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Cognitive effort avoidance in veterans with suicide attempt histories

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ABSTRACT

Suicide attempts (SA) are increasing in the United States, especially in veterans. Discovering individual cognitive features of the subset of suicide ideators who attempt suicide is critical. Cognitive theories attribute SA to facile schema-based negative interpretations of environmental events. Over-general autobiographical memory and facile solutions in problem solving tasks in SA survivors suggest that aversion to expending cognitive effort may be a neurobehavioral marker of SA risk. In veterans receiving care for mood disorder, we compared cognitive effort discounting and evidence-gathering in a beads task between veterans with (SAHx+; $n = 26$) versus without (SAHx-; $n = 22$) a history of SA. Groups did not differ in depressed mood or in a proxy metric of premorbid intelligence. Compared to SAHx- participants, SAHx+ participants self-reported significantly more severe cognitive problems in most domains, and also eschewed choice to earn higher monetary reward if earning it required a slightly increased working memory (WM) demand relative to an easy WM task. There was no group difference, however, in extent of evidence-gathering before declaring a conclusion in a beads task. These preliminary data suggest that aversion to expenditure of cognitive effort, potentially as a component of cognitive difficulties, may be a marker for SA risk.

1. Introduction

1.1. The challenge of predicting suicide attempts

Suicide rates have increased in the US in the past two decades (U.S. Centers for Disease Control), making suicide prevention especially critical. Approaches to suicide prevention have centered on psychiatric, circumstantial, and demographic risk factors for suicide attempts (SA), including recent loss of employment, conflict with intimate partners, being male, being white, being middle aged, expressing feelings of hopelessness, and especially suffering from depression or other mood disorder (McMillan et al., 2007; Wenzel, Brown, Beck, 2009b; Wenzel et al., 2011; Yen et al., 2005). Unfortunately, the power of these broader factors to predict suicide risk at the individual patient level is weak (e.g. Goldstein et al., 1991). Moreover, the majority of persons in these risk categories do not attempt suicide (Wenzel, Brown, Beck, 2009b), even in cases of depression (Pompili, 2019). Further complicating prevention efforts, psychiatric autopsy surveys that have shown that most successful suicides are *initial* attempts (Bakst et al., 2014; DeJong et al., 2010).

Comprehensive models of suicide posit that an SA stems from the intersection of these broad circumstantial risk factors with predisposing *individual*-level cognitive traits, such as elevated levels of certain types of impulsivity (O'Connor, 2011). Of interest then is discovering more specific neurobehavioral indicators of suicide-prone cognitive styles that could be applied to patients in broader risk categories (Keilp et al., 2001). First, this could help inform detection of at-risk patients if behavioral probes could be made brief and deployed at scale. Second, behavioral variables found to be linked to SA histories could serve in clinical trials of interventions for depression as suicide-relevant secondary endpoints as a proxy for the low base rate of SA. Understanding neurobehavioral markers for SA that are detectable when a patient is not actively suicidal would be especially valuable.

1.2. Avoidance of cognitive effort as a neurocognitive suicide risk marker

Human cognitive processing has been framed in terms of a dual process, wherein one brain system is thought to enable rapid, unreflective gist-based reactions to environmental challenges (System 1) and

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is ostensibly regulated by a second more deliberative system (System 2) that operates on longer time frames (Kahneman, 2011). Poor health behaviors such as substance use disorder (SUD) have been attributed to some combination of excessive System 1 processing and/or under-regulation by System 2 (Bickel et al., 2007). Many suicide attempts are preceded by development of a suicide schema or gist (Cha et al., 2010; Wenzel & Beck, 2008) that features an amplifying cycle of hopelessness. Over time, environmental challenges are increasingly interpreted in a gist-based manner to conform with this schema where the patient increasingly fails to reflect and consider benign interpretations of events or fails to access personal histories of successful resolutions of similar problems encountered previously (Sumner, 2012) and so perceives that there is no other way out but suicide (Wenzel, Brown, Beck, 2009a).

Early cognitive studies of suicide modeled gist-based thinking in SA survivors with tasks that revealed 1) an increased tendency toward dichotomous accounts of ambiguous images (Litinsky & Haslam, 1998), 2) deficits in fluency (generation of multiple unique solutions) (Bartfai et al., 1990; Patsiokas et al., 1979) and 3) deficits in social problem-solving in more complex, vignette-based tasks (reviewed in (Pollock & Williams, 2004; Wenzel, Brown, Beck, 2009b). Other early experiments centered on the patient's ability to produce detailed recollections of life events and found that suicidal patients were characterized by over-general autobiographical memory (OGM) (Williams & Broadbent, 1986). Suicidal patients often failed to describe historical events with precision (e.g., a particular beach party at age 16 where the band played a favorite song) and instead responded with a general class of events (e.g., summers at the beach as a kid). Both OGM and faltering after producing the most obvious solutions in fluency tasks are examples of *cognitive effort that stops short* of a complete solution. One mechanistic model of OGM, the CaR-FA-X model (Williams, 2006), attributes OGM in part to impaired frontocortical control, where OGM is essentially a cognitive effort-*avoidance* strategy (Sumner, 2012).

Other work has indicated that SA survivors are characterized by deficits in executive function (EF) (Bredemeier & Miller, 2015) or in emotional intelligence (Comparelli et al., 2022), especially those with violent or high-lethality attempts (Richard-Devantoy et al., 2014). These include reduced cognitive flexibility (Keilp et al., 2001) and increased motor impulsivity (Dougherty et al., 2004) that would impair successful responding in more complex tasks. In a large prospective study of army enlistees, future SA and completed suicides were linked to lower scores in an aggregate metric of neurocognitive function in a cognitive battery administered at entry into service, compared to demographically-matched enlistees (Naifeh et al., 2017). More recently, Fernández-Sevillano et al. (2021) reported poorer function on EF tasks of set-shifting and attention in recent SA survivors compared to mood-disordered patients with either distant-past SA histories or with no history of SA.

In sum, SA survivors appear to have a fundamental decrements in EF that might be manifested in relative unwillingness or lack of ability to engage System 2 mental effort (Keilp et al., 2001). Aversion to cognitive effort itself has been found to be a trans-diagnostic feature of mental illness (Patzelt et al., 2019). As such, it may be a neurocognitive "common-denominator" that mediates the poor performance of SA survivors, not only on more strenuous cognitive tasks (Keilp et al., 2001), but also on a variety of complex, unstructured or integrative cognitive tasks, such as social problem-solving, divergent thinking, fluency or autobiographical recall. Importantly, this trait could be evident even outside of emotional crisis and could provide a mechanistic account for propensity for suicide schema-based reflexive thinking. If so, behavioral activation to exert cognitive effort may serve as an intervention target to prevent SA directly (Gorlyn et al., 2015).

1.3. Probing cognitive effort preference directly

Revealed preference to avoid mental effort in SA survivors has not been probed directly. Most tests of social problem-solving and fluency frequently require labor-intensive and subjective scoring that precludes feasibility in broader clinical applications. Should willingness to expend mental effort emerge as a marker for SA history or proneness, of interest is the development of objective, computerized behavioral markers of cognitive effort preference in suicide risk. One candidate probe is the cognitive effort discounting (COGED) task (Westbrook et al., 2013), wherein the participant samples (experiences) working memory tasks of varying arduousness then completes a choice procedure wherein they must decide between opting to commit to performing harder WM tasks for more money or instead choosing the easiest WM tasks for less money. Neurotypical participant choice behavior shows progressive degradation in subjective value (SV) of a certain monetary reward the harder the mental effort required to obtain it (Westbrook et al., 2013). This devaluation has since been found to depend on engagement of general valuation neurocircuitry (Westbrook et al., 2019) and on midbrain dopamine function (Westbrook et al., 2020).

The premise of this preliminary study was to determine if preference for gist-based, schema-prone (i.e. System 1) thinking over deliberation and related mental effort (System 2 thinking) is characteristic of SA survivors and might be captured by tasks that probe preferences to avoid cognitive effort or to avoid gathering ample evidence before drawing conclusions. We investigated this in military Veterans as a high-risk population (McCarthy et al., 2009). We compared willingness to expend cognitive effort in the COGED task as well as degree of evidence-gathering under ambiguous conditions before drawing a conclusion in a beads task (Banca et al., 2015) between participants who did (SAHx+) versus did not (SAHx-) have a lifetime history of SA. We hypothesized that SAHx+ veterans would have lower SV of rewards with increased effort requirements in the COGED task compared to SAHx- veterans, and would also opt for fewer bead draws before stating a conclusion in the beads task. Finally, we hypothesized that SAHx+ veterans would also endorse greater difficulties with cognitive function than SAHx- veterans in the Neurobehavioral Functioning Inventory (NFI) (Marwitz, 2000) as a complementary subjective self-report marker.

2. Methods

All consent and testing procedures were reviewed and approved by the Hunter Holmes McGuire (Richmond) Veterans Affairs Medical Center (RICVAMC) Institutional Review Board.

2.1. Participants

These participants were recruited by either referral from an ongoing Post-Deployment Study of Mental Health (Brancu et al., 2017), direct referrals from clinicians in the RICVAMC Mental Health Service, or by IRB-authorized electronic medical records (EMR) search for diagnostic codes indicating current care for a depressive disorder, post-traumatic stress disorder (PTSD) or other mood disorder. We were not authorized to approach veterans who had an active suicide risk flag in EMR, nor veterans known to have had an SA within the past 6 months. In each EMR, clinician notes were examined for self-reported suicide histories (typically probed as part of routine suicide risk assessments). Prospective participants were excluded in cases of head injury resulting in loss of consciousness for 30+ minutes or for history of psychosis. Due to extensive comorbidity of substance use disorder (SUD) in veterans with mood disorder and to feature a naturalistic at-risk participant sample, current or past substance abuse or substance dependence were not exclusionary criteria. However, to avoid acute effects of substance intoxication on cognition, participants were required to furnish a drug-free urine sample the day of testing. Finally, prospective participants were required to have normal hand function and corrected vision. Clinical characteristics of these two groups are presented in Table 1. Participants were assigned the SAHx+ group (n = 26) based on self-report of a lifetime SA either evident in EMR or in psychiatric interview (below) or to the SAHx- group based on denial of SA history in EMR

Table 1
Demographics and clinical characteristics.

	SAHx+ (n = 26)	SAHx- (n = 22)	p-value
Demographics			
Sex-at-birth	19 M:7F	15 M:7F	0.710
Age	36.2 (7.1) range (28–54)	43.6 (7.1) range (27–55)	0.0009
Current DSM-IV diagnoses[a]			
Depressive Disorder	16 (62 %)	10 (45 %)	0.264
PTSD	19 (73 %)	16 (73 %)	0.978
Substance Use Disorder	2 (8 %)	5 (23 %)	0.141
Other Anxiety Disorder	13 (50 %)	9 (41 %)	0.529
Beck Scale for Suicidal Ideation	6.2 (7.9)	3.0 (5.6)	0.110
	age adj mean 5.6	age adj mean 3.7	0.396
Profile of Mood States			
Depression	29.0 (13.2)	24.4 (11.0)	0.194
	age adj mean 28.7	age adj mean 24.7	0.323
Tension	20.4 (7.2)	17.6 (5.9)	0.149
	age adj mean 20.5	age adj mean 17.8	0.264
Anger	19.7 (8.8)	17.2 (8.2)	0.319
	age adj mean 18.8	age adj mean 18.3	0.846
Fatigue	15.8 (6.2)	15.2 (6.8)	0.758
	age adj mean 16.0	age adj mean 14.9	0.603
Confusion	15.2 (4.7)	13.6 (4.8)	0.278
	age adj mean 15.0	age adj mean 13.8	0.459
Vigor	19.0 (5.6)	19.2 (7.4)	0.890
	age adj mean 19.6	age adj mean 18.5	0.605
Total Mood Disturbance	81.0 (37.9)	68.8 (35.8)	0.257
	age adj mean 79.2	age adj mean 70.9	0.500

[a] Non-mutually-exclusive.

or in psychiatric interview (n = 22 SAHx-).

2.2. Clinical interview

To confirm eligibility and to characterize each participant's mental illness, participants first underwent a Structured Clinical Interview for DSM-IV (SCID-IV) (First et al., 1996) across one or two laboratory visits if the participant was not already recently interviewed with the SCID-IV as part of the PDMH study. Participants for whom an SA was not evident in EMR but who endorsed a lifetime SA in the SCID-IV depression modules were assigned to the SAHx+ group. The participant then revisited the lab to complete questionnaires and perform desktop behavioral tests. At the onset of each testing visit, each participant submitted a urine sample for drug-kit screen testing. In addition to the 48 participants analyzed herein, four prospective participants were excluded due to positive urine results for a drug other than cannabis. In cases of cannabis-positive results, cognitive testing was rescheduled until provision of a clean sample.

2.3. Questionnaires and cognitive testing

To increase the validity of cognitive testing, we first administered the *Test of Memory Malingering (ToMM)* (Tombaugh & Tombaugh, 1996). In addition to the 48 participants described herein, an additional two participants were recruited but excluded for scoring below the recommended cutoff score of 45+ on Part 2 of the TOMM. Next, to obtain a proxy of (premorbid) intellectual function, we administered the *Wechsler Test of Adult Reading (WTAR)* (Wechsler, 2001). As an ancillary metric of self-perceived cognitive difficulties, participants completed the Neurobehavioral Functioning Inventory (NFI) (Marwitz, 2000), which is composed of 76 items organized into six factor analytically-derived scales: Depression, Somatic, Memory/Attention, Communication, Aggression, and Motor plus an additional six "critical items." Respondents are asked to rate items as occurring "never", "rarely", "sometimes", "often", or "always." To detect presence of acute suicidal cognition, we administered the Beck Scale for Suicidal Ideation (BSSI) (Beck et al., 1979). Finally, we administered the *Profile of Mood States-2 (POMS-2), Short Version* (McNair et al., 1992) to obtain state metrics of Anger-Hostility, Confusion-Bewilderment, Depression-Dejection, Fatigue-Inertia, Tension-Anxiety, Vigor-Activity, and Friendliness.

2.3.1. N-back and cognitive effort discounting (COGED) tasks

The COGED procedure (Westbrook et al., 2013) began with a series of "n-back" tasks of varying difficulty to provide each participant with a range of mental effort. In each n-back task, the subject views a sequence of letters presented singly, where they must press a key when a letter matches a previous letter in the sequence (see Fig. 1A). The practice phase with the n-back included two runs for every load level, each comprised of 64 items (consonants, 24-point Courier New font, 16 targets, in colors uniquely identifying n-back difficulty level). Participants had 1.5 s to respond to each item by button press, after which items were replaced by fixation cross. The inter-item interval was 3.5 s. Lures (letters appearing within n + 2, but not exactly n positions after last presentation) were included to increase difficulty. Thus, task runs were ~ 100 s long, and progressively increased whether the subject must match each letter displayed with the letter that was shown either one letter ago in the sequence (two runs of this easiest "1-back" task) or must match each letter with the letter that was presented 2, 3, or 4 letters ago in the sequence (two runs each of these progressively more difficult versions). To promote effort, the subject received a prompt of "Good job!" if responding accuracy >50 %, and "Please try harder" if their behavior indicated indiscriminate responding. Next, the participant rated on a post n-back task questionnaire how mentally difficult they thought each of the n-back task variants was on a 1–10 scale.

In the core COGED task (Fig. 1B), the subject is then presented with a series of side-by-side choices to either perform "up to 10" runs of either a harder n-back task for ~$2.00, $3.00, or $4.00 each (varied across trials) or to instead perform the easiest 1-back task for a smaller amount of money. The magnitude of the smaller-easier rewards in choices was dynamically titrated over time to converge on indifference points (between easier task versions versus harder task versions with larger payouts) at each difficulty level for each maximum amount. Thus, these indifference points represented the SV decay of the larger, harder reward as a function of increasing task difficulty to obtain it. Following the COGED choice task, one choice the participant made was selected at random and shared with the participant. Next, the participant performed exactly four n-back runs of the difficulty chosen in their randomly-selected choice, wherein the participant could win between $4 and $12 total.

2.3.2. Beads task

The Beads task (Banca et al., 2015) was included to probe free-operant behavior in service of situational evidence gathering and evaluation, where relatively few responses prior to drawing conclusions ostensibly indexes an increased tendency for reflexive deduction. In each trial block, subjects were shown two cartoon "jars" on the computer screen with opposite ratios of red and blue beads (Jar 1: P = .80 red; P = .20 blue/Jar 2: P = .80 blue; P = .20 red) displayed in the respective jars. In each of three trials, participants were instructed to press a key to have a bead drawn from one of the two jars, where every bead is ostensibly from the same jar. These "drawn" beads were presented one at a time and accumulated in the center of the screen. The participant was asked to indicate by directional key-press whether the beads were drawn from Jar 1 or Jar 2 in each trial. Importantly, the participants were free to view as many beads as desired each trial, to a maximum of 20 beads, before committing to their decision on the jar of origin. We opted to introduce no disincentives for bead draws (other

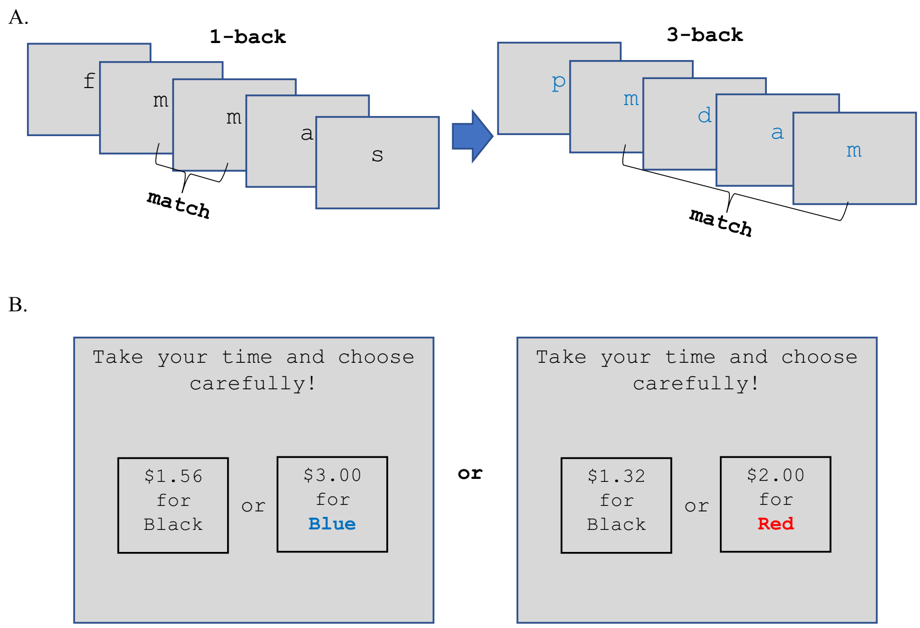

Fig. 1. Diagram of COGED task
Participants performed two runs each of 1-back, 2-back, 3-back, then 4-back working memory subtasks (Part A) to experience the cognitive load and effort required for success at each difficulty level. Letter color (e.g. black for 1-back and blue for 3-back) signaled the difficulty level (subtask type). Subjects indicated with one of two keys whether or not the displayed stimulus letter matched the letter shown n items earlier in the sequence. Following the n-back subtask runs, participants rated subtask difficulty. They then completed a choice procedure (Part B), in which they made several choices between committing to perform an easier n-back subtask for less money (ostensibly up to 10 times) or a harder subtask for more money (two example choices shown). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

than extending the task duration slightly) that may deter them, in the hope of promoting greater range of response rates. The primary outcome measure was the total number of beads drawn prior to a decision across the three trials, where for example binge-drinkers (Banca et al., 2015) and Parkinsonian patients with impulse control problems (Djamshidian et al., 2012) initiated fewer bead draws than controls. This demonstrated avoidance of effort to collect evidence under ambiguity among these groups and was interpreted as greater “reflection impulsivity.”

2.4. Data analysis

Group comparisons were planned using independent *t*-tests for continuous variables and chi-square tests for categorical variables. However, because the SAHx+ group was significantly younger than the SAHx- group, and because advancing age across adulthood decreases SV of rewards in the COGED task (Westbrook et al., 2013), our key hypotheses regarding task performance were tested using ANCOVA controlling for age. WTAR Standard scores were used that already correct for age. Significance levels were thresholded at $p < .05$. The SV decay of each of \$2, \$3, and \$4 rewards at each of the 2-back, 3-back, and 4-back tasks were calculated as a proportion of SV of the (mentally trivial) 1-back task.

3. Results

3.1. Clinical, demographic and questionnaire metrics

The SAHx+ group was significantly younger than the SAHx- group (Table 1), but groups did not differ in sex representation nor in incidence of currently meeting criteria for either substance use disorder, depressive disorder, PTSD, or other anxiety disorders. With regard to subclinical mood symptomatology as indexed by POMS subscales, there were also no group differences, and there were no significant differences between groups in suicidal ideation on the BSSI. The groups did not differ in standardized WTAR scores as an estimate of premorbid intelligence (Table 2). Conversely, the SAHx+ group self-reported significantly higher age-adjusted cognitive symptomatology scores than the SAHx- group in the Memory/Attention, Communication, and Motor subscales of the NFI, as well as in total scores, but not in the Depression or Somatic subscale scores (Table 2).

3.2. Task performance metrics

3.2.1. N-back and COGED tasks

During the preparatory training/exposure N-back sessions, neither raw nor age-adjusted signal-detection d-prime (accuracy) values, median reaction times and subjective difficulty ratings significantly differed between groups at any task difficulty level (Table 2; for brevity, only uncorrected values shown). A preliminary repeated-measures ANOVA indicated no main or interactive effect of maximum amount on offer (\$2, \$3, and \$4) on SV decay, nor interactions of amount with prospective task difficulty level or group. Therefore, SV decay values at each n-back task difficulty level were averaged across magnitudes. In the ANCOVA of SV decay in COGED decision-making, after controlling for age, SAHx+ participants showed a significantly lower relative SV of reward when it entailed having to perform a 2-back subtask relative to the simplest 1-back subtask, compared to SAHx- participants (Fig. 2). Reduced adjusted mean SV of rewards requiring 3-back and 4-back subtask conditions in SAHx+ compared to SAHx- participants did not reach significance.

3.2.2. Beads task

Due to technical issues, the BEADS task data were not collected for one participant. In addition, outlying data were excluded for bead-draw tallies ≥3 SD from group-wise mean for that trial or for total task draws. Neither raw nor age corrected tallies of bead draws differed between groups (data not shown, all $p > .27$).

3.3. Exploratory analyses

To gain insight into whether reduced SV of reward under 2-back conditions may have stemmed from self-perceived cognitive problems, we correlated NFI memory/attention subscale scores to 2-back SV. These correlations were not significant, regardless of whether age was included in the model (all $p \geq .30$). NFI memory/attention scale scores also did not correlate with subjective n-back difficulty ratings (all $p \geq .25$). The SV decay of 2-back (relative to 1-back) rewards also did not correlate with total tally of bead draws. Due to the preliminary sample size, we performed post-hoc power analyses of SV decay under the more difficult n-back conditions. These indicated that 169 participants would have been needed to detect a significant age-corrected group difference in SV for the 3-back condition, and 526 participants for the 4-back

Table 2
Cognitive symptomatology and task performance.
Results are presented as raw means with standard deviation in parentheses, as well as age-adjusted means for some assessments.

	SAHx+ (n = 26)	SAHx- (n = 22)	p-value
WTAR Standard Score	108.2 (9.8)	107.0 (8.9)	0.644
Neurobehavioral Functioning Inventory (NFI)			
Depression	42.2 (10.3)	36.2 (11.4)	0.063
	age adj mean 41.9	age adj mean 36.6	0.144
Somatic	31.8 (6.9)	27.5 (7.8)	0.052
	age adj mean 31.8	age adj mean 27.4	0.071
Memory/Attention	58.7 (15.0)	46.5 (16.8)	0.012
	age adj mean 58.3	age adj mean 47.0	0.038
Communication	26.1 (8.5)	21.7 (7.4)	0.062
	age adj mean 26.6	age adj mean 21.2	0.045
Aggression	21.4 (7.4)	19.2 (5.5)	0.247
	age adj mean 20.8	age adj mean 19.8	0.645
Motor	21.1 (7.1)	17.5 (6.4)	0.077
	age adj mean 21.6	age adj mean 17.1	0.049
NFI Total	233.8 (48.9)	198.0 (52.2)	0.020
	age adj mean 233.2	age adj mean 198.8	0.046
Test of Memory Malingering (TOMM)[a]			
Part 1	47.2 (4.9)	48.0 (2.5)	0.443
Part 2	49.8 (0.7)	49.7 (0.9)	
N-back task			
1-back d-prime	2.07 (1.25)	2.26 (1.12)	0.570
1-back median RT (ms)	625.3 (128.7)	634.0 (133.2)	0.820
1-back self-reported diffucuIty	3.0 (2.4)	2.9 (2.0)	0.935
2-back d-prime	1.32 (0.67)	1.11 (0.90)	0.374
2-back median RT (ms)	730.0 (162.5)	758.4 (130.2)	0.515
2-back self-reported diffuculty	5.3 (2.5)	4.9 (2.2)	0.598
3-back d-prime	0.66 (0.48)	0.88 (0.54)	0.164
3-back median RT (ms)	714.6 (166.7)	753.6 (137.7)	0.381
3-back self-reported diffuculty	8.0 (1.4)	6.9 (1.7)	0.016
4-back d-prime	0.79 (0.46)	0.91 (0.42)	0.361
4-back median RT (ms)	678.2 (175.4)	706.5 (140.1)	0.537
4-back self-reported diffuculty	9.5 (0.9)	9.2 (1.4)	0.300
COGED task			
Subjective value 2-back	0.72 (0.29)	0.82 (0.21)	0.182
Subjective value 3-back	0.63 (0.33)	0.74 (0.31)	0.250
Subjective value 4-back	0.58 (0.33)	0.63 (0.37)	0.590
BEADS task			
Trial 1 draws	3.4 (2.6)	2.7 (2.0)	0.308
Trial 2 draws	5.3 (4.5)	4.2 (2.9)	0.358
Trial 3 draws	3.9 (2.9)	4.0 (2.9)	0.970
Total draws	13.7 (10.8)	10.8 (6.9)	0.277

RT = Reaction Time.
ms = milliseconds.
[a] Note that this report includes only individuals with TOMM Part 2 scores 45 or greater.

condition.

4. Discussion

4.1. Cognitive difficulties and cognitive effort preference

The premise of this preliminary investigation was that one cognitive feature that may distinguish individuals who conclude that there is no solution or escape from their emotional pain or circumstances other than suicide is a marked tendency to avoid deliberative thinking in favor of gist- or schema-based thinking. To investigate this possibility, we administered the COGED task and the beads task to a high-risk population of veterans receiving treatment for mood disorder, 70 % of whom suffered from PTSD and who typically had other psychiatric comorbidities. We wished to determine if patients who have already attempted suicide (as a marker of capacity for suicide and thus at very high risk) showed aversion to cognitive effort compared to their peers who never attempted suicide.

We found in the COGED task that after adjusting for the younger age of SAHx+ participants, SAHx+ veterans showed a steeper decay in their valuation of a monetary reward when task difficulty to obtain the reward increased slightly from the easy 1-back task (pressing a certain key whenever two letters were shown back-to-back) to the 2-back condition. Conversely, the SAHx+ and SAHx- groups devalued rewards more similarly when earning them would require 3-back and especially arduous 4-back performances. Notably, the two groups did not actually differ in their n-back performances in terms of accuracy or reaction time. Similarly, both groups rated the 1-back through 4-back tasks as progressively more difficult, with no group difference in subjective impressions of difficulty. Finally, there was no correlation between SV decay under 2-back prospects (relative to the 1-back reference condition) and self-reported memory and attention difficulties on the NFI.

These findings suggest that mood-disordered patients with SA histories may have an aversion to expending cognitive effort compared to other mood-disordered patients, where this aversion is detectable only within a certain range of prospective mental effort. Moreover, other performance data indicate that this aversion does not stem from *inability* to successfully exert arduous cognitive effort, or even from a significantly increased appraisal of the difficulty. Rather, the group difference could be more confidently attributed to personal preference not to have to concentrate intensely. For realistic responding, the COGED was incentivized with real money. Thus, it could be argued that this worked against the direction of our hypothesis in that more severely impaired veterans may be more likely to be underemployed such that the task earnings would have greater marginal utility. Unfortunately, we did not probe current employment or income, and in general, assessing the marginal utility of laboratory task earnings (e.g., in terms of emotion) is challenging.

4.2. Subjective cognitive difficulties

Because a growing literature links suicidal behavior to cognitive (especially EF) abnormalities (Fernández-Sevillano et al., 2021; Naifeh et al., 2017; Richard-Devantoy et al., 2014), we also included a self-report measure of cognitive functioning difficulties across several domains (the NFI). We found that SAHx+ also self-reported more difficulties than SAHx- participants, most notably in attention/memory and communication domains. Although EF difficulties on the NFI subscale did not correlate directly with degraded reward SV under 2-back prospects or with self-reported difficulty of n-back subtasks, these differences in self-reported cognitive function may nevertheless reflect presence of cognitive challenges that could increase risk for an SA.

4.3. Group differences in mentally easy evidence-gathering

With respect to evidence-gathering behavior in the beads task, there were no differences in the number of beads drawn in each trial before coming to a conclusion on the jar of their origin in each trial. In both groups, participants drew few beads; of a possible 20 beads for each trial, participants tended to draw somewhere between 3 and 5 beads. This trend occurred even though drawing beads was not disincentivized. In other experiments with the beads task, points worth money could be won for correct jar deductions, but each bead draw would incur a point cost (e.g., (Djamshidian et al., 2012). If one posits that the beads task is conceptually more of an impulsivity task than a mental effort task per se, our negative finding may make sense. The relationship between impulsivity and suicide is complex. Not only can SA vary greatly in degree of premeditation and planning, but impulsivity itself is a multifaceted construct as it relates to psychopathology (Swann et al., 2002)

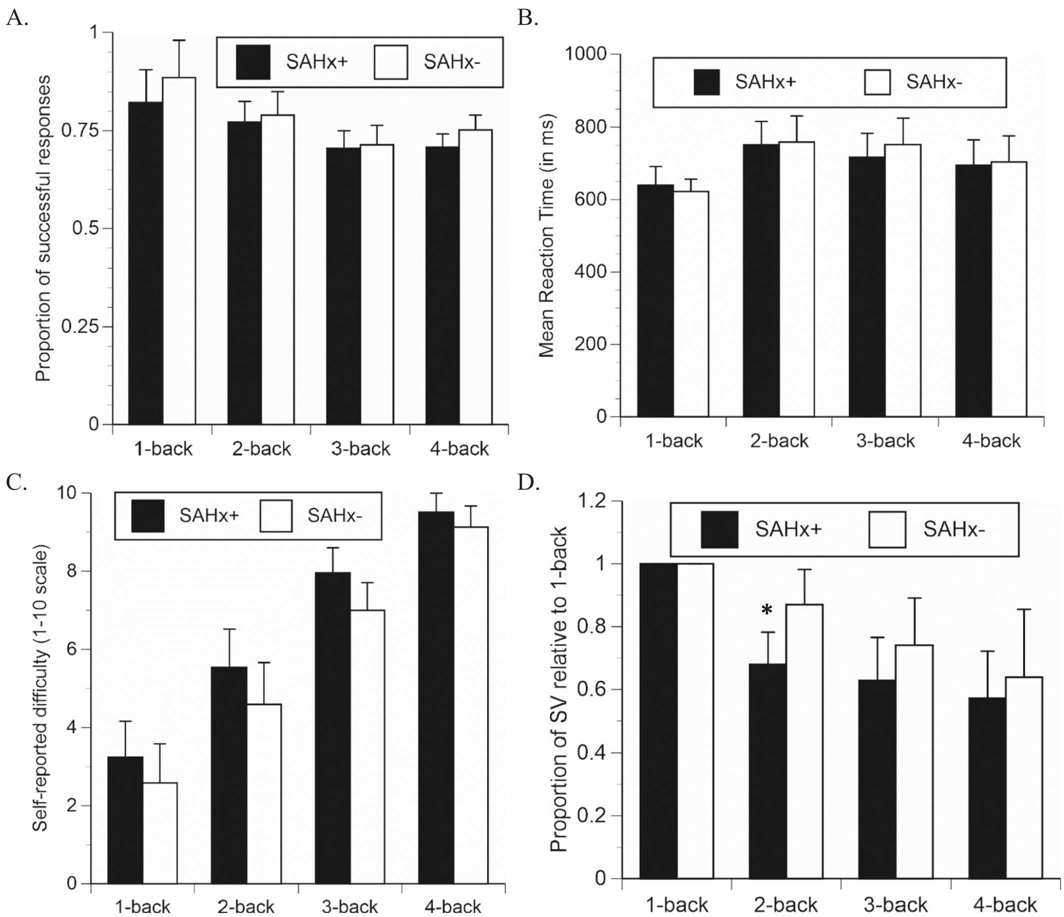

Fig. 2. N-back and COGED task behavior
Shown in Panel A are the age-adjusted mean probabilities of accurate responding (Panel A) and reaction time (RT) (Panel B) in the four n-back subtasks (averaged across the two runs of each subtask) in participants positive for suicide attempt history (SAHx+) and participants negative for SA history (SAHx-). Panel C shows (adjusted) mean self-reported n-back difficulty ratings on a 1–10 scale. Shown in panel D are the adjusted mean subjective values (SV) of monetary rewards in the COGED task as a proportion of SV for the easiest 1-back task, which was fixed at 1.0 as the reference. Error bars represent 95 % confidence intervals. * denotes group difference at $p = .026$.

with domains and assessments that typically correlate poorly within-subject (Cyders & Coskunpinar, 2011).

4.4. Population considerations

Our population of veterans was a crucial feature in that SA are particularly elevated among veterans receiving care in Veterans Health Administration (VHA) medical centers compared to the general U.S. population (McCarthy et al., 2009). These veterans are thought to have more severe mental health issues than veterans utilizing private sector care (Petersen et al., 2010; Shen et al., 2008), and veteran status itself has been associated with a host of behavioral and attitudinal attributes (Oster et al., 2017), which precluded inclusion of non-Veterans. In VHA care, administration of screening instruments based on traditional suicide risk factors not been successful in preventing veteran suicide, perhaps due to institutional factors that discourage disclosure of suicide ideation (Hoge & Castro, 2012). Notably, in a chart review of completed veteran suicides, 75 % of veterans who were asked about thoughts of suicide in the year before death *denied* these thoughts (Denneson et al., 2010). Psychiatric autopsies have indicated that the majority of completed U.S. Army suicides occurred amid a backdrop of mental illness (Logan et al., 2015). As a result, the VHA and other health systems have implemented suicide screening and prevention programs (Hoge & Castro, 2012; Matarazzo et al., 2020).

As would be expected from two groups selected from active outpatient treatment for mood disorder, there were no significant differences between groups in current mood state or in acute suicidal ideation. This suggests that propensity to avoid committing to perform the 2-back working memory task did not simply stem from SAHx+ participants being more depressed. Parenthetically, the 2-back group difference in SV held ($p = .028$) when POMS-depression scores were included in the ANCOVA model. Depression is defined in part by severe motivational deficits that could extend beyond physical activities or exertion and into cognition. Indeed, a recent experiment showed that depression itself increases COGED discounting (Westbrook et al., 2022), underscoring the interpretive importance of the groups not differing in depression severity. In sum, that the SAHx+ group here showed more severe discounting than SAHx- despite no differences in state depression suggests that severe effort discounting may be a feature of the more suicide-prone subset of mood disordered persons. In the recent COGED study (Westbrook et al., 2022), there was also heterogeneity within the depression group which was otherwise related to goal attainment and daily life and heart rate variability, implying that differences in discounting are informative of meaningful differences among those who have depression.

Finally, the totality of the findings suggests that SV of rewards that are either too mentally easy (beads) or are more arduous than the 2-back subtask (3-back, 4-back subtasks) would not be useful markers of SA risk. Designing an optimal task to detect clinical differences in revealed preference for mental effort is challenging in that gradations of perceived effort in different trial choices have to be large enough to be detectable to the participant, yet one effort (level) must be sufficiently sensitive to important phenotypic or clinical differences. Other effort tasks such as the demand selection task shown to be sensitive to schizophrenia (Kool et al., 2010) or tasks with different signaled gradations of attentional and motor effort required (Croxson et al., 2009) may be tweaked to yield an optimal trial difficulty level that is sensitive to SA histories.

4.5. Study limitations

These findings should be considered preliminary and in light of several limitations. First, the sample size may be underpowered to detect smaller effects. However, there was no hint of a decrement in evidence gathering in SAHx+ in the beads task. In the COGED task, the post-hoc analyses suggested that a very large sample would have been required to detect decrements in SV of reward with 3-back and 4-back task requirements. Both groups rated the 3-back and 4-back as difficult and perhaps even found these subtasks somewhat aversive, which likely compressed group differences. Second, our reliance on VA EMR data on suicide risk assessments to obtain SA histories seldom indicated interval of premeditation or other factors, and in many cases did not pinpoint the date of the SA. It seems likely that greater effects might have been detectable in (or specific to) certain subpopulations of SAHx+ individuals, such as defined by age, time-course of premeditation before the SA, interval between the SA and testing, or presence of substance intoxication leading to the attempt. Future larger-scale projects could explore these possibilities. Third, because we approached all referred veterans within the protocol age range (age 18–55) who met criteria, our SAHx+ sample reflects the incidence of particularly severe psychopathology among (younger) veterans of Operation Enduring Freedom/ Operation Iraqi Freedom (Burnam et al., 2009; Tanielian & Jaycox, 2008), such that we had to adjust for age in our analyses. Future larger-scale projects can better match on demographic factors. Finally, due to administrative constraints, we were unable to test veterans shortly after a SA or in suicidal crisis. Based on recent findings of differences in EF between SA survivors as a function of interval since the SA (Fernández-Sevillano et al., 2021), it seems likely that we could have detected greater abnormalities in a more acutely-suicidal SA group.

5. Conclusions and future directions

In conclusion, among outpatients treated for a mood disorder, we detected associations between (historical capacity for) SA and self-reported cognitive problems as well as relative unwillingness to expend cognitive effort within a certain range of effort. Moreover, these associations were evident when patients were not in crisis or currently or recently hospitalized for a SA. Future experiments could replicate this finding with briefer and potentially clinic-deployable cognitive effort tasks. Such studies should also expand sample size to explore sex differences, differences in effort preference as a function of SA method or premeditation and selectively recruit for demographic matching. Additionally, future studies may include patients sooner after the SA and record and vary time since SA to systematically assess the relationship between cognitive effort aversion and suicidal state.

Declaration of competing interest

None of the authors has any real or apparent financial or other conflict of interest with regard to the study findings presented in this manuscript.

Data availability

Data will be made available on request.

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