS OF INTEREST

None.

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How to cite this article: Scheunemann, J., Jelinek, L., Peth, J., Runde, A., Arlt, S., Gallinat, J., & Kühn, S. (2021). Do implicit measures improve suicide risk prediction? An 18-month prospective study using different tasks. *Suicide and Life-Threatening Behavior*, 51, 993–1004. <https://doi.org/10.1111/sltb.12785>