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Decomposing implicit associations about life and death improves our understanding of suicidal behavior

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Abstract

The Death/Suicide Implicit Association Test (IAT) is effective at detecting and prospectively predicting suicidal thoughts and behaviors. However, traditional IAT scoring procedures used in all prior studies (i.e., *D*-scores) provide an aggregate score that is inherently relative, obfuscating the separate associations (i.e., “Me = Death/Suicide,” “Me = Life”) that might be most relevant for understanding suicide-related implicit cognition. Here, we decompose the *D*-scores and validate a new analytic technique called the Decomposed *D*-scores (“*DD*-scores”) that creates separate scores for each category (“Me,” “Not Me”) in the IAT. Across large online volunteer samples ($N > 12,000$), results consistently showed that a weakened association between “Me = Life” is more strongly predictive of having a history of suicidal attempts than is a stronger association between “Me = Death/Suicide.” These findings replicated across three different versions of the IAT and were observed when calculated using both reaction times and error rates. However, among those who previously attempted suicide, a strengthened association between “Me = Death” is more strongly predictive of the recency of a suicide attempt. These results suggest that decomposing traditional IAT *D*-scores can offer new insights into the mental associations that may underlie clinical phenomena and may help to improve the prediction, and ultimately the prevention, of these clinical outcomes.

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INTRODUCTION

Suicide is a leading cause of death worldwide (Nock, Borges, & Ono, 2012). Approximately 800,000 people die due to suicide each year, with estimates of 20 times this number making suicide attempts (World Health Organization, 2014). Suicide is the 10th leading cause of death in the United States, and the second among those aged 10–34 years (Heron, 2019). Despite the high prevalence of suicide, suitable tools to accurately measure and predict this behavior are still in their infancy (Large et al., 2016). A potential reason for this underdevelopment is that, until recently, assessment methods have relied primarily on explicit self-reports.

Although self-reports of suicidal thoughts should be taken seriously, relying solely on such reports carries inherent limitations. In regard to advancing understanding, individuals may have insufficient introspective awareness of suicidal thoughts (Wilson, Lindsey, & Schooler, 2000) or actively avoid thinking about these cognitions, making it challenging to gain insight into the characteristics of such thoughts. Regarding risk, self-report is limited because patients may not accurately report or may intentionally conceal suicidal thoughts, in order to avoid being hospitalized or to gain release from a hospital (Carter et al., 2017). In addition, suicidal thoughts are transient, meaning a person may accurately report the absence of suicidal thoughts at one moment, only to have them return shortly thereafter (Kleiman et al., 2017; Nock, Prinstein, & Sterba, 2009). Approaches from psychological science that do not rely on self-report might provide insight into the characteristics of suicidal thoughts and assist in the detection of who is at the highest risk of attempting suicide in the future (Nock, 2016).

One promising avenue is using the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998), a measurement approach that uses reaction time (RT) to capture automatic, implicit processes to examine implicit self-identification with death (vs. life). Implicit measures may be less impacted

by the fluctuating nature of suicide ideation and are capable of detecting at-risk individuals. For example, the Death IAT (D-IAT) has revealed that people with more severe and more recent suicidal thoughts and behaviors consistently show decreased implicit self-identification with life and/or increased implicit self-identification with death. (Barnes et al., 2017; Ellis, Rufino, & Green, 2016; Glenn, Kleiman, et al., 2017; Harrison, Stritzke, Fay, & Hudaib, 2018). Furthermore, research using the D-IAT has found that these self-identification tendencies prospectively predict suicide attempts over a six-month follow-up, above and beyond a history of a prior suicide attempt as well as both clinicians' and patients' predictions of engaging in a suicide attempt (Nock et al., 2010). Other studies have found similar prospective prediction results with reduced identification with life/increased identification with death associated with greater risk (Randall, Rowe, Dong, Nock, & Colman, 2013; Tello, Harika-Germaneau, Serra, Jaafari, & Chatard, 2019).

Despite these promising findings, the precise nature of these death-related implicit cognitions is not well understood. One outstanding question is whether the relationship between implicit cognitions and suicidal thoughts and behaviors is driven by reduced self-identification with life ("Me = Life"), increased self-identification with death ("Me = Death"), or both. Competing theories of the suicidal mind have diverging predictions. For example, Shneidman's (1985) cubic model of suicide and Baumeister's (1990) suicide theories suggest that suicide is a method to escape seemingly intolerable life circumstances. These theories might support the hypothesis that suicidal people will show weakened "Me = Life" associations. Nock (2009) argues that people engage in behaviors that they identify with, which might support the hypothesis of a strengthening of "Me = Death" for suicide attempters. Indeed, research using explicit scales seem to indicate that a heightened wish to die, rather than a weakened wish to live, better predict suicidal intent (Kovacs & Beck, 1977), suicide

attempts (Brown, Steer, Henriques, & Beck, 2005) and suicide typology (O'Connor et al., 2012; however, see Bryan, Rudd, Peterson, Young-McCaughan, & Wertemberger, 2016). It is, of course, possible that both of these processes occur. That is, a person may experience a weakening of their identification with life, followed over time by a strengthening in their identification with death or vice versa (e.g., Bryan, 2020).

Currently, analytic methods cannot test these competing theories because the measurement of implicit cognitions with the D-IAT is inherently relative. The D-IAT requires participants to accurately and quickly classify words into either one of the two category labels ("Me," "Not Me") or one of the two attribute labels ("Death," "Life"). During one block, one button is used to classify "Me" or "Life" words and another button is used to classify "Not Me" or "Death" words (congruent block for the normative sample). Sharing the same response buttons links these items, forming an association between the two pairs. In subsequent blocks, the pairings switch such that "Me" and "Death" share a response button, as do "Not Me" and "Life" (incongruent block for the normative sample).

Implicit cognition of the suicidal mind is calculated with a *D*-algorithm, known as *D*-scores (Greenwald, Nosek, & Banaji, 2003), which is derived by comparing RTs during the congruent block with the incongruent block. If participants respond faster when "Me" and "Life," and "Not Me" and "Death" are paired, this represents both an implicit bias for self-identifying with life and/or others with death. Importantly, since *D*-scores are calculated using RTs that are averaged over all the words during the congruent and incongruent blocks, and these blocks RTs are compared, there is no way *D*-scores can separate the impact of the "Me" and "Not Me" associations from the overall effect (Blanton & Jaccard, 2006). Therefore, calculating separated *D*-scores for associations with "Me" and "Not Me," something we call the Decomposed *D*-scores (*DD*-scores), will allow us to determine if all individuals, including past suicide attempters, are faster to

associate "Me" with "Life" than with "Death."¹ Furthermore, an important aim of this research is to determine whether the *DD*-scores show worse, similar, or better psychometric properties than the relative *D*-scores.

There are three reasons why teasing apart the associations of "Me-Life/Death" and "Not Me-Life/Death" is important. First, most studies show that the majority of participants, including those with suicidal histories, have a negative *D*-score, which represents faster RTs on the "Me = Life/Not Me = Death" trials. There has been a debate that weaker "Me = Life/Not Me = Death" biases among suicidal people represent a reduced desire to live rather than an increased desire to die (Harrison, Stritzke, Fay, Ellison, & Hudaib, 2014). *D*-scores alone cannot solve this debate because they represent a combination of both "Me" and "Not Me" contributions. For example, compared with nonsuicidal people, suicidal people may show faster RTs when "Me" and "Death" are paired, contributing to their weaker "Me = Life/Not Me = Death", as opposed to slower RTs when "Me" and "Life" are paired. Only by decomposing the *D*-score can we learn what implicit cognitions say about the suicidal mind.²

The second reason for decomposing the IAT associations is because specific

¹Researchers have previously analyzed the individual components of the relative *D*-scores (e.g., de Jong, Pasman, Kindt, & van den Hout, 2001; Gemar, Segal, Sagrati, & Kennedy, 2001), but these pursuits were discontinued due to findings from Nosek, Greenwald, and Banaji (2005). However, see O'Shea and Wiers (2020) for a full discussion of relative versus decomposed/separate explicit and implicit measurement, and where they emphasize the important value the *DD*-scores can offer researchers, especially for between-group comparisons.

²The Implicit Relational Assessment Procedure (IRAP; Barnes-Holmes, Murphy, Barnes-Holmes, & Stewart, 2010) is capable of producing separate biases for "Me = Life" and "Me = Death." With this measure, Hussey, Barnes-Holmes, and Booth (2016) showed that 23 psychiatric patients with current suicidal ideation had less negativity when relating "My Death" with negative stimuli than the healthy control group (25 university students).

components of the overall *D*-score may be more prospectively predictive of later suicidal behaviors than others (e.g., “Me” associations more predictive than “Not Me” associations) or than even the overall *D*-score (c.f., Meissner & Rothermund, 2013, Study 7), and hence may eventually help us better identify at-risk patients. The third reason is that an understanding of how the component processes of implicit cognition are related to suicidal behaviors may assist with the development of new treatments that target the crucial biases maintaining suicidal thoughts and behaviors. These biases could differ depending on the level/stage of an individual’s suicidal intent (Baumeister, 1990; Joiner, 2005).

To validate our decomposing method and to gain greater insight into the nature of death-related implicit cognitions, firstly, we will specifically focus on the first reason above and use the *DD*-scores to better understand participants self-identifying with “Life” and “Death” using a large community samples of online volunteers made available by Project Implicit Mental Health (PIMH). Second, we further unpacked the “Me” *DD*-Scores to determine if a weakening of one’s self-association with life, or a strengthening of one’s self-association with death, is the primary mental association differentiating suicide attempters from nonattempters. Prior studies using PIMH have shown that traditional *D*-scores, from multiple versions of the IAT, differ between suicidal and nonsuicidal participants, as well as being more sensitive to recency of suicide attempts (Glenn, Werntz, et al., 2017; Millner, Coppersmith, Teachman, & Nock, 2018). Examining the *DD*-score and decomposition of these scores aims to advance our understanding of how implicit cognitions are related to suicidal behavior.

METHOD

Participants

Following standard exclusion criterion practices (Glenn, Werntz, et al., 2017;

Greenwald et al., 2003; Nosek, Bar-Anan, Sriram, Axt, & Greenwald, 2014),³ the final sample was composed of 6638 adult volunteers from the PIMH website (<https://implicit.harvard.edu/implicit/user/pih/pih/>).

Between March 2012 and October 2014, 2042 participants completed the “Death-IAT” (D-IAT), while 2124 participants completed the “Suicide-IAT” (S-IAT) – each differing slightly in whether the target category and relevant stimuli are related to “Death” (e.g., *dead, dying*) or “Suicide” (e.g., *hanging, overdose*). We also used a different variant of the IAT called the Brief Death (BD)-IAT (Sriram & Greenwald, 2009) with a final sample of 2472 volunteers gathered through the PIMH website between January 2015 and November 2018. The Project Implicit platform has been validated in both the clinical (Glenn, Kleiman, et al., 2017) and social (Nosek et al., 2007) psychological domains. Both the University of Virginia and Harvard University gave Institutional Review Board approval to run all the studies reported here.

Measures

Demographics. Sociodemographic information was gathered from each participant, and included their age, race, gender, ethnicity, education, and country of residence.⁴

Implicit Association Test (Greenwald et al., 1998). The number of trials and the

³For the Death and Suicide IAT, participants were excluded if they: (a) consented but did not complete the IAT, (b) were under 18 years of age, (c) had greater than 10% of IAT trials with RTs faster than 300 milliseconds (ms), and (d) had >30% of overall IAT errors. For the *D*-scores, trials above 10,000 ms were removed. For the Brief Death IAT, similar exclusion criteria were adopted with the addition of the first trial being removed from each block, RTs shorter than 400 ms were recoded to 400 ms, and RTs longer than 2000 ms were recoded to 2000 ms. For the *DD*-scores and the raw RT analysis, RTs below 300 ms and above 5000 ms were removed due to the enhanced precision required to detect response biases.

⁴See Supporting Information for sociodemographic information.

TABLE 1*The number of trials and the classification task in each block of the D-IAT, the S-IAT, and the BD-IAT*

D-IAT & S-IAT			BD-IAT	
Block	Trials	Classification	Trials	Classification
1	20	Me–Not Me	20*	Me = Life–[Not Me = Death]
2	20	Life–Death/Suicide	20*	Me = Death–[Not Me = Life]
3	20*	Me = Life–Not Me = Death/Suicide	20*	Me = Life–[Not Me = Death]
4	40*	Me = Life–Not Me = Death/Suicide	20*	Me = Death–[Not Me = Life]
5	40	Death/Suicide–Life	20*	Me = Life–[Not Me = Death]
6	20*	Me = Death/Suicide–Not Me = Life	20*	Me = Death–[Not Me = Life]
7	40*	Me = Death/Suicide–Not Me = Life	NA	NA

An asterisk (*) indicates trials used to calculate D-scores and DD-scores. The order of the classification tasks is counterbalanced across participants. Items in brackets indicate labels that never appear on the screen.

Category stimuli: Me = I, mine, myself, self; Not me = they, them, their, other; Life = alive, die, breathing, living; Death = suicide, die, deceased, dead; Suicide = gunshot, hanging, overdose, cutting.

classification task used in each block of the IAT are presented in Table 1. If an incorrect button press is made during the classification task, a red “X” will appear below the target word at the center of the screen and will remain there until the correct keypress is made. A simpler version of the IAT, called the *Brief Implicit Association Test* (B-IAT; Sriram & Greenwald, 2009) was also used. The BD-IAT is 1–1½ min shorter than the IAT, but crucially, the “Not Me” category label never appears on the screen. Consequently, participants only ever see two rather than four category labels on the screen. One button is used to classify the stimuli that match the category labels on the screen and another button is used for the stimuli that does not match these two labels. This procedural set up makes the B-IAT especially suited for the *DD*-score analysis and decomposing the *DD*-scores. The BD-IAT has previously been shown to have comparable reliability and between-group difference effect sizes, including similar classification metrics (i.e., ROC-AUC) to the D-IAT (Millner et al., 2018).

Explicit suicidality. For the D-IAT and BD-IAT versions, participants responded to the question, “To what extent do you associate yourself with the concepts of death or life?” using a 9-point scale ranging from –4

(Extremely strong self-life) and 4 (Extremely strong self-death). Participants also responded to the same questions using others instead of yourself. A relative score was created using these two questions by subtracting the “Others-Death/Life” response from the “Self-Death/Life” response. For the Suicide task, the same questions were posed, except that the term “Death” was replaced with “Suicide.”

The Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock, Holmberg, Photos, & Michel, 2007) was adapted for online use and abbreviated to a 20-item questionnaire. The items assessed the frequency and severity of nonsuicidal self-injury, suicidal thoughts, suicide plans and suicide attempts, including suicide attempts requiring medical attention for an individual over their lifetime, within the past year, and within the past week. The SITBI allowed us to create three distinct groups: (a) participants who have never made a suicide attempt (No SA; D-IAT $N = 1380$, S-IAT = 1399, BD-IAT = 1571 participants with at least one lifetime SA but none within the past year (Lifetime SA; D-IAT $N = 396$, S-IAT = 433, BD-IAT = 571), and (c) participants with at least one SA within the past year (Past Year SA; D-IAT $N = 132$, S-IAT = 140, BD-IAT = 186). The groups

selected were the same as Glenn, Werntz, et al. (2017).⁵ Although the SITBI online questionnaire has been used in two previous studies (Glenn, Werntz, et al., 2017; Millner et al., 2018), it has not yet been validated. Of note, the interview version of the SITBI has shown good interrater reliability, test–retest reliability, and concurrent validity when translated from English to German and Spanish (Fischer et al., 2014; García-Nieto, Blasco-Fontecilla, Paz Yepes, & Baca-García, 2013; Nock et al., 2007).

Procedure

Upon arrival at the PIMH website, participants were given preliminary information regarding the upcoming tasks. If they agreed to proceed, they then chose to complete one among various IAT tasks (e.g., depression IAT, Alcohol IAT). The self-harm IAT is classified as a “special task” and the informed consent is more detailed than the other IATs on the site. It gives participants examples of stimuli that they may be exposed to during the task, as well as mental health resources.

After agreeing to the informed consent, participants were randomly assigned to either the D-IAT, the S-IAT or the BD-IAT.⁶ Each participant completed the demographic questions, the explicit suicidality questions, the online SITBI, and the IAT in random order. After the final task, participants read the debriefing form and had the option to view an explanation of their implicit results (e.g., “Your responses show that you sorted words much faster when DEATH and ME were paired on the same key (relative to DEATH and NOT ME), which suggests that you may have a strong implicit association between

death and yourself.”). On the debriefing page, participants who were flagged as being at risk were given an additional message encouraging them to seek help and provided suicide hotline information and other resources. There is no evidence that completing the Death/Suicide IAT or asking participants about suicide increases suicidal ideation (see Cha et al., 2016).

Data analytic plan

Analyses were carried out using groups that are defined by behavior: (a) No SA, (b) Lifetime SA, and (c) Past Year SA. The results are presented in two separate sections. The first section focused on validating the *DD*-scoring technique. Here we tested how the new *DD*-scores compare to the traditional *D*-scores previously used in Glenn, Werntz, et al. (2017), where the authors showed that the *D*-scores were capable of differentiating between the three groups.

The *DD*-scores are an adaption of Greenwald et al., (2003) *D*-scores. The RTs for the four mental associations (“Me = Life,” “Not Me = Death,” “Me = Death,” “Not Me = Life”) in test blocks 3, 4, 6, and 7 are calculated by averaging participants’ RT scores for each association. The *DD*-scores are calculated by subtracting the mean RTs of the “Me = Death” associations from the “Me = Life” associations and this number is divided by the mean standard deviation (*SD*) across the corresponding sorting associations.⁷ The *DD*-score can also be used to calculate the association of “Not Me” with “Death” and “Life.” Similar calculations can be performed with participants’ error rate scores, as well as trials where only correct responses are made.

Since we are primarily interested in an individual’s self-identification with suicide/death, “Me” *DD*-scores, rather than “Not Me” *DD*-scores, will be analyzed. A mixed ANOVA was used to determine if the *DD*-

⁵Similar to Glenn et al. (2017b), there was not enough power to carry out an analysis that included only past week suicide attempters.

⁶The cutting IAT (associating “Me” and “Not Me” with images of cut and uncut forearms) was another IAT participants could be randomly assigned to if they selected the self-harm IAT. The focus of this paper is not nonsuicidal self-injury (NSSI), and hence this dataset was not analysed.

⁷Similar findings are shown if the pooled *SD* across the corresponding associations is used.

scores could successfully differentiate between the groups and how the magnitudes of the *DD*-scores compare to the magnitude of the *D*-scores, with Group as the between-subject factor and Scoring Type (*D*-scores, *DD*-scores) as the within-subject factor. To match the *D*-scores calculation, the *DD*-scores were calculated using the composite score of RTs and error rates. These composite scores use RTs as measured from the onset of the stimulus until the correct response is made. We visually presented *DD*-scores separately for error rates and for RTs on trials where only correct responses were made. For completeness, we also visually present all the *DD*-scores for the “Not Me” associations.

We used receiver operating characteristics (ROC) area under the curve (AUC) analysis to determine if the *DD*-scores show similar, improved, or reduced ability than the *D*-scores at predicting an individual's group classification. Groups are classified as (a) No SA versus Lifetime SA, (b) No SA and Lifetime SA (excluding Past Year SA) versus Past Year SA, and (c) Lifetime SA versus Past Year SA. Further evidence validating the *DD*-scores using implicit and explicit correlations is presented in the Supporting Information. We also reported the positive predictive values (PPVs; see Glaros & Kline, 1988) confidence intervals for the *D*-scores and the *DD*-scores before and after accounting for suicide attempt base rates. Matching prior studies, an IAT cut off score of zero was used to calculate the PPVs (e.g., Nock et al., 2010). We used 0.79% as the prevalence rate, which was based on US suicide attempts estimates from 2012 through to 2013 (Olfson et al., 2017).

The second section of analyses further unpacked the “Me” *DD*-scores for both correct RTs and error rates for the three IAT variants, to determine whether the groups differ due to a weakening of “Me = Life” associations, a strengthening of “Me = Death/Suicide” associations, or due to the equal impact of both these effects. For the decomposing *DD*-scores, the average RTs for the “Me = Death” and “Me = Life” associations are used. Mixed ANOVAs were used to test for an interaction between groups and the

two associations. We also used ROC-AUC analysis to determine which of the unpacked *DD*-scores show the strongest ability to predict an individual's group membership. The same group classifications as section one above were used here. Where appropriate, follow-up one-way ANOVAs and post hoc Tukey tests were conducted throughout. If an equal variance is not assumed, Games–Howell correction was used. Replication of the findings for the D-IAT and the S-IAT for more recent years 2015–2018 ($N = 5400$) are shown in the Supporting Information.

RESULTS

Section 1: validating the DD-scores by comparing them to the D-scores

In a 2 (Scoring Type: *DD*-score, *D*-score⁸) \times 3 (Group: No SA, Lifetime SA, Past Year SA) mixed ANOVA, a main effect of Scoring Type was shown ($F_s > 38.51$, $p_s < 0.001$, $\eta\rho^2 > 0.020$) such that the *DD* Me-RT-scores on both the D-IAT, S-IAT, and BD-IAT were significantly closer to neutral/zero than the *D*-scores of the corresponding IAT, indicating that overall the *DD*-scores showed weaker “Me = Life” or stronger “Me = Death” biases. A main effect of group also was shown across the three IAT variants ($F_s < 34.14$, $p_s < 0.001$, $\eta\rho^2 > 0.035$), such that the No SA group showed the lowest scores (stronger “Me = Life” and/or weaker “Me = Death” biases), followed by the Lifetime SA group, with the Past Year SA group showing the highest scores (weaker “Me = Life” and/or stronger “Me = Death” biases).

Importantly, a Score \times Group interaction was shown on all three IAT variants ($F_s > 5.30$, $p_s < 0.006$, $\eta\rho^2 > 0.006$). Based on visual inspections of Figure 1, this interaction occurs because a minimal difference was shown between the *D*-scores and the *DD*-Me-RT-scores for the No SA group.

⁸The *DD*-scores and *D*-scores are highly correlated ($r_s > .90$).

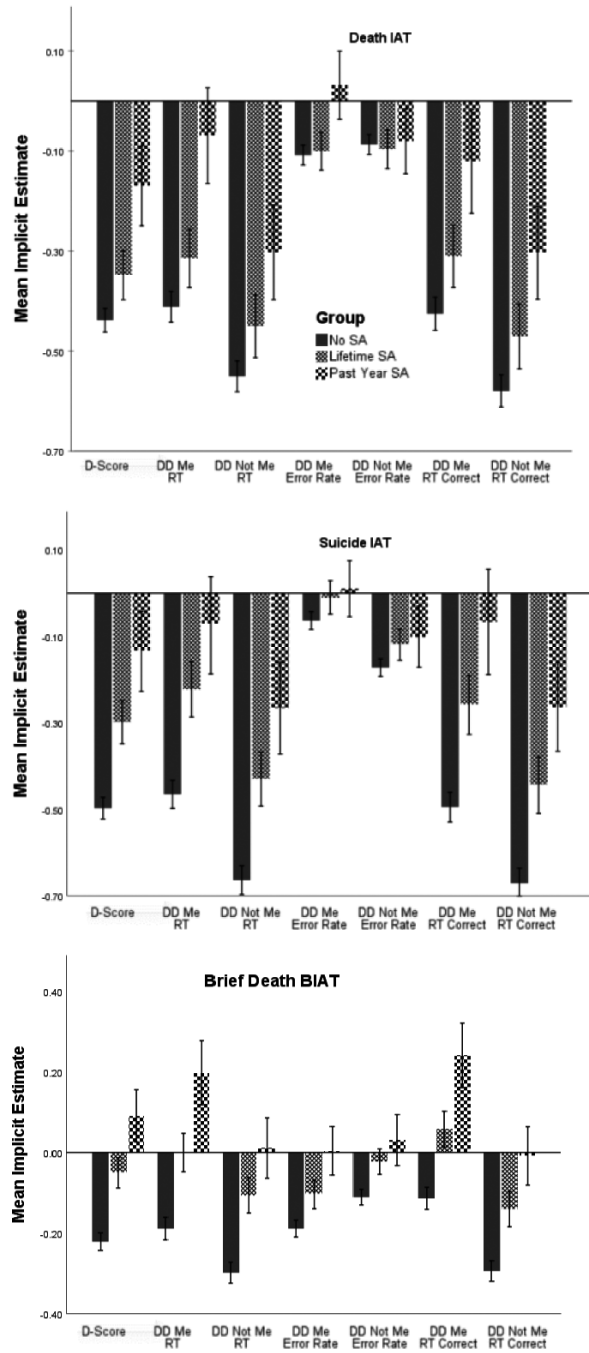


Figure 1. The traditional IAT D-scores and how it compares to the various DD-scores. Scores are coded such that lower values indicate a “Me = Life” and/or a “Not Me = Death” bias. No SA = No Suicide Attempts; RT = Reaction Time; Correct = analyses where only correct trials were used. Error bars are 95% confidence intervals

However, for Lifetime SA, but especially Past Year SA, higher *DD*-Me-RT-scores were shown than the *D*-scores. This finding offers

initial evidence that the *DD*-scores may have improved capabilities of detecting high-risk SAs because more of these participants

crossed the zero threshold, indicating they are faster on the “Me = Death” than on the “Me = Life” associations. As seen in Figure 1, a similar pattern emerged for all the conditions; however, only the *DD*-Me-scores in the D-IAT and S-IAT crossed the zero threshold for Past Year SA. In the BD-IAT, the zero threshold was crossed more often and showed especially strong “Me = Death” biases for Past Year SAs.

Table 2 shows the ROC AUC analysis, separated by IAT version, for the *D*-Score and the various *DD*-Scores for the three separate classification groups. Generally, both the *DD*-Me RT-scores performed comparably to the traditional *D*-Score at correctly classifying an individual's group membership, while the *DD*-Not Me-RT showed only slight reductions at an individual's group classification accuracy. Overall, the *DD*-Error-Rate-scores, especially the *DD*-Not Me-Error-Rates, performed worse.

These findings indicate that the *DD*-Me-RT-scores performs comparably to the traditional *D*-score at classifying an individual's group membership, even though the *DD*-scores are at a disadvantage by having 50% fewer trials than the *D*-scores. Regarding PPVs, for the *D*-scores, the confidence intervals were between 31.96%–48.33%, and for the *DD*-scores, PPVs ranged between 38.47%–53.61%. PPVs were substantially reduced when accounting for the low base rate of suicide attempts. For these *D*-score PPVs, the confidence intervals were between 0.84%–3.17%, and for the *DD*-scores PPVs, they ranged between 0.81%–2.73%. In summary, these findings offer initial evidence that the *DD*-scores, especially the *DD*-Me-RT-scores, are just as valid an analytic technique as the *D*-scores. Therefore, this validity indicates it is possible to decompose the *DD*-scores further.

*Section 2: decomposing the DD-score:
“Me” combined classification blocks of the
IAT*

This section aimed to determine if the groups differed due to a weaker “Me = Life,”

a stronger “Me = Death,” or both these associations. Using participants correct RTs for the D-IAT, the S-IAT and the BD-IAT, the 2 (Association: Me-Life, Me-Death) × 3 (Group: No SA, Lifetime SA, Past Year SA) mixed ANOVA showed a main effect of Association ($F_s > 16.43$, $ps < 0.001$, $\eta\rho^2 > 0.007$) such that RTs were faster for “Me = Life” than “Me = Death” trials; the main effect of group was not significant ($F_s < 2.30$, $ps > 0.100$, $\eta\rho^2 < 0.002$). Most importantly, a significant interaction was shown between the Association and Group (D-IAT: $F = 19.00$, $p < .001$, $\eta\rho^2 = 0.020$; S-IAT: $F = 41.54$, $p < .001$, $\eta\rho^2 = 0.040$; BD-IAT: $F = 60.52$, $p < .001$, $\eta\rho^2 = 0.049$).⁹ These interactions can be clearly seen in Figure 2. Below we will further elaborate on why the interactions are occurring.

For each IAT variant, one-way ANOVAs showed a significant main effect of Group for both the “Me = Life” associations ($F_s > 5.69$, $ps < 0.003$, $\eta\rho^2s > 0.006$) and “Me = Death” associations ($F > 4.32$, $p < .013$, $\eta\rho^2 > 0.005$). For “Me = Life” associations, the No SA group showed significantly faster RTs than both the suicidal groups (Lifetime SA: $ts > 2.77$, $ps < 0.017$, $ds > 0.160$; Past Year SA: D-IAT: $t = 1.95$, $p = .127$, $d = 0.189$,¹⁰ S-IAT & BD-IAT: $ts > 3.54$, $ps < 0.001$, $ds > 0.296$), which did not differ from each other ($ts < 0.75$, $ps > 0.732$, $ds < 0.071$). For the “Me = Death” associations, only Past Year SA showed significantly faster RTs than No SA ($ts > 2.51$, $p < .032$, $d > 0.223$). Similarly, Past Year SA had significantly faster RTs than Lifetime SA on the D-IAT and the BD-IAT ($ts > 2.33$, $ps < 0.052$, $ds > 0.232$), but not the S-IAT ($t = 1.46$, $p = .312$, $d = 0.189$). These results indicate that the correct RTs to the “Me = Life” association are effective when used for identifying groups that differ based

⁹As recommended by a reviewer, when age (continuous) and gender (dichotomous) were included as covariates, similar results were shown.

¹⁰This effect is significant (D-IAT: $t = 2.67$, $p = .023$, $d = 0.274$) if RTs from trials with errors are included (composite score).

TABLE 2

The ROC-AUC comparisons between the traditional D-Scores and various DD-scores

	No SA versus LTSA & PYSA	No SA & LTSA versus PYSA	LTSA versus PYSA
Death-IAT			
D-Score	0.54 (0.50–0.57)	0.66 (0.61–0.71)	0.61 (0.56–0.67)
DD-Me-RT	0.53 (0.50–0.57)	0.67 (0.62–0.72)	0.63 (0.57–0.69)
DD-Not Me-RT	0.53 (0.50–0.57)	0.62 (0.57–0.67)	0.58 (0.53–0.64)
DD-Me-Error Rate	0.50 (0.47–0.53)	0.61 (0.56–0.67)	0.61 (0.55–0.67)
DD-Not Me-Error Rate	0.49 (0.46–0.53)	0.51 (0.45–0.56)	0.51 (0.45–0.57)
DD-Me-RT Correct	0.54 (0.51–0.57)	0.64 (0.59–0.69)	0.60 (0.54–0.65)
DD-Not Me-RT Correct	0.54 (0.50–0.57)	0.63 (0.58–0.68)	0.59 (0.53–0.65)
Suicide-IAT			
D-Score	0.60 (0.56–0.63)	0.68 (0.63–0.73)	0.59 (0.53–0.65)
DD-Me-RT	0.60 (0.56–0.63)	0.66 (0.61–0.71)	0.57 (0.52–0.63)
DD-Not Me-RT	0.59 (0.56–0.62)	0.66 (0.61–0.71)	0.58 (0.52–0.64)
DD-Me-Error Rate	0.54 (0.51–0.57)	0.55 (0.50–0.60)	0.51 (0.45–0.57)
DD-Not Me-Error Rate	0.53 (0.50–0.57)	0.54 (0.48–0.59)	0.50 (0.45–0.57)
DD-Me-RT Correct	0.59 (0.55–0.62)	0.66 (0.61–0.71)	0.58 (0.53–0.64)
DD-Not Me-RT Correct	0.58 (0.55–0.62)	0.66 (0.61–0.71)	0.59 (0.53–0.64)
Brief Death-IAT			
D-Score	0.59 (0.56–0.62)	0.67 (0.63–0.71)	0.59 (0.54–0.64)
DD-Me-RT	0.58 (0.55–0.61)	0.67 (0.63–0.71)	0.60 (0.55–0.65)
DD-Not ME-RT	0.58 (0.56–0.61)	0.64 (0.60–0.68)	0.56 (0.52–0.61)
DD-Me-Error Rate	0.55 (0.52–0.57)	0.62 (0.58–0.66)	0.57 (0.53–0.62)
DD-Not Me-Error Rate	0.55 (0.52–0.58)	0.58 (0.53–0.63)	0.54 (0.49–0.59)
DD-Me RT-correct	0.58 (0.55–0.61)	0.66 (0.62–0.70)	0.59 (0.54–0.64)
DD-Not Me-RT Correct	0.57 (0.54–0.60)	0.64 (0.59–0.68)	0.57 (0.52–0.62)

Brackets contain the 95% bootstrapped confidence intervals. Scores in bold indicate the best classifying variable.

Correct = analyses where only correct trials were used, LTSA = Lifetime Suicide Attempts, No SA = No Suicide Attempts, PYSA = Past Year Suicide Attempts, RT = Reaction Time.

on having engaged in a SA versus those that haven't, while the "Me = Death" association is most useful when identifying groups that differ based on a more recent suicide attempt (Past Year) versus No SA and Lifetime SA.

Consistent with the RTs, for error rates we find a significant interaction between the Associations and Group (D-IAT: $F = 12.93$, $p < .001$, $\eta\rho^2 = 0.013$; S-IAT: $F = 6.87$, $p = .001$, $\eta\rho^2 = 0.007$; BD-IAT: $F = 17.99$, $p < .001$, $\eta\rho^2 = 0.015$) in all three IAT variants. These interactions occurred

because the "Me = Life" error rate associations showed a significant main effect of Group ($F_s > 8.16$, $ps < 0.001$, $\eta\rho^2_s > 0.008$), but not for "Me = Death" error rate associations ($F_s < 1.05$, $ps > 0.351$, $\eta\rho^2_s < 0.001$). For the "Me = Life" associations, in the D-IAT, only Past Year SA made significantly more errors than No SA and Lifetime SA ($ts > 3.56$, $p < .001$, $d > 0.337$), while in the S-IAT, only Lifetime SA made significantly more errors than No SA ($t = 3.42$, $p = .002$, $d > 0.204$). Finally, in the BD-IAT, all the

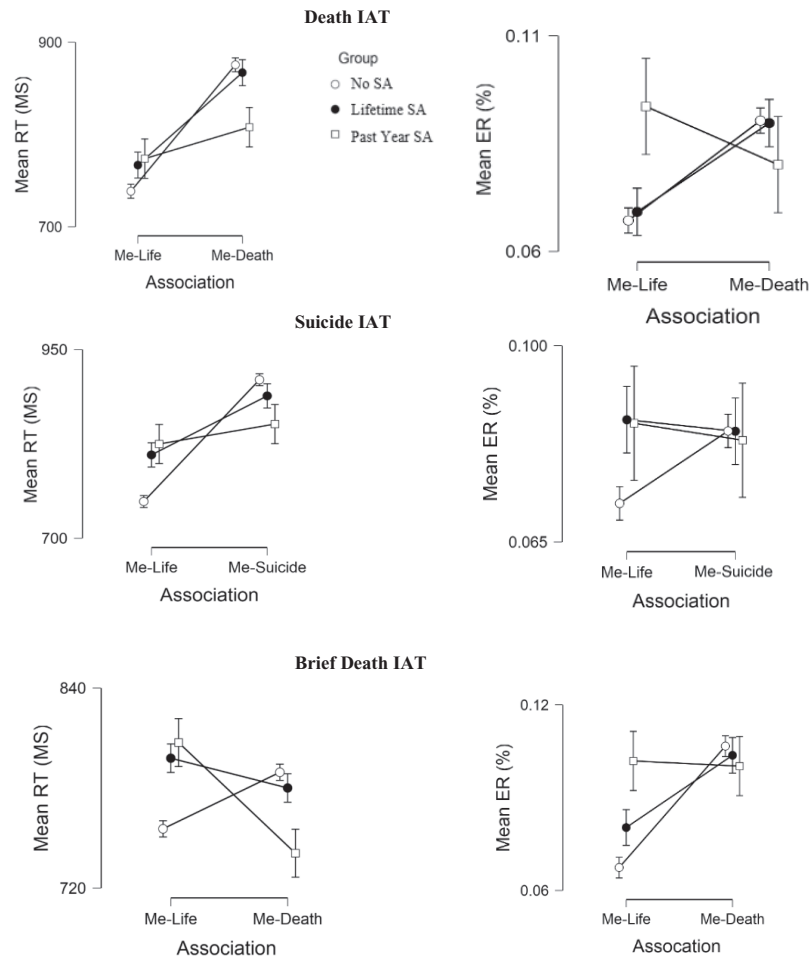


Figure 2. (Left) Interaction between Group and Association for participants reaction times (RTs), and (Right) for participants error rates, for three different IATs. Error bars are 95% confidence intervals. ER = error rate; RT = reaction time; SA = suicide attempt

groups were significantly different from each other ($t_s > 2.96$, $p < .009$, $d_s > 0.271$), such that No SA made the least errors followed by Lifetime SA, and then Past Year SA.

Finally, as shown in Table 3, the composite (RTs & error rates) “Me = Life” RT scores showed the best classification abilities when distinguishing between No SA and any SA (Lifetime & Past Year) for the three IAT variants. In contrast, for those who had previously engaged in a suicide attempt, the “Me = Death” RT association showed superior abilities at detecting those who had recently engaged in a suicide attempt on both the D-IAT and the

BD-IAT. Patterns were less consistent in the S-IAT.

DISCUSSION

The IAT, tailored to measure automatic self-associations with death/suicide, provides a promising behavioral tool to better assess and understand suicidal thoughts and behaviors. Despite research showing the ability of the IAT to differentiate individuals by suicidal history and even prospectively predict future suicidal behaviors, the precise nature of these death-related implicit cognitions

TABLE 3*The ROC AUC comparisons between the various combination of the Me-Life and Me-Death associations*

	No SA versus LTSA & PYSA	No SA & LTSA versus PYSA	LTSA versus PYSA
Death-IAT			
Life Me RT	0.54 (0.51–0.58)	0.56 (0.51–0.61)	0.52 (0.46–0.57)
Death ME RT	0.51 (0.48–0.55)	0.61 (0.56–0.66)	0.59 (0.54–0.65)
Life Me Error Rate	0.50 (0.47–0.53)	0.58 (0.53–0.63)	0.57 (0.52–0.63)
Death Not Me Error Rate	0.50 (0.47–0.53)	0.54 (0.49–0.59)	0.54 (0.48–0.59)
Life Me RT Correct	0.54 (0.51–0.57)	0.53 (0.48–0.58)	0.49 (0.44–0.55)
Death Me RT Correct	0.51 (0.48–0.54)	0.59 (0.54–0.64)	0.58 (0.52–0.63)
Suicide-IAT			
Life Me RT	0.59 (0.56–0.62)	0.61 (0.56–0.65)	0.53 (0.48–0.58)
Death ME RT	0.52 (0.48–0.55)	0.56 (0.52–0.61)	0.55 (0.49–0.60)
Life Me Error Rate	0.54 (0.51–0.57)	0.54 (0.49–0.59)	0.50 (0.45–0.56)
Death Not Me Error Rate	0.49 (0.46–0.52)	0.51 (0.46–0.56)	0.52 (0.46–0.57)
Life Me RT Correct	0.58 (0.55–0.61)	0.61 (0.56–0.65)	0.53 (0.48–0.59)
Death Me RT Correct	0.52 (0.49–0.55)	0.56 (0.51–0.61)	0.54 (0.49–0.60)
Brief Death-IAT			
Life Me RT	0.57 (0.54–0.60)	0.58 (0.54–0.63)	0.52 (0.47–0.57)
Death ME RT	0.50 (0.47–0.53)	0.59 (0.55–0.63)	0.59 (0.54–0.64)
Life Me Error Rate	0.55 (0.52–0.57)	0.61 (0.57–0.65)	0.57 (0.52–0.62)
Death Not Me Error Rate	0.51 (0.48–0.54)	0.52 (0.47–0.56)	0.51 (0.46–0.56)
Life Me RT Correct	0.56 (0.54–0.59)	0.56 (0.52–0.61)	0.51 (0.46–0.56)
Death Me RT Correct	0.50 (0.47–0.53)	0.59 (0.54–0.63)	0.59 (0.54–0.63)

Brackets contain the 95% bootstrapped confidence intervals. Scores in bold (only if significant) indicate the best classifying variable.

Correct = analyses where only correct trials were used, LTSA = Lifetime Suicide Attempts, No SA = No Suicide Attempts, PYSA = Past Year Suicide Attempts, RT = Reaction Time.

is not well understood. In this study, we sought to validate a novel method of decomposing the traditional IAT *D*-scores, called Decomposed *D*-scores (*DD*-scores), which produces separate scores for “Me = Death/Life” and “Not Me = Death/Life” associations. We also sought to disentangle whether death-related implicit cognition is driven by reduced self-identification with life, increased self-identification with death, or both.

here were two main findings¹¹ from this report based on analyses of three variants

of the death/suicide-related IATs (Death (D)-IAT, Suicide (S)-IAT, and Brief Death (BD)-IAT). First, we found that the *DD*-scores, especially the composite *DD*-scores using RTs for self-association (“Me”) trials (*DD*-Me-RT scores), performed similarly to the traditional *D*-scores based on ROC-AUC group classification metrics, positive predictive values (PPVs), and correlations with explicit responses (see Supporting Information). Second, results provided evidence for the effectiveness of decomposing the *DD*-scores further to determine whether self-identification with life (“Me = Life”), self-identification with death (“Me = Death”), or both these associations are most useful at distinguishing between three groups varying by presence and recency of past suicide attempt

¹¹In general, comparable findings were shown with the direct replication using more recent data, especially the importance of “Me = Life” associations (see Supporting Information).

(SA) (i.e., No SA, Lifetime SA, & Past Year SA). Specifically, “Me = Life” associations were most predictive when identifying suicide attempters from nonattempters, while “Me = Death” associations were most predictive when identifying Past Year SA from Lifetime SA.

New methods to investigate suicidal behaviors

Using the DD-Me-scores, we were able to determine whether “Me = Life” or “Me = Death” associations showed faster RTs across the two critical blocks. The majority of the participants, even Past Year SAs (see the D-IAT and the S-IAT in Figure 1), associated “Me = Life” faster than “Me = Death,” suggesting that participants, on average, had stronger associations with life than death. This finding is perhaps illustrating the strong evolutionary bias humans have toward living and surviving (Joiner, 2005; Joiner, Hom, Hagan, & Silva, 2016; cf. Aubin, Berlin, & Kornreich, 2013). Alternatively, the procedure of the D-IAT and the S-IAT might be impacting RTs because the BD-IAT showed that Past Year SAs were faster to associate “Me = Death” than “Me = Life.” The “Not Me” category label never appears during the BD-IAT, which might account for most of these high-risk individuals crossing the zero threshold. This finding seems to indicate that the BD-IAT is particularly suited to the DD-scores analysis technique, but unfortunately, the BD-IAT did not show enhanced group classification abilities compared to the traditional IAT procedures (see Table 2).

We further emphasize the usefulness of decomposing the DD-scores by showing that the “Me = Life” associations are particularly effective at distinguishing between individuals that have engaged in a SA (Lifetime & Past Year) and those that have never made a SA. This finding was consistent across IAT variants and method of analysis (i.e., both RTs and error rates). Therefore, what distinguishes suicide attempters from nonattempters is a reduced identification of “Me”

with “Life,” which indicates that a diminished desire to live or a need to escape intolerable aspects of life (e.g., Baumeister, 1990; Shneidman, 1985) appears to be crucial for suicide attempters. However, when distinguishing between more recent SAs (Past Year) from Lifetime SAs, an increased identification of “Me” and “Death” was a better predictor on the D-IAT and the BD-IAT (not the S-IAT), but only when using the RT analysis and not the error rate analysis. Reduced variance or a potential floor effect might account for error rates not being capable of distinguishing between any of the three groups for the “Me = Death” association (Draheim, Mashburn, Martin, & Engle, 2019). Moreover, DD-Error Rate-scores show inferior ability across all the IAT variants at correctly classifying an individual’s group membership. Regardless, for RTs, “Me = Death” associations seem to indicate that those with a more recent SA (Past Year) identify themselves more strongly with death (Nock, 2009).

Of note, those that have more recently engaged in a SA, also have engaged in significantly more SAs ($M = 4.63$, $SD = 6.88$) than the broader group of lifetime SAs ($M = 2.48$, $SD = 3.26$, $t(310.51) = 4.94$, $p < .001$),¹² which could also account for their stronger “Me = Death” association. The persistence of implicit suicidal cognitions (Wells, Tucker, Kraines, Smith, & Unruh-Dawes, 2020) or the psychological scarring (Liu, 2019) of past suicide attempts might be used to explain the stronger “Me = Death” association. Though speculative, these findings raise the possibility that perhaps those who have made a SA more recently than in the past year (i.e., past month) or who attempts suicide in the near future, may show stronger “Me = Death” associations on both RTs and error rates than those who attempted suicide in the more distant past. Using the current datasets, we are unable to

¹²A participant who claimed to have made 600 SAs and another who made 100 SAs were removed from this analysis. The range was between 1 and 50.

unpack these speculations, but existing datasets using clinical samples can be used to test the accuracy of these speculations. These analyses are important next steps.

Clinical implications

The clinical implications of these findings suggest that an implicit diminished desire to live is crucial for identifying an at-risk suicidal individual. However, it is expected that nonsuicidal individuals with other psychiatric disorders such as depression could also show weaker “Me = Life” associations. Therefore, “Me = Death” associations may be particularly useful when distinguishing between those with an imminent risk of a SA and those with other psychiatric conditions. Further research using existing datasets, with the new methods described here, can help determine whether the “Me = Death” associations are especially useful for prospectively predicting a death by suicide. This research can also add an implicit dimension to the suicidal ambivalent literature which to date has mainly focused on participants’ explicit wish to die and wish to live (see Bryan, 2020 for an overview).

The *DD*-scores and decomposing these scores may be useful when informing treatment development and targeting the specific biases with the most significant impact of reducing suicidal thoughts and behaviors. For example, perhaps therapists should focus primarily on reasons for living to increase self-identification with life, mainly emphasize the downsides of dying to decrease self-identification with death or combine both these techniques. Moreover, perhaps the emphasis of therapy should change depending on whether an individual has started to have suicidal ideations, following a SA, or during the first week after being released from the hospital (see Forte, Buscajoni, Fiorillo, Pompili, & Baldessarini, 2019).

These new analytic methods reported would also be useful for determining why an intervention or a therapy is effective at

changing implicit biases. However, caution must be applied when using the IAT in pre and post designs because it has strong practice effects (i.e., scores trend in the direction of a neutral bias; Greenwald et al., 2003). Therefore, using control conditions is crucial (see Teachman & Woody, 2003). Furthermore, we believe that testing the effectiveness of different therapies on implicit mental associations across different clinical settings would be especially useful with the new analytic methods proposed here. This recommendation is based on recent evidence that RT differences scores are particularly suited to testing between-group differences/context effects (e.g., Draheim et al., 2019; Payne, Vuletich, & Lundberg, 2017).

The new methods reported in this paper to decompose the IAT can easily be extended to other areas of psychopathology. For example, Project Implicit Mental Health uses the IAT to measure bias toward various clinical conditions (e.g., alcoholism, self-esteem, depression, etc.) Recently they have expanded their research to also include physical health (e.g., exercise IAT, healthy food IAT) and therefore, testing the effectiveness of *DD*-scores and the unpacked *DD*-scores across both the mental and physical domains are important next steps.

Limitations and conclusion

A limitation of this study is that data collection was conducted online with volunteer samples who may not be representative of the general population (Glenn, Wernitz, et al., 2017). The online nature of the studies means we relied on participants’ self-report of past engagement in SAs. But regardless, this limitation would make our findings more conservative because it would create more noise in the dataset. Related to this point, and something we regard as a strength of this study, we measured a specific behavior (SAs) as opposed to proxies to these behaviors, such as suicidal thoughts. Future studies that examine how the *DD*-scores and the unpacked *DD*-scores relate to an individuals’ suicide plan or their desire to die (suicide ideation) are warranted.

One could argue that simply asking how many SAs an individual has previously made or determining the recency of a SA could be more useful indicators of suicide risk than getting individuals to complete the IAT. However, these variables would be less useful for those who die by suicide on their first attempt or for those wishing to conceal suicidal ideations. For example, a recent study using a large adolescent sample at 13 emergency departments found that the D-IAT was predictive of future SAs among those who denied suicide intent but not among those who disclosed this information (Brent et al., 2020).

Positive predictive value (PPV) indicates the proportion of positive test results (i.e., IAT scores above zero) which are actually positive (i.e., individuals that previously made a suicide attempt) (Glaros & Kline, 1988). So, if 10% of IAT scores were above zero and 8% of these participants reported having made a suicide attempt, the PPV would be 80%. However, this PPV would be reduced to 22.28% when taking account of the base rate for suicide attempts (0.79%). Therefore, with this low base rate, low sensitivity, and hence low PPVs are to be expected, resulting in critics arguing that suicide prevention tools, such as the IAT, have no clinical value (e.g., Belsher et al., 2019). However, Kessler, Bossarte, Luedtke, Zaslavsky, and Zubizarreta (2020), argues that evaluating the Net Benefits of using a suicide prevention tool relative to its cost may have value for rare outcomes. For example, even if the IAT shows low PPV, the tool is cheap, has a short duration, and easy to implement (i.e., the Death IAT can be completed in a waiting room prior to a clinical consultation) and has the potential of flagging up at-risk individuals who may initially deny suicidal intent (Brent et al., 2020). Importantly, we would not recommend practitioners rely solely on the IAT as a marker of suicide risk. Instead, the IAT could be used in conjunction with additional metrics with good psychometric properties to more comprehensively evaluate risk. For instance, advances in machine learning techniques could be used to help

identify the most at-risk individuals (e.g., Barak-Corren et al., 2020; Ribeiro, Huang, Fox, Walsh, & Linthicum, 2019).

The D/S-IATs and the explicit measures aiming to determine how a participant associates oneself and others with death/suicide or life are limited because they do not specify the relationship between the concepts (De Houwer, 2014; Hughes, Barnes-Holmes, & De Houwer, 2011). For example, a respondent might have a strong "Me = Suicide" association, not because they are suicidal, but because one of their family members or close friends died by suicide. One option would be to adapt the IAT and the explicit measures to include propositional statements that define the relationship between the self and suicide/death (e.g., I want to die by suicide versus I want to continue living; see Irving & Smith, 2020), though this would change the nature of the associations being measured. Relatedly, further psychometric work is needed to determine the suitability of the word stimuli used in the Death and Suicide IAT. Stimuli that shows an enhanced ability at effectively differentiating between SAs and non-SAs and which clearly reflect the superordinate category's concept (without activating other potential meanings) are likely to show improved prospective predictions, especially when using the DD-scores.

It should be emphasized that the *DD*-scores can only be decomposed if no major differences in RTs or error rates are shown at baseline between the groups used in the analysis. Therefore, the average scores of "Me," "Not Me," "Life" and "Death" on the practice block of the IAT where no associations are being performed (Blocks 1,2, and 5, see Table 1) should be similar for each group. As an example, if recent SAs had faster RTs to all stimuli during these blocks where no associations are formed, then they would be faster when associating "Me = Death" due to both their baseline RT speed and their stronger identification with death. Correspondingly, their baseline RT speed will also impact the "Me = Life" associations and could result in similar or potentially even faster RT than nonattempters even when SAs could actually

have far weaker “Me = Life” associations (see Supporting Information where we provide these additional tests).

In conclusion, results from this study support the validity of the *DD*-scores analysis technique on the IAT and address a key gap in our understanding of the nature of death-related implicit cognition. Specifically, across all IATs, a decreased desire to live, as opposed to an increased desire to die, appears to be crucial in distinguishing SAs from nonattempters. However, an

increased desire to die seems to be especially suited at detecting higher frequency suicide attempters, including more recent attempts. Using the new methods reported here to analyze IAT data, researchers across a host of domains (clinical, social, and forensic) can glean important new insights into why implicit biases are occurring and being maintained. An important next step includes expanding the new analysis techniques reported here to IAT datasets that prospectively predicted SAs.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Supplementary Materials: Main Report: Original Samples, Pages 1–10