Cognitive Control Deficits Differentiate Adolescent Suicide Ideators From Attempters

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ABSTRACT

Objective: Mental illness and suicidal ideation are among the strongest correlates of suicidal behaviors, but few adolescents with these risk factors make a suicide attempt. Therefore, it is critical to identify factors associated with the transition from suicide ideation to attempts. The present study tested whether deficits in cognitive control in the context of suicide-relevant stimuli (ie, suicide interference) reliably differentiated adolescent ideators and attempters.

Methods: Adolescents (n = 99; 71 girls) aged 13–18 years (mean = 15.53, SD = 1.34) with recent suicide ideation (n = 60) or a recent suicide attempt (n = 39) were recruited from an acute residential treatment facility between August 2012 and December 2013. We measured interference to suicide-related, negative, and positive words using the Suicide Stroop Task (SST).

Results: When stimuli were analyzed separately, suicide attempters showed greater interference for suicide ($t_{97} = 2.04$, $P = .044$, $d = 0.41$) and positive ($t_{97} = 2.63$, $P = .010$, $d = 0.53$) stimuli compared to suicide ideators. An additional omnibus interference (suicide, negative, positive) x group (suicide ideator, suicide attempter) analysis of variance revealed a main effect of group ($F_{1,97} = 4.31$, $P = .041$, $\eta_p^2 = 0.04$) but no interaction ($P = .166$), indicating that attempters showed greater interference for emotional stimuli, regardless of valence. Multiple attempters drove this effect; single attempters and ideators did not differ in SST performance ($P = .608$).

Conclusions: General deficits in cognitive control in the context of emotional stimuli may be a marker of adolescent suicide risk.

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Suicide is the second-leading cause of adolescent death in the United States, and in 2015, nearly 1,800 adolescents 13 to 18 years old died from suicide.[1] Additionally, 8% of high school students report having made a suicide attempt in the past year.[2] Previous suicide attempts are among the strongest predictors of suicide deaths[3] and are associated with negative psychiatric and psychosocial outcomes in adulthood.[4] Given these unsettling statistics, it is critical to identify factors that contribute to adolescent suicide.

Suicidal ideation is very common among adolescent psychiatric patients[5] and is associated with attempts after hospitalization.[6] At the same time, only one-third of adolescents who think about suicide make an attempt.[7] Research has begun to identify factors that predict the transition from ideation to suicide attempt; however, to date these factors explain only a small amount of variance in this transition.[8] Therefore, the identification of novel risk factors of this transition is critical.[9] A related concern is that because suicide risk assessments rely primarily on questionnaires or clinical interviews, they are subject to self-presentation biases (eg, minimizing suicidality to avoid hospitalization). To overcome this challenge and identify objective factors that may confer risk for suicidal behaviors among ideators, we tested whether a cognitive marker of suicide risk differentiated adolescent ideators from attempters.

There is mounting evidence that neurocognitive alterations, and particularly deficits in cognitive control, play a critical role in vulnerability for suicidal behavior.[10] Cognitive control refers to the capacity to adapt one's attention, thoughts, or behavior to facilitate an internal goal. Several studies have used the Stroop Task[11] to measure aspects of cognitive control among suicidal adults. In the Stroop Task, participants name the ink color in which words are written; the words are either congruent or incongruent with the ink color. Thus, on incongruent trials, participants must selectively attend to features of a stimulus (ie, ink color) while disregarding others (ie, word content) and suppress a prepotent response (ie, reading the name of the word) to a distracting or competing stimulus. The magnitude of the difference in reaction time on incongruent versus congruent trials is called "interference," and greater interference reflects cognitive control deficits.* Several studies have reported greater interference on the Stroop Task among adult suicide attempters compared to healthy controls[12,17,18] and psychiatric patients with no lifetime suicide attempts.[10,13]

Recent theory suggests that individuals vulnerable to suicide attempts may exhibit cognitive control deficits specific to suicide-relevant stimuli.

*To maintain consistency with previous studies[10,12,13] of the neuropsychological underpinnings of suicide, the Stroop interference is conceptualized as a marker of cognitive control. At the same time, it is important to note that the classic Stroop effect may be driven by a number of alternative processes.[14] Furthermore, emotional Stroop tasks (eg, the Suicide Stroop Task) have been thought to reflect biases in attention for certain types of words,[15] difficulties in accessing the construct that is activated by particular words, and response biases.[16]

Clinical Points

- Deficits in cognitive control, particularly in the context of suicide-related stimuli are markers of suicide risk among adults. No study has tested whether adolescent suicide attempters show deficits similar to those of adult attempters.
- In adolescents, suicide attempters showed a general deficit in cognitive control across different types of emotional stimuli (suicide-related, negative, and positive) relative to ideators.
- Deficits in cognitive control may hinder high-risk adolescents' capacity to redirect their attention from hopeless cognitions and negative affect. Interventions like mindfulness that provide adolescents with tools to redirect focus from painful thoughts and emotions may be particularly helpful in preventing suicide attempts among adolescents.

According to the cognitive model of suicide,[19] acutely suicidal individuals have active suicide schemas, and consequently, their attention is preferentially drawn to suicide-relevant information. Poor cognitive control over suicide-related stimuli is hypothesized to lead suicidal individuals to fixate on suicide as their only option or escape and, ultimately, to attempt suicide. In this model, poor cognitive control is a proximal risk factor for attempts; the inability to disengage from suicide stimuli prolongs distress, exacerbates negative emotional states, and may culminate in suicidal acts. Outside of suicidal crises, poor cognitive control over suicide-related stimuli also may reflect a more easily activated suicide schema and therefore may be a marker of suicide vulnerability.

Several studies have used a modified Stroop Task to investigate cognitive control in the context of suicide stimuli. In the Suicide Stroop Task (SST),[15] the word stimuli are changed from color names to neutral, emotional, and suicide-related words. Suicidal individuals are hypothesized to be preoccupied by suicide stimuli, which are expected to interfere with their ability to name the ink color of words (ie, suicide-related interference: slower reaction times to suicide-related words vs neutral or emotional words). One study[20] found that recent attempters showed greater suicide-related interference compared to nonpsychiatric inpatients and controls. Extending this work, Becker and colleagues[21] reported greater suicide-related interference among attempters compared to psychiatric controls but found no differences in interference for negative words. Further, Cha and colleagues[15] found that suicide-related interference prospectively predicted attempts following hospitalization among patients with and without a history of suicide attempts. However, the only study[22] of nonpatients found that college students with and without lifetime suicide attempts did not differ in terms of suicide-related interference. Together these studies indicate that poor cognitive control over suicide-related stimuli, but not other emotional stimuli, reliably differentiates hospitalized adult suicide attempters from nonattempters and may predict risk for future suicidal behavior.

Research on suicide-related cognitive control has been limited to adults, and extending this research to adolescents is important. First, adolescence is a key developmental period wherein rates of suicidal thoughts and behaviors,[7] as well as related psychopathology (eg, depression),[23] surge. Identifying correlates of suicidal behavior in youth may provide important insight into potential mechanisms underlying the development of suicidality. Second, adolescents differ from adults in that they are still developing executive function relevant to cognitive control.[24] Consequently, findings on Stroop interference in internalizing disorders are inconsistent across development.[25–28] Research is needed to determine whether patterns of cognitive control deficits found in adults replicate in adolescent samples.

Psychiatric patients are at greatest risk for attempting suicide within 1 month of hospital discharge,[29] and it is therefore critical to develop risk markers among inpatients. The goal of the present study was to test whether suicide-related cognitive control deficits differentiated suicide ideators and attempters, and we extend previous research in several important ways. First, this is the only study to examine cognitive control in suicide attempters and suicide ideators, allowing us to test whether suicide interference is a specific marker of attempts or an indicator of suicidal thinking more generally. We hypothesized that attempters would show greater interference to suicide-related, but not negative or positive, words than ideators. Second, on the basis of the theory suggesting that a history of suicidality may strengthen underlying suicide schemata,[19] we expected suicide-related cognitive control deficits to track adolescents' suicide attempt history. Specifically, we hypothesized that deficits in cognitive control would be more pronounced among multiple attempters compared to single attempters. Given past research[10] in adults using the classic Stroop Task, we also explicitly tested the alternative hypothesis that adolescent suicide attempters show general cognitive control deficits, regardless of stimulus valence (eg, suicide, negative). Last, we tested whether suicide-related interference was associated with suicide attempt recency, and, consistent with previous findings,[15] we hypothesized that this interference would be strongest among adolescents with the most recent suicide attempts.

METHODS

Participants

Our initial sample included 109 adolescents recruited within 48 hours of admission to a short-term (10–14 days) inpatient treatment program between August 2012 and December 2013. Patients in this program are admitted for acute clinical care, including failure to thrive in outpatient treatment, symptom severity, and safety concerns (eg, active suicidal ideation, suicidal behaviors). Participants were selected if they reported suicidal ideation, measured using the Self-Injurious Thoughts and Behaviors Interview (SITBI),[30] on at least 1 day in the week prior to the assessment. Of the initial sample, 3 participants (2.8%) elected not to complete the SST and 7 (6.4%) were removed as SST outliers. The remaining participants were 99 adolescents (71 girls;

ideators = 60, attempters = 39) between 13 and 18 years old (mean = 15.53, SD = 1.34) and predominantly white (n = 77; 77.8%). Included participants did not differ from excluded adolescents on any demographic or clinical factor assessed.

Procedure

Study procedures were approved by the institutional review board. Adult legal guardians and 18-year-old adolescents provided written informed consent, and 13- to 17-year-old participants provided written assent. Participants attended a laboratory session within 48 hours of hospital admission. During this assessment, they were administered the 2 clinical interviews—the Mini-International Neuropsychiatric Interview for Children and Adolescents (MINI-KID)[31] and the SITBI.[30] Participants also completed the SST, the Center for Epidemiologic Studies Depression scale (CES-D),[32] and the Multidimensional Anxiety Scale for Children (MASC).[33]

Instruments

Psychiatric diagnoses. The MINI-KID[31] is a structured diagnostic interview that was used to assess current and past psychopathology in our adolescent participants. Study staff (ie, BA-level research assistants and graduate students) received a minimum of 25 hours of training prior to conducting live interviews with participants. The MINI-KID has demonstrated concordance with gold-standard interviews.[31]

Suicidality. The SITBI[30] is a structured interview that was used to assess the presence, frequency, and severity of suicidal thoughts and behaviors over the following time frames: past week, past month, past year, and lifetime. On the basis of SITBI data, we created the following post hoc groups: single attempters (n = 12; 1 lifetime suicide attempt), multiple attempters (n = 26; 2 or more attempts), and ideators (n = 60; thoughts of suicide but no lifetime attempts). All groups reported past week suicidal ideation. Among multiple attempters, 10 (38.5%) reported 2 lifetime attempts, 7 (26.9%) reported 3 attempts, 5 (19.2%) reported 4 attempts, and 4 (15.4%) reported 5 or more attempts. Suicide attempt recency was coded in the following manner: 0 (no attempts; n = 60), 1 (lifetime attempt but not past month; n = 21), and 2 (past month attempt; n = 18). We did not create "past week but not past month" or "past year but not past month" categories, as others[15] have done, as too few (between 3% and 4%) participants made attempts in these time frames. The SITBI possesses strong psychometric properties[30] and adequate concurrent validity within adolescent inpatient samples.[34]

Cognitive control. Cognitive control in the context of emotionally salient words was measured using the SST. Participants were instructed to indicate the color (red or blue) of each word they saw as quickly as possible by pressing the red or blue key on a keyboard. There were 8 practice trials followed by 48 test trials. Neutral (*museum*, *paper*, *engine*), suicide-related (*suicide*, *dead*, *funeral*), negative (*alone*, *rejected*, *stupid*), and positive (*happy*, *success*, *pleasure*) words were equally represented in the test trials, which were randomized for each participant. These words did not differ in emotionality, length, concreteness, or frequency of use.[15] Trials began with a white screen (4 seconds), followed by a fixation "+" (1 second) and a second white screen (1 second). Next, a blue- or red-colored word appeared in the center of the screen and remained until a response was made and reaction times were recorded.

Only data from trials in which participants made correct responses were used. We removed trials with reaction times ± 2 SDs from individual participants' mean latency (4.9% of trials). Further, we removed 4 participants whose mean response latencies were ± 2 SDs from the sample mean and 3 participants whose error rate was greater than 2 SDs above the sample mean. We found no significant differences in reaction times to the 4 types of words in our sample ($F_{3,294} = 0.81$, $P = .490$, $\eta_p^2 = 0.01$). To control for scaling effects and general slowing, we computed SST interference ratio scores for the 3 categories of emotion words using the following formula: (emotion word reaction time – neutral reaction time)/neutral reaction time.[35] Positive ratio scores indicate more interference from the emotion word, and negative ratio scores indicate facilitation.*

Depressive symptoms. Depression symptom severity was measured using the 20-item CES-D.[32] Items are rated on a scale from 0 (rarely or none of the time) to 3 (almost or all of the time), and total scores range from 0 to 60. The CES-D items demonstrated excellent internal consistency (α = .93) in this sample.

Anxiety symptoms. Anxiety symptom severity was assessed using the 39-item MASC.[33] Items are rated on a scale from 0 (never true about me) to 3 (often true about me), and total scores range from 0 to 117. In our sample, the internal consistency of the MASC was excellent (α = .92).

Data Analysis

We conducted our primary analyses in 2 stages. First, to test our hypothesis that ideators and attempters would differ in suicide-related, but not negative or positive, interference, we analyzed each interference type separately, consistent with previous SST research.[15,20–22] Specifically, we tested group differences (ideators vs attempters) on suicide-related, negative, and positive interference scores using independent sample *t* tests. We further probed potential group differences by dividing attempters into single and multiple attempter groups and tested 3 analysis of variance (ANOVA) models. Demographic and clinical characteristics that were significantly different ($P < .05$) across our groups were entered as covariates. Second, to evaluate the alternative possibility that attempters and ideators differ in cognitive control to emotional stimuli, regardless of valence, we ran analyses that included all 3 interference variables. Specifically, we conducted an interference (suicide, negative, positive) × group (suicide ideator, suicide attempter)

*Results were unchanged when interference was operationalized using simple difference scores (emotion word reaction time – neutral reaction time).

Table 1. Demographic and Clinical Characteristics of Single Attempters, Multiple Attempters, and Ideators[a]

Characteristic	Single Attempters (n = 12)	Multiple Attempters (n = 26)	Suicide Ideators (n = 60)	SA + MA vs SI			SA vs MA vs SI		
				Test	*P*	Effect Size	Test	*P*	Effect Size
Age, mean (SD), y	15.58 (1.44)	15.58 (1.36)	15.52 (1.32)	$t_{97} = 0.08$	.937	$d = 0.02$	$F_{2,95} = 0.03$	.975	$\eta_p^2 = 0.001$
Female sex, n (%)	8 (66.7)	21 (80.8)	41 (68.3)	$\chi^2_1 = 0.86$	.354	$\Phi = 0.09$	$\chi^2_2 = 1.53$	.466	$\Phi = 0.13$
Race, n (%)									
White	9 (75.0)	21 (80.8)	46 (76.7)						
Black	1 (8.3)	0 (0.0)	3 (5.0)						
Asian	1 (8.3)	3 (11.5)	6 (10.0)	$\chi^2_5 = 1.96$	.855	$\Phi = 0.14$	$\chi^2_{10} = 3.45$	.969	$\Phi = 0.19$
Pacific Islander	0 (0.0)	0 (0.0)	1 (1.7)						
Native American	0 (0.0)	0 (0.0)	1 (1.7)						
2 or more races	1 (8.3)	2 (7.7)	3 (5.0)						
DSM-IV-TR disorders present, n (%)[b]									
Any mood	12 (100.0)	23 (88.5)	55 (91.7)	$\chi^2_1 = 0.013$	.909	$\Phi = 0.01$	$\chi^2_2 = 1.46$	.481	$\Phi = 0.12$
Any anxiety	9 (75.0)	20 (76.9)	43 (71.7)	$\chi^2_1 = 0.34$	.561	$\Phi = 0.06$	$\chi^2_2 = 0.27$	.872	$\Phi = 0.05$
Any psychotic	0 (0.0)	1 (3.8)	2 (3.3)	$\chi^2_1 = 0.05$	.827	$\Phi = 0.02$	$\chi^2_2 = 0.45$	.799	$\Phi = 0.07$
Any eating	1 (8.3)	0 (0.0)	5 (8.3)	$\chi^2_1 = 1.38$	.240	$\Phi = 0.12$	$\chi^2_2 = 2.31$	.315	$\Phi = 0.15$
Any impulse	2 (16.7)	2 (7.7)	9 (15.0)	$\chi^2_1 = 0.47$	.495	$\Phi = 0.07$	$\chi^2_2 = 0.98$	.613	$\Phi = 0.10$
Any substance use	2 (16.7)	5 (19.2)	4 (6.7)	$\chi^2_1 = 3.05$	.081	$\Phi = 0.18$	$\chi^2_2 = 3.28$	.194	$\Phi = 0.18$
Any alcohol use	0 (0.0)	2 (7.7)	3 (5.0)	$\chi^2_1 = 0.001$	.977	$\Phi = 0.003$	$\chi^2_2 = 1.01$	.604	$\Phi = 0.10$
No. of disorders, mean (SD)	2.92 (1.83)	2.31 (1.61)	2.77 (1.74)	$t_{93.77} = -0.81$	.418	$d = -0.17$	$F_{2,95} = 0.91$	.406	$\eta_p^2 = 0.02$
CES-D, mean (SD)	37.00 (11.09)	35.45 (12.77)	35.12 (11.54)	$t_{97} = 0.51$	.608	$d = 0.10$	$F_{2,95} = 0.13$	.882	$\eta_p^2 = 0.003$
MASC, mean (SD)	62.77 (18.97)	60.54 (17.85)	64.06 (18.77)	$t_{97} = -0.65$	.677	$d = -0.13$	$F_{2,95} = 0.35$	.347	$\eta_p^2 = 0.01$
Ideation, mean (SD)[c]	3.92 (2.43)	3.92 (2.38)	3.78 (2.35)	$t_{97} = 0.45$	.657	$d = 0.09$	$F_{2,95} = 0.04$	.961	$\eta_p^2 = 0.001$
Plans, mean (SD)[c]	1.17 (2.21)	0.81 (1.90)	0.73 (1.69)	$t_{97} = 0.71$	.478	$d = 0.14$	$F_{2,95} = 0.29$	.752	$\eta_p^2 = 0.01$
SST errors (count)	2.42 (2.07)	1.27 (2.07)	1.77 (1.73)	$t_{97} = -0.45$	.657	$d = 0.09$	$F_{2,95} = 2.11$	.127	$\eta_p^2 = 0.04$
SST total latency (ms)	439.7 (127.4)	554.0 (143.5)	529.5 (139.9)	$t_{97} = 0.32$	.749	$d = 0.07$	$F_{2,95} = 0.79$	.459	$\eta_p^2 = 0.02$

[a]One suicide attempter did not provide information on the number of lifetime attempts. Therefore, this participant was included only in analyses comparing suicide attempters and ideators and was excluded from analyses that tested group differences between ideators, single attempters, and multiple attempters.
[b]Psychiatric disorders assessed using the Mini-International Neuropsychiatric Interview for Children and Adolescents.
[c]Frequency in the past week measured by the Self-Injurious Thoughts and Behaviors Interview.
Abbreviations: CES-D = Center for Epidemiologic Studies Depression scale, MA = multiple attempters, MASC = Multidimensional Anxiety Scale for Children, SA = single attempters, SI = suicide ideators, SST = Suicide Stroop Task.

Table 2. Pearson Product-Moment Correlation Coefficients Among Study Variables

	1	2	3	4	5	6	7	8	9
1 Negative interference[a]	…	**0.53*** **	**0.53*** **	−0.12	−0.05	0.04	−0.05	−0.06	0.04
2 Positive interference[a]		…	**0.49*** **	−0.14	−0.08	0.02	−0.11	−0.06	−0.01
3 Suicide interference[a]			…	−0.17	−0.17	−0.15	0.07	−0.15	**−0.21***
4 Age				…	0.13	0.02	0.03	−0.11	−0.03
5 No. of disorders[b]					…	**0.24***	**0.59*** **	0.15	0.15
6 CES-D total						…	**0.46*** **	**0.56*** **	**0.40*** **
7 MASC total							…	**0.26****	**0.24***
8 Past week ideation[c]								…	**0.33****
9 Past week plans[c]									…

[a]Measured using the Suicide Stroop Task.
[b]Measured using the Mini-International Neuropsychiatric Interview for Children and Adolescents.
[c]Measured using the Self-Injurious Thoughts and Behaviors Interview.
*$P < .05$. **$P < .01$. ***$P < .001$.
Abbreviations: CES-D = Center for Epidemiologic Studies Depression scale, MASC = Multidimensional Anxiety Scale for Children.

mixed-model ANOVA and an interference (suicide, negative, positive) × group (suicide ideator, suicide single attempter, suicide multiple attempter) mixed-model ANOVA. In these models, nonsignificant interference × group interactions indicated that group effects did not significantly vary across interference type.

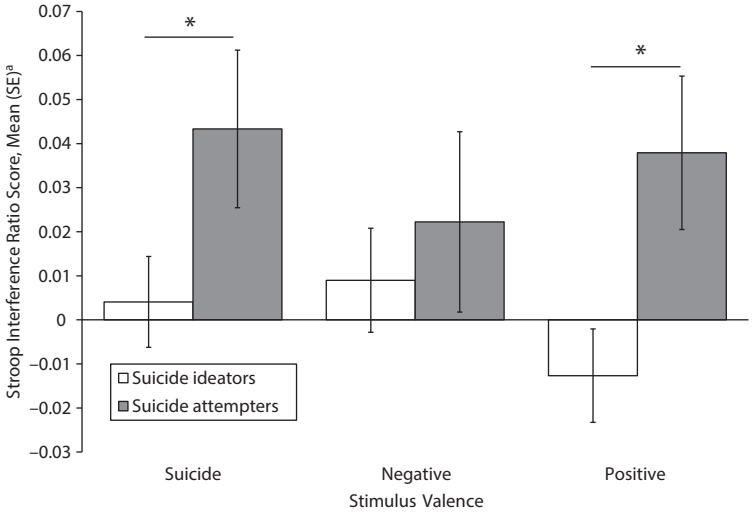
Finally, we tested the association between the interference effects and suicide attempt recency in a multinomial logistic regression model. We chose this approach to examine the simultaneous effects of the 3 interference variables on attempt recency. Prior to testing of our multinomial regression model, all predictors were simultaneously entered into a regression analysis with subject number as a dummy dependent variable, and collinearity diagnostics were computed using established recommendations.[36,37] Multicollinearity was defined as a conditioning index > 30 on any root plus variance proportions greater than 0.50 for at least 2 variables on that dimension (ie, the row corresponding to the root). Predictors were standardized before they were entered into the model to obtain standardized β values, which allowed us to compare the relative strength of the predictors.

RESULTS

Preliminary Analyses

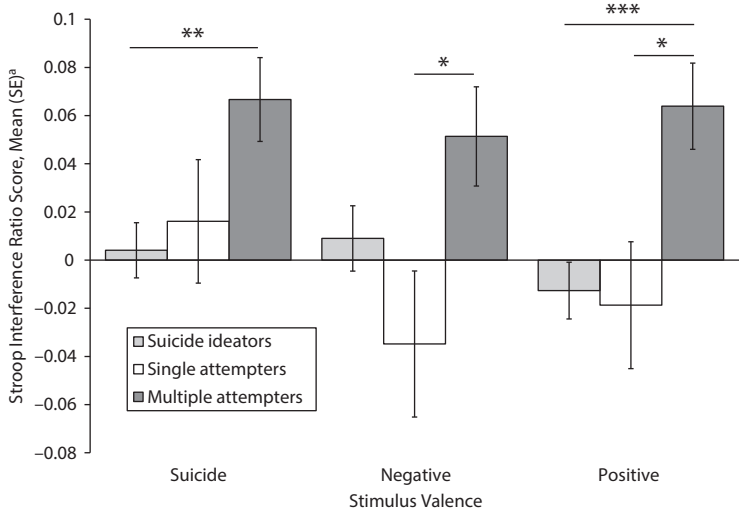
Table 1 presents the results of analyses comparing adolescent ideators to lifetime attempters, single attempters, and multiple attempters across demographic and clinical

Figure 1. Interference Ratio Scores for Suicide, Negative, and Positive Interference, Stratified by Lifetime Suicide Attempter Status



[a]The interference ratio score was computed using the following formula: (emotion word reaction time [RT] – neutral RT)/neutral RT.
*P < .05.

Figure 2. Interference Ratio Scores for Suicide, Negative, and Positive Interference, Stratified by Suicide Attempter Status (ideator, single attempter, multiple attempter)



[a]The interference ratio score was computed using the following formula: (emotion word reaction time [RT] – neutral RT)/neutral RT.
*P < .05. **P < .01. ***P < .001.

characteristics. The groups differed on none of the demographic or clinical variables assessed. Therefore, our primary group analyses did not include covariates. Table 2 presents correlations among major study variables.*

Suicide attempt recency (no attempt, lifetime attempt but not in past month, past month attempt) was not related to participant age, sex, or race (P values > .46). Recency was also not associated with the presence of any Axis I disorder (P values > .17) or with psychiatric symptoms (P values > .66). However, recency was associated with the presence or absence of a substance use disorder (n = 99; $\chi^2_2 = 8.25$, $P = .016$, $\Phi = 0.29$). Substance use disorders were more common among lifetime attempters without an attempt in the past month (28.6%) compared to past-month attempters (5.6%) and nonattempters (6.7%). We therefore controlled for the presence of a substance use disorder in our multinomial regression analysis. Further, among suicide attempters (n = 39), single versus multiple attempter status was not associated with suicide attempt recency (attempt in past month vs earlier attempt: n = 38; $\chi^2_1 = 0.20$, $P = .658$, $\Phi = 0.07$).

Collinearity diagnostics for the 4 independent variables (suicide, negative, and positive interference, as well as presence or absence of a substance use disorder) in the multinomial regression analysis revealed 5 roots. None of the conditioning indexes exceeded 30; further, no dimension corresponding to any of the roots had more than 1 variance proportion > 0.50 (2 separate dimensions had 1 variable with a variance proportion > 0.50). Therefore, no multicollinearity was evident among our predictor variables.[36,37]

Group Differences

Total reaction time and errors. Attempters and ideators did not differ in their number of SST errors or in total reaction time across valences. Further, there were no group differences among ideators, single attempters, and multiple attempters for errors and total latency (see Table 1).

Suicide interference. Attempters had significantly greater suicide-related interference than ideators ($t_{97} = 2.04$, $P = .044$, $d = 0.41$) (Figure 1). When attempters were further divided, the effect of group was significant ($F_{2,95} = 4.54$, $P = .013$, $\eta_p^2 = 0.09$). Multiple attempters had significantly greater suicide interference than ideators ($P = .004$, $d = 0.64$), but single and multiple attempters did not differ ($P = .163$, $d = -0.48$), nor did ideators and single attempters ($P = .629$, $d = -0.12$) (Figure 2).

Negative interference. Attempters and ideators did not significantly differ in their negative interference scores ($t_{97} = 0.60$, $P = .549$, $d = 0.12$) (Figure 1). However, when attempters were divided into single and multiple attempters, the group effect was at a statistical trend ($F_{2,95} = 3.01$, $P = .054$, $\eta_p^2 = 0.06$).

*Although age was not associated with interference scores, younger age was associated with faster reaction times during the SST ($r = -0.20$, $P = .044$). We ran all our primary analyses with age included as a covariate, and the pattern and statistical significance of our effects were unchanged. Further, we found no evidence for age × group interactions in any model (all P values > .09).

Table 3. Results of the Multinomial Regression Analysis Predicting Suicide Attempt Recency[a] From Suicide, Negative, and Positive Interference

	Total Effect	Ideators[b] vs Lifetime			Ideators[b] vs Past Month		
Variable	χ^2_2	β (SE)	OR[c]	95% CI[c]	β (SE)	OR[c]	95% CI[c]
Any substance[d]	7.97*	0.60 (0.24)*	1.82	1.14–2.91	−0.12 (0.37)	0.89	0.43–6.90
Suicide[e]	4.45	0.72 (0.36)*	2.06	1.02–4.17	0.07 (0.35)	1.08	0.54–2.15
Negative[e]	1.93	0.40 (0.36)	0.67	0.33–1.36	−0.41 (0.37)	0.66	0.32–1.37
Positive[e]	5.99*	0.28 (0.35)	1.33	0.66–2.66	0.92 (0.41)*	2.51	1.13–5.55

[a]Suicide ideator, no attempt (n = 60); lifetime attempt but not in past month (n = 21); and past month attempt (n = 18).
[b]Comparison group.
[c]Odds ratios and their 95% CIs indicate the odds related to a 1 SD change in the predictor variable. Thus, for example, OR = 1.08 indicates that for each 1 SD increase in interference for emotion words, there is an 8% greater odds of a past month attempt (versus no attempts).
[d]Any substance use disorder present (measured using the Mini-International Neuropsychiatric Interview for Children and Adolescents).
[e]Measured using the Suicide Stroop Task.
*$P < .05$.
Abbreviation: OR = odds ratio.

Follow-up comparisons indicated that ideators did not significantly differ from single ($P = .120$, $d = 0.38$) or multiple ($P = .089$, $d = -0.36$) attempters, but multiple attempters had significantly greater interference than single attempters ($P = .015$, $d = 0.85$) (Figure 2).

Positive interference. Attempters showed significantly greater interference for positive words than ideators ($t_{97} = 2.63$, $P = .010$, $d = 0.53$) (Figure 1). When we compared ideators, single attempters, and multiple attempters, a significant effect of group was indicated ($F_{2,95} = 6.93$, $P = .003$, $\eta_p^2 = 0.13$), such that multiple attempters had significantly greater positive interference than ideators ($P < .001$, $d = 0.79$) and single attempters ($P = .030$, $d = 0.76$), who did not differ from one another ($P = .823$, $d = 0.05$) (Figure 2).

General differences in cognitive control. In the mixed model ANOVA for suicide ideators versus attempters, the main effect of interference was nonsignificant ($F_{2,194} = 0.65$, $P = .523$, $\eta_p^2 = 0.01$). A main effect of group was indicated ($F_{1,97} = 4.31$, $P = .041$, $\eta_p^2 = 0.04$), such that attempters (mean = 0.03, SE = 0.01) showed greater interference for emotional stimuli than ideators (mean = 0.0001, SE = 0.01), regardless of stimulus valence. The main effect of group was not qualified by an interference × group interaction ($F_{2,194} = 1.81$, $P = .166$, $\eta_p^2 = 0.02$).

In the mixed-model ANOVA for ideators versus single attempters versus multiple attempters, the main effect of interference was nonsignificant ($F_{2,190} = 1.77$, $P = .174$, $\eta_p^2 = 0.02$). The main effect of group was significant ($F_{1,95} = 6.36$, $P = .003$, $\eta_p^2 = 0.12$); multiple attempters (mean = 0.06, SE = 0.02) showed greater interference, regardless of stimulus valence, than both ideators (mean = 0.0001, SE = 0.01; $P = .001$) and single attempters (mean = −0.01, SE = 0.02; $P = .008$), who did not significantly differ from one another ($P = .608$). Finally, the interference × group interaction was nonsignificant, ($F_{4,190} = 1.29$, $P = .275$, $\eta_p^2 = 0.03$).

Suicide Attempt Recency

The multinomial regression model predicting suicide attempt recency from suicide-related, negative, and positive interference, while controlling for the presence or absence of a substance use diagnosis, was significant (n = 98; $R^2_{C\&S} = 0.18$, $\chi^2_8 = 19.24$, $P = .014$). Suicide-related interference was associated with lifetime attempts (vs no attempts) but not with past month attempts. Negative interference was nonsignificant in the model. Positive interference was associated with suicide attempts occurring in the past month (vs no attempts) but not suicide attempts occurring prior to the past month (Table 3).*

DISCUSSION

This study, which is the first to examine cognitive control in the context of suicide-related stimuli among youth and to compare suicide ideators and attempters, yielded 3 important findings. First, in models that replicated previous research[15,20–22] by analyzing suicide-related, negative, and positive interference separately, attempters showed significantly greater suicide-related interference, but the groups did not differ in terms of negative interference. Surprisingly, suicide attempters also showed greater positive interference than did ideators. Second, multiple attempters had greater suicide-related and positive interference than did ideators; single attempters and ideators did not differ across conditions. Third, omnibus analyses testing group differences across all conditions simultaneously showed that, compared to ideators, attempters (particularly multiple attempters) had greater interference for emotional, compared to neutral, stimuli. Last, only positive interference was uniquely associated with suicide attempt recency.

Only one-third of adolescent suicide ideators transition to suicide attempt,[7] and identifying factors associated with this transition is critical.[9] Our findings suggest that interference for emotional stimuli, regardless of valence, may be a marker of suicide attempts among adolescents.

*We conducted an additional multinomial regression analysis that did not control for the effects of substance use disorders; the pattern of effects was unchanged.

This pattern is in line with adult research using the classic Stroop Task[10,12,13,17,18] and extends these findings to adolescents and to ideators versus attempters. Further, multiple attempters may drive this effect, as single attempters did not differ from ideators in SST performance. A series of previous studies found that cognitive control deficits are more pronounced among high lethality attempters and violent attempters compared to low lethality, nonviolent attempters.[12,13] Our results may therefore have been due to higher incidence of high-lethality attempts among multiple attempters compared to nonattempters. Future research should thoroughly assess suicide attempt characteristics (eg, violent means, lethality, injuries sustained) to more precisely characterize the link between cognitive control deficits and suicide attempts among adolescents.

The pattern of our findings for suicide-related and negative interference was similar to previous SST studies.[15,21] However, that cognitive control deficits were not specific to suicide-related stimuli is inconsistent with the cognitive model of suicide.[19] Instead, our results may have been due to a general deficit in cognitive control over emotional stimuli among adolescent attempters. Research has shown that adolescent suicide attempters may have reduced functional connectivity between the dorsal anterior cingulate cortex and the insula when viewing emotional faces, which suggests inefficient regulation of attention to emotional stimuli.[38] In our study, poor regulation of attention to emotional stimuli may have impaired adolescent attempters' task-relevant behaviors. Alternatively, as we did not measure how subjectively emotional participants found study stimuli, attempters may have experienced positive (and negative) words as more emotional than ideators, which may explain differences in interference. Future research measuring cognitive control in emotional and nonemotional contexts is needed to better understand these processes in adolescent suicidality.

Our findings have noteworthy clinical implications. First, traditional risk assessments rely on patient report, which can be unreliable when patients are motivated to minimize suicidal thoughts or are simply unaware of their suicidality. Our results highlight the promise of performance-based measures for augmenting existing suicide risk assessment tools and bolstering clinical decision making. Second, our findings support the view that existing clinical translations of neurocognitive models of suicide[10,13] may apply to adolescents. Following negative life events, deficits in cognitive control may preclude vulnerable adolescents from redirecting attention away from hopelessness, dejection, and other negative affective states—suicide may seem like the only relief from extremely painful circumstances. Therapeutic interventions that provide adolescents with tools (eg, distraction) to better manage intense affect (eg, mindfulness)[39] may be especially useful to adolescents at risk for suicide.

An unexpected pattern also emerged in our recency findings: positive interference differentiated adolescent past-month attempters from ideators, while suicide-related interference differentiated ideators from lifetime attempters whose attempts were not in the past month. These results are inconsistent with adult findings showing that suicide-related interference differentiated only the most recent attempters (ie, past week) from nonattempters.[15] Our findings may indicate that cognitive control deficits in the context of positive and suicide-related stimuli are linked with distinct aspects of suicide risk among adolescents. Whereas suicide-related interference may be associated with general vulnerability to suicidal behavior, positive (or emotional) interference may differentiate ideators from adolescents in acute or recent suicidal crisis. A growing literature is finding that suicide ideators and attempters are differentiated by approach motivational states (eg, anhedonia, aggression, agitation, impulsivity).[40,41] Positive interference may be a proxy of approach motivational states linked to acute suicide risk; future research is needed to explicitly test this possibility.

The implications of our results should be interpreted in light of several limitations. First, our study is cross-sectional, and longitudinal research is warranted to elucidate the direction of the association among cognitive control deficits and suicide attempts. Second, along with deficits in cognitive control, interference to emotional words on the SST may reflect other cognitive processes, such as threat-related slowing.[42] Future research employing more precise measurement of cognitive control (eg, flanker task, probe discrimination) and alternatives to reaction time measurement (eg, eye tracking, event-related potentials) is needed. Relatedly, we found some counterintuitive effects using the SST with adolescents, such as the inverse relationship between suicide interference and past week suicide plans. These results require further study and replication to ensure their reliability. Third, our modest sample size resulted in small subgroups of single and multiple attempters, which precluded examination of more fine-grained groupings of frequency within multiple attempters. However, all of our significant results had medium-to-large effect sizes. Fourth, we had no data on psychoactive medications prescribed to participants, nor were data recorded on patients' reason(s) for admission. We therefore could not account for the potential impact of these factors on SST performance. Finally, participants were selected based on recent ideation frequency, not the seriousness of the ideation they endorsed, and we did not include a group of healthy adolescents or a psychiatric control group of nonideators. Grouping adolescents based on ideation severity and comparing ideators and attempters to nonideators are critical avenues for future study.

Despite these limitations, the present study is an important step toward identifying reliable, objective markers of suicide risk among adolescent suicide ideators. Our main findings show that adolescent attempters, especially multiple attempters, exhibit pronounced cognitive control deficits in the context of emotional stimuli compared to ideators. Ultimately, this research holds great promise for improving clinical detection of high-risk adolescents and ultimately reducing suicide-related death in youth.

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