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Towards the Objective Assessment of Suicidal States: Some Neurocognitive Deficits may be Temporally Related to Suicide Attempt

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Abstract

Neurocognitive detection of suicidal states has the potential to significantly advance objective risk assessment. This goal requires establishing that neurocognitive deficits fluctuate around the time of a suicide attempt. The current study therefore evaluated whether neurocognitive performance is temporally related to suicide attempt, in a sample at high-risk for suicide (n=141). Evaluations consisted of a clinician-administered interview, self-report questionnaires, and neurocognitive tasks assessing response inhibition, attentional control, and memory recognition. Analyses examined whether neurocognitive scores significantly differed according to the following temporal suicide attempt categories: a) past-week attempt; b) past-year attempt (not in past week); and c) no past-year attempt. Univariate results showed that response inhibition and memory recognition were significantly related to suicide attempt recency. Post-hoc pairwise tests showed that participants with a past-week suicide attempt showed greater impairments than those without a

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past-year attempt. Multivariate tests showed the same pattern of results, adjusting for age, suicide attempts prior to past year, mood disturbance, and suicidal ideation. These results show that neurocognitive assessment of response inhibition and memory recognition shows sensitivity to the recency of a suicide attempt. While future prospective studies are needed, results suggest that phasic neurocognitive deficits may serve as objective markers of short-term suicide risk.

2. Background

Suicide is the 10th leading US cause of death (Kochanek et al., 2016) and suicide deaths have been rising in recent years (Centers for Disease Control, 2018). A priority in the field is to advance our understanding of risk factors and the mechanisms that underlie the transition from suicidal thoughts to behavior (Aleman & Denys, 2014; Glenn & Nock, 2014), with the ultimate objective of informing assessment and prevention strategies. Deficits in neurocognition are among the known vulnerabilities associated with suicide (Jollant et al., 2011). Understanding whether these vulnerabilities fluctuate around the time of a suicide attempt can potentially improve objective risk assessment and elucidate key processes underlying suicidal behavior.

Among the known neurocognitive deficits is reduced attentional control or the ability to maintain attention in the face of distracting stimuli (Keilp et al., 2013; Keilp et al., 2014; Keilp et al., 2008; Keilp et al., 2001; Richard-Devantoy et al., 2012). Another known deficit is response inhibition, or the ability to suppress inappropriate actions (Keilp et al., 2013; Richard-Devantoy et al., 2012; Westheide et al., 2008), which is a subtype of impulse control. Similarly, memory impairment has been observed among patients with prior suicide attempts, including both working and autobiographical memory (Richard-Devantoy et al., 2015). Neurocognitive impairments associated with suicide attempts have also been observed with higher-order functions, such as decision making (Brenner et al., 2015; Jollant et al., 2005).

In addition to these general deficits, assessments have also evaluated neurocognitive processing of cues that are salient to suicidal thoughts or emotional distress. For example, among individuals seen for a psychiatric emergency, a task measuring implicit association of self with concepts of death versus living correlated with having previous suicide attempts (Glenn et al., 2017; Nock et al., 2010), and predicted suicide attempts within the following 6-month period (Barnes et al., 2017; Nock et al., 2010). It should be noted that some studies contrast the implicit association of self with concepts of death (Barnes et al., 2017; Nock et al., 2010), while others evaluate implicit association with concepts of suicide (Glenn et al., 2017). Similarly, individuals with a history of suicide attempt have shown poorer attentional control when presented with distractions containing suicide-relevant content (also described as attentional bias towards suicide-related cues; Cha et al., 2010; Williams & Broadbent, 1986). This deficit has also been demonstrated prospectively (Cha et al., 2010). However, others have not replicated findings with this task (Richard-Devantoy et al., 2016; Wilson et al., 2019). Still, this overall body of literature points to several neurocognitive domains that are impaired in individuals who attempt suicide, along with possible differences in processing suicide-related cues.

Assessing neurocognitive deficits holds promise for overcoming the challenge of limited specificity of suicide risk assessment in mental health settings (Franklin et al., 2017). Common risk factors (e.g., psychiatric comorbidity, substance use, hopelessness, depressed mood; Hawton et al., 2013) are frequently encountered, but many patients with these factors do not attempt suicide. With this limitation in mind, neurocognitive assessments have been sensitive to history of suicide attempt within psychiatric samples (Keilp et al., 2013; Keilp et al., 2008; Keilp et al., 2001). Neurocognitive processing of suicide-related cues has also demonstrated predictive validity in emergency psychiatric settings, characterized by acute symptoms and high suicide risk (Barnes et al., 2017; Cha et al., 2010; Nock et al., 2010). Much of this work has shown these neurocognitive deficits to be independent of suicidal ideation and mood severity (Barnes et al., 2017; Cha et al., 2010; Jollant et al., 2005; Keilp et al., 2013; Nock et al., 2010). Neurocognitive assessment may therefore provide utility in psychiatric settings to differentiate risk among patients presenting at the high end of the risk spectrum. Further, neurocognitive deficits are objectively measurable and therefore serve as possible behavioral markers of suicide risk that can augment assessments that rely mostly on self-report.

Less is known about whether neurocognitive assessment can detect state-like changes associated with a suicide attempt. Such assessment would point to objective assessment of short-term risk, which is a high research priority (Glenn & Nock, 2014). Towards this goal, one study examining patients in a psychiatric emergency department showed that decreased attentional control when facing suicide-content was associated with suicide attempt recency (i.e., past-week attempts; Cha et al., 2010). A recency effect on the same task was also observed in a college student population (Chung & Jeglic, 2016), as well as with the Implicit Association Test (Glenn et al., 2017). Moreover, another study examined participants with a recent suicide attempt (≤ 3 months) and found that those with current suicidal ideation showed deficits on a problem-solving task (Iowa Gambling Task; Westheide et al., 2008). By demonstrating a temporal relationship to suicide attempt (Cha et al., 2010; Chung & Jeglic, 2016; Glenn et al., 2017) and changes with suicidal state (Westheide et al., 2008), these studies highlight the possibility that phasic neurocognitive deficits can signal periods of increased short-term suicide risk.

Such objective detection of short-term suicide risk would significantly aid psychiatric settings (e.g., emergency departments, acute inpatient) with disposition decisions. These decisions are typically based on short-term risk, given that intense psychiatric treatment cannot be provided indefinitely and must therefore accurately target critical periods. Additionally, assessing risk based on suicidal ideation is complicated by short-term fluctuations in suicidal ideation (Kleiman et al., 2017). Also, history of suicide attempt, which is strongly predictive of lifetime risk (Hawton et al., 2013), provides limited information on immediate risk, as the amount of time between repeated suicide attempts can span years (Fridell et al., 1996). Also, many individuals die by suicide on their first attempt. Clinical practice in psychiatric emergency settings can therefore benefit from risk factors that provide not only greater specificity, but also indicate if the individual is entering a period of heightened risk.

The goal of identifying neurocognitive markers of suicidal states, requires demonstrating that neurocognitive deficits temporally fluctuate around the time of a suicide attempt. With this goal in mind, this study's first research question examined whether neurocognitive tasks can detect recency of a suicide attempt. The second research question examined whether neurocognitive test performance is related to suicide attempt recency above and beyond traditional risk factors (e.g., suicidal ideation). While the current study is retrospective, evaluating the temporal relationship between neurocognition and suicide attempt is important for identifying markers of suicidal states, especially within high-risk samples where greater specificity is needed. Based on previous research, we hypothesized that neurocognitive tasks assessing response inhibition, memory, and attention would reflect greater deficits among individuals with a more recent suicide attempt.

3. Methods

2.1 Participants

Participants (N=141) were Veterans recruited after an index suicide event, ranging from suicide attempt to suicidal ideation resulting in acute hospitalization or suicide prevention services. Participants were recruited from two acute psychiatry inpatient units (89.3%) or from suicide prevention services within the Veterans Health Administration (VHA). Most participants received a full range of psychotropic medication regimens typical of these treatment settings. Inclusion criteria were 1) significant suicidal ideation during the past-month; and 2) past-year suicide attempt (actual, aborted, or interrupted attempts; Posner et al., 2014) or placement on the VHA's high-risk for suicide list. Exclusions were made based on clinically significant cognitive deficits, severe hallucinations or delusions, disorganized or disruptive behaviors, or medical instability. Participants were recruited for a clinical trial examining a psychotherapy to reduce suicide (Kline et al., 2016) and were therefore also excluded if they received the study therapy during the previous year. The current study focused on data obtained from baseline assessments from the clinical trial.

2.2 Procedures

A clinical interview assessed psychiatric diagnosis, history of suicidal thoughts and behaviors, and substance use. Participants also completed several self-report questionnaires. These interviews and questionnaires are described below. Several computerized neurocognitive tasks were subsequently administered in a single session of 20–25 minutes. Prior to each neurocognitive task, a short practice was provided to ensure understanding. The entire research assessment was typically divided into several shorter sessions, included long breaks, and was flexibly scheduled to accommodate participant preference and complicated mental status (e.g., acute withdrawal). All research procedures were reviewed by the local institutional review board and all participants provided signed statements of informed consent.

2.3 Measures

2.3.1 Neurocognitive measures

2.3.1.1 Go/No-Go (GNG) task.: Response inhibition was assessed with a previously used GNG task (Moore et al., 2017), that presented participants with a series of X's and Y's at six different screen locations. One stimulus appeared every 1200 milliseconds (duration 300 milliseconds). The task required a key press when an X appeared on the top half of the screen (Go trial), but not if the X appeared on the bottom half of the screen, or if Y appeared anywhere on the screen (No-Go Trial). X was presented 180 times (144 top; 36 bottom), while Y was presented 45 times (36 top; 9 bottom), resulting in a total of 144 Go and 81 No-Go trials. Based on previous research (Keilp et al., 2005), the key score used to assess response inhibition was the prorated number of commission errors (sum of total key presses during a No-Go trial, multiplied by the ratio of the total Go Trials to total correct Go responses).

2.3.1.2 Color Stroop task.: Attentional control was assessed with a computerized task based on the traditional color-word Stroop test (Stroop, 1935). The task required a key response to indicate the font color (red, blue, green) of word cues. Some trials presented congruent cues (e.g., RED printed in red font), while others present incongruent cues (e.g., RED in green font). A total of 108 words were presented in fixed order (56 incongruent, 52 congruent). Words remained visible until a correct response was made. Interstimulus interval was 50 milliseconds, so that items were presented in a rapid series. Since the incongruent trials were expected to be more difficult due to competing stimuli (semantic and font color), an interference effect was calculated by subtracting median reaction times to correctly identify font color in the congruent trials from incongruent trials and dividing by congruent median reaction time (i.e., ratio score). Higher scores indicated greater interference from incongruent stimuli and thus poorer attentional control.

2.3.1.3 Emotion Stroop task (E-Stroop).: Whereas the Color Stroop involved interference due to color incongruence, the E-Stroop task created interference with different sets of emotion categories. Attentional control difficulty with emotionally salient content has been previously described (Williams et al., 1996), and is manifested in slower reaction times for emotionally-relevant than emotionally-neutral words. The current version (Moore et al., 2017) required pressing one of three keys to indicate font color (red, blue, green) across 54 trials that included 27 negatively-valenced emotional words (e.g., STRESSFUL), nine positively-valenced emotional words (e.g., ECSTATIC), nine emotionally-neutral words (e.g., CHALK), and nine non-lexical items (e.g., XXXX). The negatively-valenced words were further subcategorized as related to suicide (e.g., OVERDOSE; n=9), combat stress (EXPLODE; n=9), or general negative emotion (STRESSFUL; n=9). The 54 trials were presented in a pseudorandom order, with the same order used for all participants. Upon starting, two additional trials (nonlexical word and emotionally-neutral words) were presented for practice. Words remained visible until a correct response was made. Neutral and nonlexical words were administered to measure control reaction times, but neutral words were ultimately used as control words due to slightly faster reaction times. An interference index for each negative emotion subtype, and for positive words, was derived (median reaction time to neutral words was subtracted from that of each emotion type and divided by neutral median reaction time). Higher scores indicated poorer attentional control to emotion cues.

2.3.1.4 Related/Unrelated Recognition Memory task (RUMR).: The RUMR was based on the work of Savage et al. (2001), who devised the task to identify possible orbitofrontal contributions to memory organization. The RUMR incorporates elements of both a memory task and a manipulation designed to assess orbitofrontal efficiency for encoding of semantic relatedness. A 40-word list was presented, including 20 semantically related words with five words from each of four categories (fruits, clothing, office supplies, musical instruments), as well as 20 semantically unrelated words. Words appeared in blocks of 10 words, with block 1 containing fruit and clothing words, block 3 containing office and musical words, and blocks 2 and 4 containing semantically unrelated words. Each word appeared for one second, preceded by a 20-millisecond fixation cross and followed by a 1.2 second intertrial interval (blank screen). Within a block, word order was pseudorandom but fixed across subjects. Next, participants completed the other neurocognitive tasks, resulting in a delay of about 15 minutes before the recognition phase, which presented the 40 target words and 80 foils. Words were presented in the same pseudorandom order for all participants. Participants pressed one of two keys to indicate whether the word was previously viewed or not. The score of interest was the hit-rate difference between semantically related and unrelated words. Larger scores reflect a relative difficulty with semantically unrelated word recognition.

2.3.2 Suicidal thoughts and behavior—Suicidal thoughts and attempts were assessed with the Columbia Suicide Severity Rating Scale (C-SSRS; Posner et al., 2011). The C-SSRS was used to categorize suicidal ideation severity (0–5) occurring at the worst point during the previous year (past-year) or prior to the previous year (lifetime). This score represents severity in terms of ideation about death or suicide, degree of planning, and suicidal intent (scores ≥ 4 indicate severe suicidal ideation with intent). The C-SSRS was also used to identify suicidal behavior (i.e., actual/aborted/interrupted attempts and preparatory behaviors) occurring during the past-year or lifetime. The current study's independent variable was past-year actual suicide attempt status, stratified according to: a) past week; b) past year but not past week; or c) not in the past year. This stratification was informed by previous research (Cha et al., 2010). The C-SSRS is a widely used measure, with demonstrated reliability and validity (Mundt et al., 2013; Posner et al., 2011).

2.3.3 Diagnostic interviews and questionnaires—Psychiatric diagnosis was established using the Mini International Neuropsychiatric Interview (MINI v5.0.0; Sheehan et al., 1998), a brief structured interview with demonstrated criterion-related validity (Sheehan et al., 1997). A separate structured interview evaluated past-month use of addictive substances. Participants also completed several self-report measures to assess depression level (Beck Depression Inventory [BDI]; Beck, 1961) and hopelessness (Beck Hopelessness Scale [BHS]; Beck et al., 1975).

2.4 Analyses

Examination of the neurocognitive scores for each past-year attempt group revealed outliers. These influential scores were exactly the behavior of interest in the task, making deletion of these scores inappropriate. Consistent with recommendations for working with outliers (Ghosh & Vogt, 2012), we retained outlier scores by clipping their values at a maximum equivalent to the group mean ± 2 standard deviations.

The first research question was evaluated with univariate tests that compared whether neurocognitive composite scores significantly differed according to past-year suicide attempt status. For these univariate tests, p-values < .05 were considered statistically significant, except for the Stroop tasks. Since five Stroop task scores were evaluated, a p-value < .01 was applied based on Bonferroni adjustment. GNG and RUMR scores required normalization for univariate analyses, using square-root transformations. Significant differences identified by the univariate tests were followed by Tukey posthoc pairwise comparisons between the three past-year attempt categories.

To examine the second research question, neurocognitive tasks that were significantly different in univariate tests were subsequently evaluated via multinomial logistic regressions that adjusted for several established suicide risk factors selected *a priori* based on previous research (number of actual suicide attempts prior to the past year, presence of a mood disorder, and suicidal ideation severity at worst-point past-year; Cha et al., 2010; Nock et al., 2010). Mood disorder was defined as a current major depressive episode on the MINI, within Major Depressive or Bipolar Disorders. These regressions also adjusted for age, given age-related effects on these and related neurocognitive tasks (Bender et al., 2010; Mani et al., 2005; West & Alain, 2000).

3. Results

For the study's categorization of past-year suicide attempt status, frequencies were as follows: 54 (38.30%) not in past-year; 52 (36.88%) attempt in past year but not past week; 35 (24.82%) past week attempt. Demographic characteristics are summarized in Table 1. The lifetime history of suicidal thoughts and behavior (prior to past-year) between the groups is summarized in Table 2. Notably, all groups had high-rates of severe suicidal ideation, actual attempts, interrupted/aborted attempts, and preparatory behavior and did not significantly differ on any of these variables.

Other clinical characteristics between the groups are shown in a supplementary table. These results show that the groups did not significantly differ according to depression or hopelessness. However, suicidal ideation severity during the worst point in the past year significantly differed among the groups (Kruskal-Wallis test, $p<.001$). Pairwise comparisons showed that those without a past-year attempt had significantly lower suicidal ideation severity, compared to those with a past-year attempt (not past week; $p<.001$) and past week attempt ($p=.007$). Still, all groups had means greater than 4 on C-SSRS severity during the past year, indicating severe suicidal ideation with some level of intent. Notably, all BDI means were within or slightly below the severe range (i.e., ≥30; Beck, Steer, & Carbin, 1988) and all BHS were in the moderate range (i.e., 9–14; Beck, Steer, & Pompili, 1988).

Univariate tests examining the first study question are presented in Table 3. Only GNG and RUMR showed significant differences between groups. The number of prorated commission errors on the GNG task significantly differed according to past-year attempt status (F [2, 136]=3.17, p=.045). Tukey post hoc comparisons showed that participants with a past-week attempt made significantly (p=.044) more GNG prorated commission errors, compared to those without a past-year attempt. A greater difference in recognition between related versus unrelated words on the RUMR was also significantly related to past-year attempt status (F[2, 133]=3.22, p=.043). Tukey post hoc comparisons similarly showed that participants with a past-week attempt had a significantly (p=.038) greater difference between related and unrelated word recognition, relative to those without a past-year attempt. On both of these tasks, there were no other significant post hoc differences.

The second research question was examined through a series of multinomial logistic regressions that focused on the neurocognitive tasks showing significant univariate effects (GNG, RUMR). The first multinomial regression model examined GNG and showed overall significant effects for the independent variables (R^2=.16, X^2=23.58, p=.009). Compared to participants without a past-year attempt, those with a past-week suicide attempt made significantly more GNG prorated commission errors (p=.012). Relative to no past-year attempt, each commission error was associated with a 6% increased likelihood of a pastweek attempt. A second multinomial regression examining RUMR also found overall significant model effects (R^2=.15, X^2=21.37, p=.020), with significant effects for RUMR (p=.020) between participants without a past-year suicide attempt and those with a past-week attempt. Each unit increase in hit rate of related recognition over unrelated recognition is associated with a 3.4% greater likelihood of a pastweek suicide attempt, versus no past-year attempt. Neither of these models showed significant effects for task scores between the no past-year attempt and the intermediate group (past year, not past week).

A final model (Table 4) incorporated both GNG and RUMR scores and produced a similar pattern of results. The overall model showed significant effects for the independent variables (R^2=.18, X^2=27.30, p=.007). GNG prorated commission errors (p = .018) and RUMR (p=.021) were both significantly different among participants with an attempt in the past week, compared to those without an attempt in the past year. As with the previous models, there were no significant neurocognitive effects when comparing the groups with no past year attempt vs. past year (not past week) attempt.

To better understand these neurocognitive findings, we note that component neurocognitive scores showed several important patterns (supplementary table). GNG omission error means did not show a pattern of greater Go responding (i.e., more key pressing) among those with a past-week attempt. This group also did not show a global pattern of slower reaction times (Stroop & E-Stroop) or poorer memory recognition. In fact, all Stroop reaction times trended towards being faster among those with a past-week attempt, with significant differences observed for Color Stroop Congruent and EStroop Suicide. For both of these scores, Tukey pairwise comparisons showed that those with a pastweek attempt had significantly faster reaction times than those without a past-year attempt on Color Stroop Congruent (p=.038) and E-Stroop-Suicide (p=.04).

4. Discussion

The study's primary results showed that response inhibition and memory recognition were related to how recently a suicide attempt occurred in a population at high-risk for suicide. The study's multivariate analyses showed that these neurocognitive tasks were associated with suicide attempt recency, above and beyond factors commonly applied in clinical assessment of suicide risk, such as history of suicide attempts, suicidal ideation, and mood disturbance. These findings add to an emerging body of research showing that some neurocognitive deficits are associated with the recency of a suicide attempt (Cha et al., 2010; Chung & Jeglic, 2016; Glenn et al., 2017).

Additional analyses address alternative explanations to the current results. For example, it was also considered whether the differences that emerged were due to severity differences between the attempt groups. However, results showed that all groups had past-year (worst-point) suicidal ideation that was in the severe range. Also, all groups had nearly identical levels of depressed mood in the severe range, and nearly identical levels of hopelessness in the moderate range. Moreover, prior to the past year, lifetime severe suicidal ideation and behaviors (i.e., actual/aborted/interrupted attempts and preparatory behaviors) were equivalent between the three study groups. Because the groups were equivalent on these key factors, observed neurocognitive differences are therefore best interpreted as being due to the recency of suicide attempt. In addition, GNG and RUMT scores distinguished participants with a past-week suicide attempt, where other key risk factors showed no difference.

An additional explanation for the main findings is that individuals with a more recent suicide attempt could have systematically differed in medication use or mental status. Indeed, most testing occurred on acute psychiatric inpatient units, with participants presenting with varied mental statuses typical of this setting and receiving a range of psychotropic medications. However, the overall pattern of results was inconsistent with global neurocognitive impairment in the past-week attempt group. Specifically, this group did not evidence slower reaction times across several tasks (in some instances, they had significantly faster reactions times) or general memory deficits as would be reflected by differences in component scores for memory recognition. Instead, deficits were unique to response inhibition and relatively greater difficulty with memory recognition of unrelated words. This pattern of results bolsters the interpretation that these neurocognitive deficits were related to suicide attempt recency. In addition, they support the utility and feasibility of neurocognitive testing in these real-world conditions.

The current GNG findings highlight the role of response inhibition in the recency of suicide attempt. Poorer response inhibition was not simply an artifact of greater key pressing, as there were no significant differences in omission errors. Rather, those with a past-week attempt showed a selective deficit in their ability to prevent or inhibit a prepotent response. This form of executive control is informative for understanding why some individuals who think about suicide go on to make an attempt, while others do not. Several theories of suicide identify impulsivity as a key vulnerability that marks the transition from suicidal ideation to suicide attempt (Klonsky & May, 2015; O'Connor, 2011; Van Orden et al., 2010). The critical nature of response inhibition is illustrated by the current sample, where most participants presented with several risk factors, including severe ideation and history of suicide attempt. Individuals with these factors likely experience suicidal urges that are stronger and more frequent, placing greater demands on response inhibition. Among individuals with impaired response inhibition, GNG performance may show a relation to suicide attempt recency due to decreased executive control resources devoted to response inhibition. This is consistent with previous work finding poorer GNG performance in relation to negative affective states (Swick et al., 2015). Response inhibition has been well-studied in neuroimaging research, with results pointing to a range of cortical areas depending on GNG task type (for a review; Mostofsky et al., 2003; Winstanley et al., 2006). The current GNG task involved holding a set of no-go conditions in working memory, which has been suggested to involve the pre-supplementary motor area and dorsolateral prefrontal cortex in regulating response inhibition (Mostofsky et al., 2003). The current findings add to a growing body of research pointing to impaired response inhibition involved with suicide attempt (Keilp et al., 2013; Keilp et al., 2014; Richard-Devantoy et al., 2012; Westheide et al., 2008), and as a marker or endophenotype for suicidal behavior (Mann et al., 2009).

Also, in the current study, greater relative difficulty in memory recognition with words that were semantically unrelated (versus related) was associated with a recent suicide attempt. By contrasting recognition of semantically related and unrelated words, the memory task used in this study may have indirectly assessed orbitofrontal cortex efficiency, based on previous positron emission tomography findings (Savage et al., 2001). Specifically, during attempts to recall semantically related and unrelated word lists, the orbitofrontal cortex is activated to the extent that individuals actively attempt to organize their encoding around semantic relatedness. This is consistent with research pointing to the executive role of the orbitofrontal cortex in memory (Barbey et al., 2010). In this respect, current findings converge with previous ones pointing to orbitofrontal dysfunction in suicide attempt (Jollant et al., 2011). They also converge with studies showing that prefrontal deficits tend to be most pronounced with novel and unstructured stimuli (Shallice & Burgess, 1996), similar to recognition of unrelated words requiring a less evident encoding strategy. The current results add to the growing body of literature pointing to a range of memory deficits associated with suicide attempt (Keilp et al., 2013; Keilp et al., 2014; Keilp et al., 2001; Richard-Devantoy et al., 2015; Williams & Broadbent, 1986). As with response inhibition, because encoding strategies require effortful executive control, it may be that mobilization of these strategies is impacted by factors such as rumination and emotional distress. This would be consistent with research showing that overgeneral autobiographical memory, also shown to be related to suicide, is negatively impacted by rumination (Raes et al., 2006).

Other neurocognitive functions were not currently found to be related to suicide attempt recency. Deficits in attentional control with the Color Stroop task have been consistently found to be related to suicide attempt, but not in the current study (Jollant et al., 2011). A likely explanation is that attentional control difficulty may be a trait vulnerability, which was consistently present and showed little variation in the current high-risk sample. Illustrating trait vulnerability, deficits on this task persist even among those recovered from a mood episode (Keilp et al., 2014). Thus, it may be that attentional control when presented with emotional stimuli may be more sensitive to emotional states. Such deficits have been reported in some previous studies (Cha et al., 2010; Chung & Jeglic, 2016; Williams & Broadbent, 1986), but not others (Richard-Devantoy et al., 2016; Wilson et al., 2019). Still, current results did not point to recency effects for attentional control when presented with suicide cues. One explanation for this inconsistency is that studies with positive findings included a substantial portion of the sample without a history of suicide attempt, unlike the current sample where the vast majority had a history of suicide attempt, which again may have restricted variability on this task.

The current study has several limitations. The high-risk nature of the sample, where most had a history of suicidal behavior and severe ideation, offered an advantage for examining tasks that can differentiate suicide attempt status in high-risk populations. Still, this sample limited comparability to previous research that has utilized non-suicidal comparators. It is therefore best to interpret the current findings in that light. A second limitation is this study's cross-sectional design with retrospective reporting. While most previous related research has been retrospective, it will be important to study these tasks utilizing prospective designs to fully inform clinical risk assessment. Our study was strengthened by the short lag between recent index event and assessment, as most participants were assessed while receiving inpatient treatment for a suicidal event. Given this design, it is best to interpret current results as showing a temporal relation between neurocognitive deficits and the period after a suicide attempt. Prospective studies would be required to confirm whether these deficits also precede the attempt and truly qualify as risk factors. Furthermore, prospective studies that employ multiple assessments can shed light on whether increased suicide risk is preceded by phasic decrements in neurocognitive performance within individual. A third limitation is the lack of general cognitive ability assessment or data pertaining to concurrent medications. However, this study's component neurocognitive scores were not consistent with a pattern of general cognitive slowing or overall poorer recognition memory. In addition, previous research has not found that general intellectual functioning accounts for suicide-related neurocognitive deficits (Keilp et al., 2001; Keilp et al., 2008; Jollant et al., 2005). Finally, the sample studied consisted of military Veterans with a limited number of female subjects, which limits generalizability and assessment of gender effects.

5. Conclusions

Tasks measuring response inhibition and recognition memory of related versus unrelated words show promise for assessing neurocognitive deficits that may temporally fluctuate with a recent (past week) suicide attempt. This is a necessary step for identifying neurocognitive markers associated with suicidal states among individuals at high-risk for suicide. Neurocognitive assessments can provide noninvasive, short, objective measurements that are difficult to feign and are sensitive enough to detect recent suicide attempt in real-world settings. Future research is needed to determine if these same deficits vary within individuals and precede the brief period prior to an attempt.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Sample characteristics by past-year suicide attempt status

	Total Sample (n = 141)		No Past-Year Attempt (n = 54)		Past-Year Attempt (not past week) (n = 52)		Past Week Attempt (n = 35)	
	n	%	n	%	n	%	n	%
Age (M, SD)	46.59	13.78	49.48	13.94	45.94	13.28	43.09	13.72
Female	17	12.06	7	12.96	6	11.54	4	11.43
Race/Ethnicity								
White	65	46.10	27	50.00	23	44.23	15	42.86
Black	39	27.66	12	22.22	16	30.77	11	31.43
Latino or Hispanic	29	20.57	13	24.07	8	15.38	8	22.86
Asian, Native Hawaiian, American Indian, “other”	8	5.67	2	3.7	5	9.62	1	2.86
Marital								
Separated/divorced	60	43.17	22	40.74	23	46.00	15	42.86
Married/living as married	37	26.62	20	37.04	10	20.00	7	20.00
Never married	37	26.62	10	18.52	15	30.00	12	34.29
Widowed	5	3.60	2	3.70	2	4.00	1	2.86
Education								
High school or less	50	36.23	16	30.19	20	39.22	14	41.18
Some college	61	44.20	26	49.06	21	41.18	14	41.18
College degree or higher	27	19.57	11	20.75	10	19.61	6	17.65
Employment								
Unemployed	102	73.38	40	74.07	39	78.00	23	65.71
Employed	33	23.74	12	22.22	10	20.00	11	31.43
Full-time student	3	2.16	1	1.85	1	2.00	1	2.86
Compensated work therapy	1	0.72	1	1.85	0	0.00	0	0.00
Psychiatric Diagnoses								
Major Depressive Disorder	99	70.21	37	68.52	41	78.85	21	60.00
Post-traumatic Stress Disorder	86	60.99	40	74.07	27	51.92	19	54.29

	Total Sample (n = 141)		No Past-Year Attempt (n = 54)		Past-Year Attempt (not past week) (n = 52)		Past Week Attempt (n = 35)	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Any Substance Use (excluding Alcohol) past 30 days	64	45.39	18	33.33	21	40.38	25	71.43
Alcohol Binge drinking past 30 days	55	39.29	16	30.19	22	42.31	17	48.57
Bipolar Disorder	19	13.48	7	12.96	4	7.69	8	22.86
Panic Disorder	17	12.06	10	18.52	4	7.69	3	8.57
Generalized Anxiety Disorder	11	7.80	5	9.26	5	9.62	1	2.86
Schizoaffective Disorder	8	5.67	5	9.26	2	3.85	1	2.86
Social Phobia	6	4.26	3	5.56	0	0.00	3	8.57
Obsessive-Compulsive Disorder	4	2.84	2	3.70	2	3.85	0	0.00

Note. Due to missing data for some items, category totals are less than the corresponding sample size. Percentages were calculated based on participants with non-missing data. Psychiatric diagnoses are not mutually exclusive.

Table 2.

Life-time severe suicidal ideation and suicidal behavior (prior to past year)

	Total sample (n = 141)		No Past-Year Attempt (n = 54)		Past-Year Attempt (not past week) (n = 52)		Past Week Attempt (n = 35)		p-value
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Severe Suicidal Ideation	110	78.01	40	74.07	45	86.54	25	71.43	0.167
Actual Suicide Attempts									0.935
0	57	40.43	22	40.74	20	38.46	15	42.86	
1	43	30.5	16	29.63	18	34.62	9	25.71	
2 or more	41	29.08	16	29.63	14	26.92	11	31.43	
Interrupted/Aborted Suicidal Attempts									0.911
0	99	70.21	39	72.22	36	69.23	24	68.57	
1	32	22.7	12	22.22	11	21.15	9	25.71	
2 or more	10	7.09	3	5.56	5	9.62	2	5.71	
Preparatory Behaviors									0.619
0	112	79.43	41	75.93	40	76.92	31	88.57	
1	23	16.31	11	20.37	9	17.31	3	8.57	
2 or more	6	4.26	2	3.7	3	5.77	1	2.86	

Note. Severe suicidal ideation defined as suicidal ideation involving suicidal intent, as measured by the Columbia Suicide Severity Rating Scale (C-SSRS). Suicidal behaviors are not mutually exclusive. P-values represent χ^2 tests comparing the 3 groups according to past-year attempt status.

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Table 3.

Neurocognitive composite scores according to past-year suicide attempt status

	No past-year attempt (n = 54)		Past-year attempt (not past-week) (n = 52)		Past-week attempt (n = 35)		Overall p-values	Post-Hoc
	M	SD	M	SD	M	SD		
GNG Prorated Commission Errors	10.08	7.90	13.36	10.75	16.07	13.34	0.045	PW > NA
Color Stroop Interference	19.33	13.61	18.48	8.88	20.26	17.30	0.827	
E-Stroop Positive Word Interference	5.86	17.61	8.78	18.51	7.55	22.78	0.754	
E-Stroop Suicide Word Interference	−3.74	16.79	−3.40	14.24	−8.23	13.87	0.317	
E-Stroop Combat Word Interference	11.36	23.26	13.92	16.24	8.66	20.37	0.524	
E-Stroop General Negative Word Interference	1.05	15.89	6.74	12.17	2.39	18.98	0.184	
RUMR	7.62	17.92	12.20	17.00	16.43	17.93	0.043	PW > NA

Note. GNG=Go/No-Go task; E-Stroop=Emotion Stroop task. NA=no past-year attempt; PY=past year attempt (not past week); PW=past week attempt

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Table 4.

Past-year attempt status according to GNG, RUMR, and established suicide risk factors.

	Past week attempt			Past-Year (not including past week)		
Variable	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
GNG	1.06	1.01 - 1.11	0.018	1.03	0.99 - 1.08	0.163
RUMR	1.03	1.01 - 1.06	0.021	1.02	1.00 - 1.05	0.089
Age	0.97	0.93 - 1.00	0.059	0.98	0.95 - 1.01	0.123
Mood Disorder	1.69	0.49 - 5.80	0.405	1.68	0.55 - 5.16	0.368
Suicidal ideation severity (worst point past year)	1.48	0.86 - 2.55	0.157	2.20	1.18 - 4.13	0.014
# of suicide attempt prior to past year	1.15	0.91 - 1.46	0.234	1.01	0.79 - 1.30	0.926

Note. GNG=Go/No-Go task; RUMR=Related/Unrelated Memory Recognition test. Reference group is no past-year attempt.