

Executive Function and Self-Injurious Thoughts and Behaviors: A Systematic Review and Meta-Analysis

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ABSTRACT

BACKGROUND: Although executive functioning (EF) deficits have been implicated in self-injurious thoughts and behaviors (SITBs), the strength of their associations remain unclear. Few mechanisms reliably differentiating between suicidal thoughts and suicide attempts have been identified. The degree to which EF deficits may differentiate suicidal thoughts from behavior is undetermined.

METHODS: PubMed and PsycInfo were searched from inception through June 4, 2025. Two reviewers independently identified studies on core EFs (inhibitory control, cognitive flexibility, and working memory) and their sub-components in relation to SITBs. Associations between each core EF and their composite parts in relation to suicidal ideation, suicide attempts, and nonsuicidal self-injury were extracted. Hedges' g was derived from random-effects meta-analyses.

RESULTS: A total of 127 studies were included. Deficits in inhibitory control, cognitive flexibility, and working memory were associated with suicidal ideation (g s = $|0.15|$ – $|0.23|$) and suicide attempts (g s = $|0.21|$ – $|0.28|$). Medium pooled effects were observed for cognitive flexibility (g = 0.52, 95% CI [0.10 to 0.93]) and working memory (g = –0.69, 95% CI [–1.00 to –0.38]) in relation to nonsuicidal self-injury. Sensitivity analyses suggested that task switching and response inhibition were specifically related to suicidal ideation, whereas working memory and attentional control were specific to suicide attempts.

CONCLUSIONS: While other neurocognitive functions have also been associated with SITBs, EF deficits may be particularly promising candidate mechanisms. Future longitudinal work will be important for establishing prognostic value to inform selection of brain regions to target with neuromodulation treatment paradigms.

<https://doi.org/10.1016/j.biopsych.2026.05.010>

Suicide is a leading cause of death worldwide (1). Despite efforts to address this concern, suicide rates have not declined (2). Self-injurious thoughts and behaviors (SITBs) including suicidal ideation, suicide attempts, and nonsuicidal self-injury (NSSI) are well-established risk factors for suicide (3). A better understanding of processes underlying SITBs is critical for predicting and preventing these outcomes.

Substantial evidence points to neurocognitive deficits as meaningful contributors to suicide risk. Suicidal behavior has been associated with worse performance on tasks measuring decision making, probabilistic reward learning, long-term memory, implicit associations with suicide, and semantic language fluency (4–12). For example, meta-analytic findings have demonstrated disadvantageous decision making among suicide attempters (13), with converging neuroimaging work highlighting reductions in lateral orbitofrontal response during risky versus safe decision making (14). Relatedly, there has been increasing interest in neurocognitive processes underlying NSSI (15), and individuals who engage in NSSI may have a preference toward more immediate rewards (i.e., delayed

discounting), possibly reflecting underlying processes leading to the decision to engage in NSSI as a broader emotion regulatory mechanism (16). While these higher-order processes are clearly relevant to suicide and self-injury risk, they integrate cognitive, affective, and motivational components, making it challenging to isolate specific cognitive operations or neural systems that give rise to SITB vulnerability.

Executive function (EF) is one of several key cognitive processes that may be relevant to SITB risk and address this challenge (17–19). EF encompasses a set of foundational skills that may underlie higher-order goal-directed behaviors when automatic responses are insufficient (20), including self-regulatory processes that are relevant to control, intentionality, and decision making (21,22). Three core EFs are thought to be foundational abilities that inform higher-order processes such as problem solving, decision making, and planning (21,22). These core EFs include 1) inhibitory control (IC) of behavior (i.e., response inhibition) and attention (i.e., attentional control [AC]); 2) cognitive flexibility (CF), or the ability to shift cognitive sets (i.e., task switching) and generate

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alternatives in response to internal and external demands; and 3) working memory (WM), which includes holding and manipulating information in one's mind (20,23–25). Thus, research investigating EF provides a direct avenue for isolating core cognitive mechanisms that may underlie and contribute to broader neurocognitive deficits associated with SITB risk.

EF is also particularly well suited for translational suicide research. EF processes are state sensitive (26,27), amenable to treatment (28,29), and show meaningful within-person variability (30–32). Furthermore, EF processes map onto identifiable neural substrates, including the dorsolateral prefrontal cortex, anterior cingulate cortex, and related frontostriatal circuitry (30–33). Critically, the specificity of EF-related neural circuits makes them well suited as targets for intervention development, including neuromodulation approaches aimed at enhancing cognitive control and reducing acute risk during periods of elevated risk (34). Thus, a deeper understanding of EF and SITB risk offers a promising framework for informing models of short-term risk and maximizing translational impact by enabling the development of mechanistically grounded, actionable intervention targets.

A few meta-analyses on EFs and suicidal thoughts and behaviors (STBs) have reported associations between EF deficits and these outcomes. However, most examined these associations in specific disorders, particularly depression (9,35,36). Although STBs are common in depression, epidemiological studies make clear that most STBs occur outside the context of depression, reflecting their transdiagnostic nature (37). Importantly, diagnosis of schizophrenia spectrum disorders may also yield a reversal of expected effects. Evidence suggests that risk for suicide attempts increases with self-awareness of psychosis. Self-awareness and insight are associated with better cognitive functioning (38,39), therefore suggesting a possible inversion of the hypothesized relationship between EF and SITBs for other mental health conditions. Therefore, we intend to examine all studies, regardless of primary diagnosis, while also accounting for potential effects of diagnoses. Another meta-analysis focused only on memory and suicide attempts (10). Only one meta-analysis has been conducted on NSSI (40), and analyses were limited to response inhibition, a subdomain of IC; a small association was found. Suicidal ideation and behavior were not directly compared in any meta-analyses.

Measurement considerations are also critical in evaluating previous meta-analyses of EF. Specifically, while previous psychometric work has supported the assertion that IC of attention and behavior fall along one factor (24,41), the International Society for Research on Impulsivity has come to a consensus that tasks representative of behavioral impulsivity (e.g., tasks reflective of response inhibition) do not include those used to assess AC (42). Furthermore, there are differing views regarding whether verbal fluency (VF) is reflective of CF (20,25,43,44). Meta-analyses reported to date have not addressed the inconsistencies in operationalization.

The current study provides the first comprehensive meta-analysis of distinct core EFs (CF, IC, and WM) and their composite parts (response inhibition, AC, task switching, and VF) in relation to suicidal ideation, suicide attempts, and NSSI. Our goal is to comprehensively quantify the current evidence

to direct future research in this area and contribute to the broader literature on neurocognitive markers of SITB risk.

METHODS AND MATERIALS

Search Strategy and Eligibility

A systematic review of the literature was conducted in PubMed and PsycInfo from inception to June 4, 2025 (see [Supplemental Methods](#) for search terms and inclusion and exclusion criteria). The current review was restricted to English-language and peer-reviewed articles. A search of relevant reference sections was also conducted. The current review was preregistered in PROSPERO ([CRD42024503302](#)) and conformed to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Search results were reviewed by 2 independent coders, and discrepancies were resolved by discussion and consultation with the first author (SMC). Where eligibility could not be ascertained by full-text review (e.g., a measure was not adequately described to determine eligibility), efforts were made to obtain further details in other publications (e.g., those using the same dataset or measure), and corresponding authors were contacted to obtain additional quantitative information where appropriate, resulting in additional data for 7 studies (45–51).

Data Extraction

Data on 9 study characteristics were extracted. Study sample characteristics included 1) mean age of sample, 2) percentage of female participants in the sample, 3) sample type (clinical, community, military, or mixed), and 4) primary diagnosis. The latter was included to examine effects by diagnosis in sensitivity analyses. Psychotic disorder was included as a moderator, given the inversion of a hypothesized relationship between EF and SITBs mentioned above. Study design characteristics included 1) SITB type assessed (i.e., suicidal ideation, suicide attempts, NSSI); 2) EF type (i.e., IC, CF, WM) and component assessed (i.e., AC, response inhibition, task switching, and VF); 3) time frame covered by SITB assessment; 4) SITB measure type (interview vs. self-report); and 5) task assessing EF, for the purposes of sensitivity analyses.

We examined AC and response inhibition separately, as well as a unified construct. Similarly, task switching and VF were analyzed together and separately. When studies included mixed samples with both healthy control participants and psychiatric control participants, data were extracted comparing the SITB group to each comparison group independently whenever possible, in addition to control groups combined, to conduct sensitivity analyses by comparison group. For suicide attempts, where possible, additional analyses were conducted comparing with suicidal ideation only.

Data Analysis

Analyses were conducted using Comprehensive Meta-Analysis version 4.0 (52). Hedges' *g* was used as an index of effect size. Pooled associations were calculated for each component of EF. For IC and CF, values >0 indicated positive associations between deficits in these abilities and SITBs. For WM, values <0 indicated that better-developed WM is

negatively associated with SITBs. Pooled associations were also separately calculated for each subtype of IC and CF.

Random-effect size models were generated as high levels of heterogeneity were expected. Heterogeneity was assessed using the following statistics: 1) I^2 , indicating the percentage of variance in an effect estimate that is due to heterogeneity across studies rather than random error, with values $>75\%$ reflecting substantial heterogeneity; 2) τ^2 , an estimate of the variance of the true effect sizes (i.e., between-study variance due to heterogeneity rather than measurement error); and 3) Q and its associated p value. Significant heterogeneity suggests that moderator analyses are indicated. Moderator analyses were conducted for suicide attempts and suicidal ideation analyses with significant heterogeneity. Each prespecified moderator was first assessed at the bivariate level, and meta-regression was conducted accounting for the effect of each moderator simultaneously. Sensitivity analyses were also conducted to stratify pooled effect sizes by 1) widely used paradigms to assess EF constructs (e.g., the Go/NoGo or stop signal task to assess response inhibition), 2) primary diagnosis of sample, and 3) characteristics of suicide attempts (i.e., medical lethality).

Study quality was assessed by SMC using the Joanna Briggs Institute Checklist for Analytical Cross-Sectional Studies, which includes 8 criteria (53). Overall study quality was derived by summing the number of criteria met (54), with fewer than 50% of criteria met considered high risk of bias (55). Sensitivity analyses were conducted excluding studies with high risk of bias. Publication bias was assessed with funnel plots, Tweedie's trim-and-fill analysis, and Egger's regression intercept test.

RESULTS

In total, 136 publications satisfied eligibility criteria (Figure S1). Studies featuring overlapping samples ($k = 30$) were retained if they included unique data on EFs in relation to SITBs. In studies featuring overlapping samples but not presenting unique effects ($k = 9$) (56–64), the publication with the largest sample for relevant analyses was retained, resulting in 127 publications with unique data for meta-analysis (see Table S1 for study characteristics).

EF and Suicide Attempts

Pooled effects were calculated for each core EF and suicide attempts, further stratified by comparison group (Table 1). In analyses with all comparisons included, the 3 core EFs were related to suicide attempts, and pooled effects were generally small ($g = [0.21] - [0.29]$). Verbal fluency was the only EF ability without a significant pooled effect. Compared with healthy control individuals, individuals with suicide attempt histories exhibited worse EF across all core functions and their components, with medium to large pooled effects. However, compared with clinical control participants, individuals with suicide attempts demonstrated worse IC ($g = 0.12, p < .01$) and WM ($g = -0.14, p < .01$). Compared with suicidal ideation only, suicide attempts were associated with worse AC ($g = 0.35, p = .04$) and WM ($g = -0.24, p = .02$).

Heterogeneity was high across analyses (Table S2). Results from moderator analyses and core EFs are presented in Table 2, and their components parts are presented in the

Table 1. Suicide Attempts and Executive Functioning by Comparator Group

EF Component	Suicide Attempt Comparison Group									
	All Control Conditions Combined					Suicide Attempt Comparison Group				
	k	n	p	g (95% CI)		Clinical Control Only	Healthy Control Only	Suicidal Ideation Control Only		
Inhibitory Control	48	42,767	<.001	0.28 (0.19 to 0.37)		k n p g (95% CI)	k n p g (95% CI)	k n p g (95% CI)		p
Attentional control	25	8271	<.001	0.32 (0.17 to 0.47)		42 5335 <.01 0.14 (0.06 to 0.23)	20 1640 0.69 (0.45 to 0.93)	10 1543 0.19 (-0.00 to 0.38)		.05
Response inhibition	34	40,355	<.001	0.30 (0.20 to 0.40)		24 3740 0.16 (0.04 to 0.29)	11 964 1.00 (0.58 to 1.41)	6 1165 0.35 (0.03 to 0.67)		.04
Cognitive Flexibility	42	32,730	.01	0.21 (0.05 to 0.37)		28 3166 0.17 (0.06 to 0.27)	16 1157 0.55 (0.33 to 0.78)	6 1300 0.08 (-0.11 to 0.27)		.44
Task switching	35	31,931	<.01	0.18 (0.06 to 0.30)		39 4923 0.04 (-0.08 to 0.15)	17 1594 0.71 (0.49 to 0.92)	10 1222 0.10 (-0.10 to 0.30)		.33
Verbal fluency	21	3089	.38	0.12 (-0.15 to 0.40)		32 4333 0.07 (-0.06 to 0.20)	13 1179 0.85 (0.51 to 1.19)	8 1110 0.13 (-0.11 to 0.36)		.30
Working Memory	24	30,176	<.001	-0.28 (-0.42 to -0.14)		21 2716 -0.05 (-0.16 to 0.06)	8 745 0.52 (0.37 to 0.67)	3 617 -0.06 (-0.33 to 0.21)		.67
						22 3002 -0.14 (-0.25 to -0.04)	9 892 -0.90 (-1.27 to -0.52)	9 2174 -0.24 (-0.44 to -0.03)		.02

k indicates number of unique effects and *n* indicates total number of participants included in pooled analyses. To address the possibility of an outsized influence of studies with very large *ns*, the primary analyses were repeated with these studies removed. Results remained largely unchanged.
EF, executive function.

Table 2. Moderator Analyses for Core EF Domains in Relation to Suicide Attempts

Core EF	<i>k</i>	<i>n</i>	<i>b</i>	SE	<i>g</i>	95% CI	<i>p</i>
Inhibitory Control							
Percentage Female	41	5397	<0.01	<0.01	–	–	.21
Age, Continuous	42	10,241	0.01	<0.01	–	–	.02
Age, Categorical							.02
Adult	36	36,838	–	–	0.34	0.24 to 0.44	<.001
Youth ^a	12	5929	–	–	0.11	–0.07 to 0.29	.23
Sample Type							<.01
Clinical	24	3110	–	–	0.15	0.04 to 0.26	<.01
Community/mixed/at risk	24	39,657	–	–	0.41	0.28 to 0.54	<.001
Psychosis							<.001
Psychotic disorders	5	691	–	–	–0.06	–0.23 to 0.10	.45
No psychosis	43	42,076	–	–	0.32	0.23 to 0.42	<.001
Suicide Attempt Measure Type ^b							.61
Interview	35	4413	–	–	0.30	0.18 to 0.42	<.001
Questionnaire/clinical data	13	38,354	–	–	0.25	0.10 to 0.40	<.01
Suicide Attempt Measure Time Frame ^c							.65
≤1 year	14	1518	–	–	0.33	0.08 to 0.58	.01
>1 year	34	41,249	–	–	0.27	0.18 to 0.36	<.001
EF Subcomponent ^d							.78
Attentional control	15	2427	–	–	0.26	0.06 to 0.47	.01
Response inhibition	23	34,507	–	–	0.23	0.13 to 0.34	<.001
Cognitive Flexibility							
Percentage Female	38	5684	0.01	<0.01	–	–	.10
Age, Continuous	38	5648	<0.01	0.01	–	–	.81
Age, Categorical							.97
Adult	36	31,747	–	–	0.21	0.04 to 0.38	.02
Youth	6	983	–	–	0.20	–0.29 to 0.69	.42
Sample Type							.27
Clinical	24	3344	–	–	0.12	–0.15 to 0.39	.39
Community/mixed/at risk	18	29,386	–	–	0.30	0.14 to 0.45	<.01
Psychosis							<.01
Psychotic disorders	7	916	–	–	–0.16	–0.33 to 0.01	.06
No psychosis	35	31,814	–	–	0.28	0.11 to 0.46	<.01
Suicide Attempt Measure Type							.51
Interview	32	4434	–	–	0.18	–0.04 to 0.39	.10
Questionnaire/clinical data	10	28,296	–	–	0.29	0.04 to 0.53	.02
Suicide Attempt Measure Timeframe							.01
≤1 year	7	1534	–	–	0.74	0.31 to 1.17	<.01
>1 year	35	31,196	–	–	0.10	–0.06 to 0.26	.21
EF Subcomponent ^d							.92
Task switching	22	29,843	–	–	0.26	0.08 to 0.43	<.01
Verbal fluency	7	813	–	–	0.30	–0.56 to 1.17	.49
Working Memory							
Percentage Female	20	2927	<0.01	<0.01	–	–	.10
Age, Continuous	22	3156	<0.01	0.01	–	–	.93
Age, Categorical							.10
Adult	20	29,671	–	–	–0.31	–0.47 to –0.15	<.001
Youth	4	505	–	–	–0.11	–0.29 to 0.08	.25
Sample Type							.01
Clinical	14	1982	–	–	–0.12	–0.27 to 0.03	.11
Community/mixed/at risk	10	28,194	–	–	–0.50	–0.75 to –0.26	<.001

Table 2. Continued

Core EF	<i>k</i>	<i>n</i>	<i>b</i>	SE	<i>g</i>	95% CI	<i>p</i>
Psychosis							.09
Psychotic disorders	7	1240	–	–	–0.10	–0.34 to 0.14	.41
No psychosis	17	28,936	–	–	–0.36	–0.52 to –0.19	<.001
Suicide Attempt Measure Type							.10
Interview	21	3312	–	–	–0.29	–0.46 to –0.12	<.01
Questionnaire/clinical data	3	26,864	–	–	–0.13	–0.22 to –0.04	.01
Suicide Attempt Measure Time Frame							.90
≤1 year	6	557	–	–	–0.27	–0.66 to 0.13	.18
>1 year	18	29,554	–	–	–0.24	–0.40 to –0.08	<.01

b and SE are reported for continuous moderator variables, and Hedges' *g* and 95% CI are reported for categorical moderator variables. *k* indicates number of unique effects, and *n* indicates total number of participants included in pooled analyses.

EF, executive function.

^aYouth includes samples composed of children, adolescents, and young adults (e.g., samples composed of individuals <25 years, as EF capabilities are still developing).

^bStudies that combine interview measurement of self-injurious thoughts and behaviors with other sources of information (e.g., chart review) are categorized as interview measurement.

^cWhen separate effect sizes for more recent suicide attempts and lifetime suicide attempts are both provided in one study, the effect size for the more recent suicide attempt was chosen for analyses.

^dTo maintain independence of effects, studies that included tasks of both subcomponents were excluded from analyses. Sensitivity analyses were conducted such that all studies with both were included in each subcomponent separately. The pattern of results remained consistent across sensitivity analyses.

Supplement (Table S3). For the relationship between IC and suicide attempts, the pooled effect was larger for adult participants relative to youths in community and mixed samples relative to clinical samples and among individuals without diagnoses of psychotic disorders. Age ($b = -0.28, p = .01$) and psychotic disorder diagnosis ($b = -0.37, p = .02$) remained significant predictors of effect size in multivariable meta-regression. For the association between CF and suicide attempts, a larger pooled effect was observed for past-year suicide attempts compared with longer time frames. CF was not related to suicide attempts among individuals with psychotic disorders. Time frame of SITB assessment remained significant in a multivariable meta-regression ($b = 0.71, p < .01$). Finally, for the association between WM and suicide attempts, a larger pooled effect was found among community and mixed samples compared with clinical samples.

EF and Suicidal Ideation

Deficits in all 3 core EFs and their subcomponents (except for AC and VF) were associated with suicidal ideation, with small pooled effects observed (Table 3). In comparisons with healthy control participants, large pooled effects were observed for CF, its subcomponents, and WM. However, compared with clinical control participants, only IC, response inhibition, and task switching remained associated with suicidal ideation, with small pooled effects observed.

Heterogeneity was high across analyses (Table S2). The strength of the association between IC and CF and suicidal ideation increased as the percentage of female participants in the study increased (Table 4). Adult samples generated a larger pooled effect for IC and suicidal ideation than youth samples, and interview measures generated larger pooled effects than self-report measures. Age and sex remained significant in multivariable meta-regression. For CF, pooled effects were larger among community/mixed samples relative to clinical samples, among individuals without psychotic disorders, and for current suicidal ideation rather than a history of

suicidal ideation (Table 4). In multivariable meta-regression, sample type ($b = -0.21, p = .01$), percentage of female participants ($b = 0.01, p = .01$), and time frame of SI assessment ($b = 0.21, p < .001$) remained significant predictors. Moderator analyses for response inhibition and task switching with suicidal ideation are presented in the Supplement (Table S4).

EF and NSSI

CF and WM deficits were associated with NSSI, with medium pooled effects observed (Table 5). IC deficits were not associated with NSSI. CF deficits remained associated with NSSI relative to clinical control participants, with large pooled effects observed. Deficits in CF and WM were related to NSSI compared with healthy control participants, with large pooled effects emerging for WM and small pooled effects emerging for CF. Compared with healthy control participants, individuals with NSSI histories exhibited worse AC specifically but not response inhibition.

Publication Bias and Study Quality

Overall, there was modest evidence of publication bias (see Table S5 and Figures S2–S4). Egger's regression intercept was significant for IC (AC in particular) and suicide attempts and for IC (response inhibition in particular), VF, and suicidal ideation. Asymmetrical funnel plots were observed only for IC (response inhibition specifically) and suicide attempts; response inhibition, CF (VF specifically), WM, and suicidal ideation; and IC, WM, and NSSI. Across all analyses, adjusted effects decreased only modestly. Risk of bias in individual studies was generally low (mean = 5.87, SD = 1.20), with only 3 studies identified as high risk. In sensitivity analyses excluding these studies, results remained largely unchanged.

Sensitivity Analyses

Results of sensitivity analyses stratifying pooled effects by neurocognitive task and primary diagnosis of sample are available in the Supplement (Tables S6–S8). Additionally,

Table 3. Suicidal Ideation and Executive Functioning by Comparator Group

EF Component	Suicidal Ideation Comparison Group											
	All Control Conditions Combined				Clinical Control Only				Healthy Control Only			
	<i>k</i>	<i>n</i>	<i>g</i> (95% CI)	<i>p</i>	<i>k</i>	<i>n</i>	<i>g</i> (95% CI)	<i>p</i>	<i>k</i>	<i>n</i>	<i>g</i> (95% CI)	<i>p</i>
Inhibitory Control	23	18,578	0.23 (0.10 to 0.35)	<.01	12	940	0.20 (0.04 to 0.37)	.02	5	363	0.54 (−0.02 to 1.10)	.06
Attentional control	9	16,108	0.22 (−0.01 to 0.45)	.06	5	265	0.16 (−0.17 to 0.49)	.35	–	–	–	–
Response inhibition	16	6946	0.21 (0.07 to 0.35)	<.01	8	704	0.22 (0.01 to 0.42)	.04	3	259	0.39 (0.15 to 0.64)	<.01
Cognitive Flexibility	25	15,019	0.20 (0.09 to 0.31)	<.01	21	3086	0.10 (−0.01 to 0.22)	.08	7	1074	0.64 (0.52 to 0.77)	<.001
Task switching	21	14,005	0.28 (0.14 to 0.41)	<.01	17	2155	0.20 (0.06 to 0.33)	.01	5	936	0.82 (0.40 to 1.24)	<.001
Verbal fluency	8	1557	0.13 (−0.06 to 0.32)	.17	8	1426	0.01 (−0.16 to 0.18)	.92	3	317	0.63 (0.19 to 1.07)	<.01
Working Memory	24	28,488	−0.15 (−0.24 to −0.07)	<.01	17	2061	−0.06 (−0.20 to 0.08)	.41	6	468	−0.76 (−1.20 to −0.33)	<.01

k indicates number of unique effects, and *n* indicates total number of participants included in pooled analyses. To address the possibility of an outsized influence of studies with very large *ns*, the primary analyses were repeated with these studies removed. Results remained largely unchanged.

EF, executive function.

deficits in CF (task switching) and IC (AC) were not significantly associated with lethality of attempts (Table S9).

DISCUSSION

The current study offers the most comprehensive meta-analysis reported to date of the association between EF and SITBs, providing support for the relationship between each core EF and suicide attempts and suicidal ideation. Altogether, significant, small pooled effects were observed for CF and WM for each SITB, whereas IC was specifically related to suicidal ideation and suicide attempts. However, the small pooled effect sizes may underestimate the true effects, as EF is state sensitive (40,65,66), and most studies examined SITBs over long periods (e.g., lifetime history). Similar to the depression literature, which has found small pooled effects for individuals with a history of depression and current remission at the time of assessment (67), it is likely that the lack of proximity to suicidal outcomes generated underestimates of true effects. Larger effects (medium to large) for CF deficits were found when suicide outcomes were measured more proximally to the time of the assessment, consistent with prior meta-analytic findings of larger effects in studies of impulsivity assessed more proximally to suicide attempts (40). Although SITB assessment time frame was not a significant moderator for IC and WM, this is likely an artifact of studies that examined SITBs more proximally to the time of assessment, almost exclusively featuring clinical control groups.

In direct comparisons with clinical control participants, IC and WM deficits remained related to suicide attempts, and IC and task switching remained associated with suicidal ideation. Within the construct of IC, this effect was specific to AC in the case of suicide attempts and response inhibition in the case of suicidal ideation. Given that EF deficits are common across psychiatric conditions (68–70), the current findings differentiating SITBs from other psychopathology are particularly notable, suggesting that these deficits cannot be fully accounted for by co-occurring psychiatric disorders. Given that suicide is a symptom of depression, it is particularly noteworthy that significant pooled effects for IC and WM largely held in sensitivity analyses with samples of participants with depression, suggesting that their associations with SITBs are not simply a function of depression.

Age is also an important consideration in interpretation of the current findings. Results demonstrate that age is a significant moderator of the association between IC and SITBs such that the pooled effect size is larger for adult samples than it is for youth samples. This effect seems to be particularly present for response inhibition, suggesting that behavioral impulsivity is more strongly associated with suicide attempts among adults relative to youths. For suicidal ideation, the pooled effect size of the association between task switching in particular is larger among adult samples relative to youth samples. Complicating interpretation of these findings is the fact that EF performance is not stable across development, particularly during adolescence (71), and given that the study design for most studies included in this meta-analysis is cross-sectional, involving retrospective measures of past SITBs in relation to current EF, the instability of EF measurement may be attenuating the pooled effect size for younger individuals. As such, proximal measurement is even more critical for youth samples to elucidate the true relationship between EF and SITBs during this developmental period.

Our current results are also important to consider in the context of relevant theoretical models, specifically the ideation-to-action framework (72). The ideation-to-action framework encompasses a set of suicide theories that consider the generation of suicidal ideation and transition from thoughts to attempts as distinct processes with separable explanations (72). According to the 3-step theory of suicide (73,74), a prominent theory within the ideation-to-action framework, suicidal ideation results from psychological pain and hopelessness. The inability to shift cognitively (i.e., CF, particularly task switching) may be of particular importance to the development of suicidal thoughts inasmuch as deficits in this area facilitate hopelessness, as found in previous research (75). Task switching was one of two EF subcomponents associated with suicidal ideation in comparison to clinical control participants. The fact that task switching was not associated with suicide attempts compared with clinical control participants suggests that this aspect of EF is specific to suicidal ideation. A somewhat similar pattern was observed for response inhibition. Here, although response inhibition deficits were found for both suicidal ideation and suicide attempts compared with psychiatric control participants, these deficits did not differentiate between suicidal ideation and

Table 4. Moderator Analyses for Core EF Domains in Relation to Suicidal Ideation

Core EF	<i>k</i>	<i>n</i>	<i>b</i>	SE	<i>g</i>	95% CI	<i>p</i>
Inhibitory Control							
Percentage Female	22	18,478	0.01	<0.01	–	–	<.001
Age, Continuous	20	13,928	<0.01	<0.01	–	–	.30
Age, Categorical ^a							.02
Adult	14	1561	–	–	0.34	0.13 to 0.56	<.01
Youth	9	17,017	–	–	0.06	–0.04 to 0.15	.24
Sample Type							.55
Clinical	11	900	–	–	0.19	0.01 to 0.36	.04
Community/mixed/at risk	12	17,678	–	–	0.26	0.09 to 0.43	<.01
Psychosis							.17
Psychotic disorders	3	312	–	–	0.07	–0.15 to 0.29	.53
No psychosis	20	18266	–	–	0.26	0.12 to 0.39	<.001
Suicidal Ideation Measure Type ^b							.03
Interview	14	12,792	–	–	0.33	0.11 to 0.55	<.01
Questionnaire/clinical data	9	5786	–	–	0.06	–0.03 to 0.16	.19
Suicidal Ideation Measure Time Frame ^c							.64
≤2 weeks	12	1997	–	–	0.20	0.05 to 0.35	.01
>2 weeks	11	16,581	–	–	0.26	0.06 to 0.46	.01
EF Subcomponent ^d							.61
Attentional control	7	11,632	–	–	0.35	–0.06 to 0.76	.10
Response inhibition	14	2470	–	–	0.24	0.09 to 0.38	<.01
Cognitive Flexibility							
Percentage Female	24	14,936	0.01	<0.01	–	–	.01
Age, Continuous	25	15,019	0.01	<0.01	–	–	.15
Age, Categorical ^a	–	–	–	–	–	–	.15
Adult	17	2970	–	–	0.25	0.10 to 0.40	<.01
Youth	8	11,989	–	–	0.10	–0.03 to 0.24	.13
Sample Type							<.01
Clinical	14	2191	–	–	0.05	–0.07 to 0.18	.39
Community/mixed/at risk	11	12,828	–	–	0.37	0.22 to 0.51	<.001
Psychosis	–	–	–	–	–	–	<.001
Psychotic disorders	4	1081	–	–	–0.11	–0.23 to 0.02	.10
No psychosis	21	13,938	–	–	0.27	0.16 to 0.38	<.001
Suicidal Ideation Measure Type ^b							.75
Interview	12	13,316	–	–	0.22	0.06 to 0.38	.05
Questionnaire/clinical data	13	1703	–	–	0.19	0.03 to 0.34	.04
Suicidal Ideation Measure Time Frame ^c							.02
≤2 weeks	13	1872	–	–	0.31	0.16 to 0.46	<.001
>2 weeks	12	13,147	–	–	0.09	–0.04 to 0.21	.19
EF Subcomponent ^d							.38
Task switching	17	13,462			0.20	0.08 to 0.32	<.01
Verbal fluency	4	1104			0.07	–0.20 to 0.34	.62
Working Memory							
Percentage Female	21	17,686	<0.01	<0.01	–	–	.78
Age, Continuous	22	17,769	<0.01	<0.01	–	–	.82
Age, Categorical ^a							.88
Adult	18	12,696	–	–	–0.16	–0.29 to –0.04	.01
Youth	6	15,792	–	–	–0.15	–0.29 to –0.00	.05
Sample Type							.28
Clinical	13	1754	–	–	–0.09	–0.26 to 0.08	.29
Community/mixed/at risk	11	26,734	–	–	–0.20	–0.30 to –0.10	<.001

Table 4. Continued

Core EF	<i>k</i>	<i>n</i>	<i>b</i>	SE	<i>g</i>	95% CI	<i>p</i>
Psychosis							.55
Psychotic disorders	7	1304	–	–	–0.11	–0.32 to 0.11	.34
No psychosis	17	27,184	–	–	–0.18	–0.28 to –0.08	<.001
Suicidal Ideation Measure Type ^b							.26
Interview	15	16,385	–	–	–0.22	–0.37 to –0.08	<.01
Questionnaire/clinical data	9	12,103	–	–	–0.13	–0.22 to –0.03	.01
Suicidal Ideation Measure Time Frame ^c							.55
≤2 weeks	7	1253	–	–	–0.10	–0.32 to 0.13	.40
>2 weeks	17	27,235	–	–	–0.17	–0.27 to –0.07	<.01

k indicates number of unique effects, and *n* indicates total number of participants included in pooled analyses. *b* and SE are reported for continuous moderator variables, and Hedges' *g* and 95% CI are reported for categorical moderator variables.

EF, executive function.

^aYouth includes samples composed of children, adolescents, and young adults (e.g., samples composed of individuals <25 years, as EF capabilities are still developing).

^bStudies that combine interview measurement of self-injurious thoughts and behaviors with other sources of information (e.g., chart review) are categorized as interview measurement.

^cWhen separate effect sizes for more recent suicidal ideation and lifetime suicidal ideation are both provided in one study, the effect size for the more recent suicidal ideation was chosen for analyses.

^dTo maintain independence of effects, studies that included tasks of both subcomponents were excluded from analyses. Sensitivity analyses were conducted such that all studies with both were included in each subcomponent separately. The pattern of results remained consistent across sensitivity analyses.

behavior, as reflected by a negligible pooled effect ($g = 0.08$), suggesting that the significant response inhibition finding for suicide attempts may be largely explained by the presence of suicidal ideation among individuals who attempted suicide. Therefore, task switching and response inhibition deficits may be particularly relevant in the development of suicidal ideation and could serve as early intervention targets for prevention of escalation from suicidal ideation to behavior.

Identifying risk factors that separate suicide attempts from ideation is a longstanding challenge, in part because many studies of suicide attempts do not use suicidal ideation-only comparators and thus often capture risk for ideation rather than attempts (72,76). Therefore, EF deficits that differentiate individuals with suicidal behavior relative to ideation only are findings of particular clinical importance. Our findings that WM and AC deficits 1) are not associated with suicidal ideation in clinical samples, 2) are related to suicide attempts in psychiatric samples, and 3) differentiate between suicide attempts and ideation suggest that poor WM and AC may be specific to suicidal behavior. Given the paucity of well-established factors that distinguish behavior from ideation, WM and AC may be especially valuable assessment and intervention targets. However, it is important to note that the cross-sectional nature of these studies complicates interpretation of findings. Specifically, suicidal ideation only is not a stable category inasmuch as a subset of individuals experiencing suicidal ideation may eventually transition from ideation to attempt. This is especially true for studies with youth samples, for whom both measurement of EF and suicide attempt status are particularly unstable. Longitudinal studies will be critical to elucidate whether measurement of EF at one point in time predicts future transition to suicidal behavior. Given the paucity of longitudinal research, we are unable to estimate the predictive value of EF deficits on suicidal behavior among individuals with suicidal ideation. Furthermore, without longitudinal work, accurate characterization of the temporal frame for maximal predictive power is not possible. Given preliminary evidence

found here that for some aspects of EF, the association is larger with more proximal assessment to the suicide outcome, it is reasonable to expect that shorter time frames between assessments would generate larger effects. Future longitudinal research is necessary to determine whether targeting EF-related neural circuits would facilitate a decrease in suicide risk.

Finally, this was the first meta-analysis of associations between core EF deficits and NSSI. Although there was some evidence of EF deficits, particularly CF and NSSI, it remains unclear to what degree NSSI is associated with EF deficits independent of its relationship with suicidal behavior, given that NSSI has been linked to STBs (3). Specifically, too few studies examining EF deficits and NSSI accounted for history of STBs, and thus, it is unclear whether these relationships merely reflect neurocognitive deficit characteristic of STBs. Future studies should directly compare individuals engaging in NSSI with and without STB histories to disentangle EF deficits specific to NSSI.

Several limitations of the current review should be noted. Despite rapid growth in research in this area, almost all studies were cross-sectional. Only 8 studies included prospective analyses (49,77–84), with fewer than 3 for each core EF. More prospective research is necessary to elucidate the prognostic value of EF deficits, particularly as short-term predictors of SITBs. Approaches to understanding neurocognitive risk and suicidal behavior in other, related areas may inform future directions for longitudinal research. For example, longitudinal work has found that implicit associations with death relative to life represent a stable marker rather than a proximal risk factor (11). Future longitudinal studies of EF deficits may similarly investigate the stability of these deficits over time as prospective predictors of SITBs. With the development of mobile application-based measures of EF deficits in real-life contexts, it is now possible to conduct temporally sensitive and externally valid examinations of this relationship. Also, for NSSI and core EFs, there were too few studies to conduct moderator analyses across all constructs for reliable pooled

Table 5. Nonsuicidal Self-Injury and Executive Functioning by Comparator Group

EF Component	Nonsuicidal Self-Injury Comparator Group											
	All Control Conditions Combined				Clinical Control Only				Healthy Control Only			
	k	n	g (95% CI)	p	k	n	g (95% CI)	p	k	n	g (95% CI)	p
Inhibitory Control	19	7077	0.04 (−0.14 to 0.22)	.67	6	1319	−0.18 (−0.69 to 0.34)	.50	8	625	0.24 (−0.17 to 0.66)	.25
Attentional control	5	1225	−0.07 (−0.80 to 0.65)	.85	−	−	−	−	3	173	0.60 (0.30 to 0.91)	<.001
Response inhibition	14	5852	0.07 (−0.08 to 0.23)	.36	4	267	0.20 (−0.04 to 0.44)	.10	5	452	0.06 (−0.53 to 0.66)	.84
Cognitive Flexibility	10	4299	0.44 (0.14 to 0.73)	<.01	5	3402	0.81 (0.33 to 1.30)	<.01	3	523	0.39 (0.19 to 0.59)	<.001
Task switching	8	4005	0.44 (0.09 to 0.79)	.01	4	3282	0.95 (0.37 to 1.53)	<.01	−	−	−	−
Verbal fluency	3	415	0.39 (0.19 to 0.59)	<.001	−	−	−	−	−	−	−	−
Working Memory	6	904	−0.69 (−1.00 to 0.38)	<.001	−	−	−	−	3	523	1.00 (−1.65 to −0.35)	<.01

k indicates number of unique effects, and n indicates total number of participants included in pooled analyses.
EF, executive function.

estimates. Similarly, too few studies were found investigating differences among aspects of suicidal behavior, such as medical lethality, to generate stable pooled effect sizes across all EF components. This is particularly important given previous research on decision making, which has found that high-lethality suicide attempters have poorer decision-making skills than individuals who make lower-lethality attempts (13). While we did not find a significant pooled effect in our preliminary analyses, this question warrants additional empirical attention.

Finally, the current review focuses specifically on core EFs rather than higher-order cognitive processes such as decision making. There may be broader cognitive domains that are also important to understanding SITB risk that were not reviewed in the current study. Therefore, the results should be considered jointly with other neurocognitive meta-analytic findings, which also implicate poorer decision making (13) and long-term memory (10) as neurocognitive risk factors for STBs, so as to better understand the full context of neurocognitive risk. The current findings build on past meta-analyses by suggesting specific foundational cognitive skills that may underlie performance across more complex tasks of decision making. However, other important variables (e.g., acute stress) may interact with EFs in a manner that provides a fuller and more nuanced model of risk for STBs (65). Future research should evaluate this possibility.

Relatedly, task impurity, or the difficulty wherein an individual task measures only the specific construct that it is intended to measure, also represents a significant challenge in the neurocognitive literature, and this is especially challenging in measurement of higher-order processes such as problem solving or decision making. While this continues to be of concern in understanding relationships between specific components of EF and SITBs, the current study provides granularity in neurocognitive risk with its explicit focus on EF.

Conclusions

EF deficits are associated with SITBs, particularly task switching and response inhibition for suicidal ideation and WM and AC for suicide attempts. Core EF dimensions map onto distinguishable and well-characterized neural circuits (e.g., dorsolateral prefrontal cortex, anterior cingulate cortex, and frontostriatal networks), which represent precise mechanistic targets for intervention development, including neuro-modulation approaches, suggesting exciting avenues for novel treatment approaches. For example, excitatory repetitive transcranial magnetic stimulation has been found to improve EF (85) and decrease suicidal ideation (86). The current findings may lend specificity to brain regions to target with this and other neuromodulation treatment paradigms. Future research on the short-term predictive value of EF deficits will be a necessary step to determine whether improvements in EF can reduce SITBs.

ACKNOWLEDGMENTS AND DISCLOSURES

This work was supported in part by the National Institute of Mental Health of the National Institutes of Health (Grant Nos. R01 MH115905, R01 MH124899, R01 MH137793, K24 MH136418, and R21 MH130767 [to RTL]). The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agencies.

The authors report no biomedical financial interests or potential conflicts of interest.

If you are contemplating suicide, please reach out for help; resources are available at <https://www.iasp.info/suicidalthoughts/>.

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Received Aug 27, 2025; revised Apr 29, 2026; accepted May 11, 2026.

Supplementary material cited in this article is available online at <https://doi.org/10.1016/j.biopsych.2026.05.010>.

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