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LITERATURE REVIEW

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Do neurocognitive abilities distinguish suicide attempters from suicide ideators? A systematic review of an emerging research area

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Recent findings suggest that neurocognitive deficits may hasten progression from suicidal thoughts to behavior. To test this proposition, we examined whether neurocognitive deficits distinguish individuals who have attempted suicide (attempters) from those who have considered suicide but never attempted (ideators). A comprehensive literature search yielded 14 studies comparing attempters to ideators on a range of neurocognitive abilities. In general, attempters and ideators scored comparably across neurocognitive abilities (median Hedges' $g = -.18$). An exception was a moderate difference for inhibition and decision making (median Hedges' $g = -.50$ and $g = -.49$, respectively). Results suggest that some neurocognitive abilities might help explain the transition from suicidal thoughts to suicide attempts. However, findings are regarded as suggestive, given the small number of studies, few cross-study examinations of neurocognitive domains, and variability in sample characteristics. Recommendations for future research are included.

KEYWORDS
neurocognitive abilities, neurocognitive functioning, suicide, suicide prevention, suicide risk

1 | INTRODUCTION

Although suicide is a leading cause of death worldwide (World Health Organization, 2008), the field has struggled to realize improvements in suicide prediction and prevention (Franklin et al., 2017; Klonsky, May, & Saffer, 2016). One explanation for the limited progress is that the majority of the risk factors for suicide appear to be more closely associated with suicidal thoughts, not suicidal acts—an important distinction given that most people who think about suicide will not act on their thoughts (Fergusson, Beautrais, & Horwood, 2003; ten Have et al., 2009). For example, using data from the National Comorbidity Survey, Kessler, Borges, and Walters (1999) reported that the presence of any mood disorder greatly increased the odds of thinking about suicide (odds ratio [OR] = 10.7). However, the impact of mood disorders was reduced more than fivefold (OR = 2.0) in increasing the odds of attempting suicide among individuals with a history of suicidal thoughts. A similar pattern has been observed for a range of risk factors, including depression, hopelessness, and even impulsivity, across both meta-analytic (May & Klonsky, 2016) and global epidemiological studies (Nock et al., 2008). Such findings suggest that the risk factors for suicide ideation might be distinct from the risk factors for suicide attempts (Klonsky & May, 2014; May & Klonsky, 2016), and that little is known about the latter.

Neurocognitive abilities represent an umbrella term for cognitive functions that support the production of perception, thought, action, and emotion and are thought to be closely related to particular neural pathways and networks in the brain (Lichtenberger & Kaufman, 2009). These

abilities are thought to mediate the relationship between thoughts and behaviors (Lezak, Howieson, Bigler, & Tranel, 2012), and therefore might be uniquely positioned to help explain the progression from suicidal thoughts to suicidal acts. For example, neural functioning in prefrontal cortical regions has been closely associated with maintaining neurocognitive abilities required for purposeful and goal-directed behaviors (Miller & Wallis, 2009). These abilities are often collectively referred to as executive functions (Strauss, Sherman, & Spreen, 2006), and results from both meta-analytic (Morgan & Lilienfeld, 2000; Ogilvie, Stewart, Chan, & Shum, 2011) and review studies (Brower & Price, 2001) have repeatedly observed that individuals engaging in violent and criminal behaviors exhibit impaired executive functions on neuropsychological measures, with medium effect sizes reported (Cohen's d range = .5–.6). Deficits in executive functions have also been found to precede future substance use (Tarter et al., 2003) and are consistently observed among individuals diagnosed with attention-deficit/hyperactivity disorder (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Given that impaired executive functions have been implicated in difficulties regulating negative emotions, finding alternative solutions to problems, and inhibiting maladaptive behaviors, they might help explain who among those thinking about suicide is most likely to act on their thoughts.

Results from a growing number of studies suggest that suicide attempters exhibit altered neurocognitive abilities on a range of neuropsychological measures (Jollant, Lawrence, Olié, Guillaume, & Courtet, 2011). For example, a meta-analysis of 25 studies by Richard-Devantoy, Berlim, and Jollant (2014) observed that individuals with a history of suicide attempts performed worse than patient and healthy controls on three measures of executive functions: the Iowa Gambling Task (Hedges' $g = -.47$ and $-.65$, respectively), categorical verbal fluency ($g = -.32$ and $-.67$, respectively), and the Stroop task ($g = .37$ and .91, respectively). Similarly, a systematic qualitative review of 43 studies (Bredemeier & Miller, 2015) concluded that impairments in executive functions are associated with a history of suicide attempts and that these deficits are not fully accounted for by psychiatric disorders and psychological distress. A separate meta-analysis of 24 studies (Richard-Devantoy, Berlim, & Jollant, 2015) found that individuals with a history of suicide attempts performed worse than healthy controls on measures of short-term memory ($g = -.30$), long-term memory ($g = -.40$), and working memory ($g = -.40$). Although no meta-analysis has examined differences in attentional abilities, results from individual studies suggest that individuals with a history of suicide attempts demonstrate an attentional bias toward suicide-related words (Becker, Strohbach, & Rinck, 1999; Nock & Banaji, 2007) and that this bias appears to prospectively predict suicide attempts (Cha, Najmi, Park, Finn, & Nock, 2010; Nock et al., 2010).

These studies represent important progress in understanding the potential role of neurocognitive abilities in suicide and suggest the intriguing possibility that neurocognitive deficits are key for understanding the transition from suicide ideation to suicide attempts. For example, Bredemeier and Miller (2015) speculated that "people with EF deficits might have difficulty resisting the urge to act on thoughts about self-harm when they occur." It is therefore important to specifically determine whether neurocognitive abilities can differentiate between suicide attempters and ideators, a comparison not analyzed by the aforementioned systematic review.

Thus, the primary goal of this systematic review was to examine whether neurocognitive functioning differs between individuals with a lifetime history of suicide attempts (attempters) and individuals with a lifetime history of suicide ideation but no history of attempts (ideators). A secondary goal was to examine whether neurocognitive functioning in the same studies also differs between ideators and nonsuicidal individuals (no lifetime history of either suicide attempts or suicide ideation) in order to better understand whether neurocognitive functioning is best conceptualized as relating to suicide ideation, suicide attempts, or both.

2 | METHOD

2.1 | Inclusion and exclusion criteria

Publications included in this systematic review were empirical studies that compared performance between attempters and ideators on one or more neurocognitive measures. Eligible studies were publications, dissertations, or theses that assessed one or more domains of neurocognitive functioning as outlined in Lezak et al. (2012) and Strauss et al. (2006), and that compared suicide attempters to ideators using definitions consistent with that of Silverman, Berman, Sanddal, O'Carroll, and Joiner (2007) whereby a suicide attempt is defined as a "self-inflicted, potentially injurious behavior(s) with a nonfatal outcome for which there is evidence … of intent to die" (p. 273). Suicide ideation was defined as "any self-reported thoughts of engaging in suicide-related behaviour" (O'Carroll et al., 1996, p. 247). For studies using ambiguous terminology to define groups of participants (e.g., "suicidal," "self-harming," "parasuicide"), the Methods section of the manuscript was reviewed to ensure that the authors were, in fact, referring to attempters or ideators rather than groups composed of a combination of attempters, ideators, and/or individuals with a history of nonsuicidal self-injury (NSSI).

Publications were excluded from the review if they were not in English or if they were not empirical (e.g., case reports, reviews, replies, comments, practice recommendations). Publications were further excluded if they did not examine the relationship of variables to a history of suicide attempts (e.g., correlates for suicide ideation, risk for suicide, deliberate self-harm or NSSI) or if they did not include at least one neurocognitive measure. Publications that grouped suicide attempters with participants with a history of suicide ideation and/or NSSI and publications that did not directly compare attempters to ideators were also excluded from the systematic review.

2.2 | Search strategy

A systematic literature search of three online databases (PsycInfo, PubMed, and Web of Science) was performed on June 8, 2017. The Medical Subject Heading (MeSH) terms used were as follows: suicide attempt*, suicide act*, and suicidal behavio* were combined with the MeSH terms memor*, executive function*, dysexecutive, decision making, problem solving, attention*, concentrate*, processing speed, language, visual perception*, and motor function*. These terms and appropriate wildcard operators were selected to be as inclusive as possible, given the wide variety of terms used in both the suicide and neurocognitive literature. No restrictions were applied when conducting these searches. A hand search of known relevant publications was also conducted, including reviews, meta-analyses, and articles, in the introductions of other relevant papers.

These searches yielded a combined total of 9,406 publications, of which a total of 2,888 publications were identified as duplicates, resulting in 6,518 original publications. The primary author (BYS) inspected the abstract and/or text of each potentially eligible article to determine whether it met inclusion criteria. Of the 6,518 original publications, 2,510 publications were determined to have been published in a language other than English or were classified as nonempirical publications, leaving 4,008 publications. A total of 2,387 publications did not include one or more correlates for suicide attempts and 1,462 of the remaining 1,621 publications did not include a neuropsychological measure, yielding a total of 159 studies. Reviewing these publications revealed that 144 publications either did not compare attempters to ideators or grouped attempters with ideators and/or participants with a history of NSSI, leaving 15 studies. One publication reported values for the same measure using the same sample in two separate manuscripts, resulting in a final pool of 14 eligible publications, of which seven used unique samples and seven used an overlapping sample. These steps are outlined in Figure 1.

2.3 | Test scores and neurocognitive domains

Scores from neurocognitive measures were matched to neurocognitive domains and subdomains using Strauss and colleagues' (2006) *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary* and Kreutzer, DeLuca, and Caplan's (2011) *Encyclopedia of Clinical Neuropsychology*. When not enough information was provided to definitively match a test score to a neurocognitive domain, the manual for the neurocognitive test was reviewed. Given the multifaceted nature of neurocognitive domains, test scores were also grouped based on the specific neurocognitive ability they most closely aligned with. In total, 38 scores were extracted and matched to six neurocognitive domains: global cognitive functioning, intelligence, executive functions, processing speed, memory, and attention. Three of those domains were subdivided as follows: (a) intelligence: full-scale IQ and premorbid IQ, (b) executive functions: global executive functions, cognitive flexibility, decision making, inhibition, verbal fluency, and (c) memory: general memory and working memory. Although our classification of neurocognitive measures into corresponding domains would ideally be based on psychometric data, the majority of measures in our review have not been subjected to psychometric methods of classification. More information about matching of test scores to neurocognitive domains is available from the primary author by request.

2.4 | Statistical analyses

A purely meta-analytic approach was not feasible because no neurocognitive ability, apart from intelligence, was examined in more than three studies. Also, seven of the 14 studies used overlapping samples of participants (Clark et al., 2011; Dombrovski et al., 2010, 2011; Gujral et al., 2014, 2016; Richard-Devantoy, Szanto, Butters, Kalkus, & Dombrovski, 2014; Szanto et al., 2015) and only one longitudinal study was identified (Naifeh et al., 2017). However, aggregate effect sizes were computed for the cross-sectional analyses, as they shared a common research design and there was a sufficient number to aggregate. Findings from the longitudinal study are not aggregated but summarized and highlighted as part of the systematic review.

For each study, we converted reported quantitative differences into a standardized effect size metric: Hedges' g (Hedges, 1981). To calculate Hedges' g, number of participants, means, and standard deviations were obtained for each study either directly from the publication or by contacting the study authors directly. Of the five authors contacted, four provided the requested information. Comprehensive Meta-Analysis Software, version 3.0

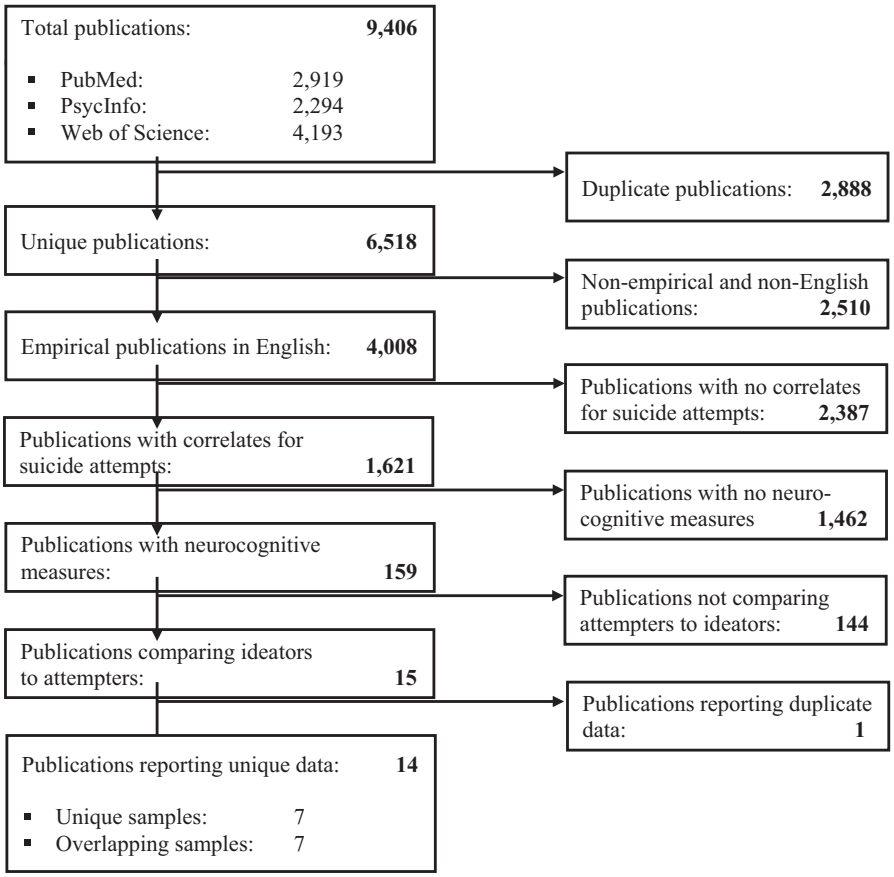

FIGURE 1 Study selection

(Borenstein, Hedges, Higgins, & Rothstein, 2016) was used to calculate the Hedges' *g* value for each comparison. Hedges' *g* effect sizes are considered negligible between .00 and .19, small between .20 and .49, medium between .50 and .79, and large when equal or >.80 (Cohen, 1988). Negative values indicate that attempters and ideators obtained a worse score than ideators and nonsuicidal individuals, respectively. The directionality of the effect size metric was reversed for measures where a greater score indicated worse performance.

When a single study reported findings from two groups of attempters or nonsuicidal individuals (e.g., single attempters and multiple attempters, nonsuicidal patient controls and nonsuicidal healthy controls), the means and standard deviation from these groups were combined into a single group using Bessel's unbiased estimator of population variance (Farebrother, 1999) before calculating the effect size metric between the three participant groups.

For comparisons reported in studies using an overlapping sample to analyze the same neurocognitive domain (Clark et al., 2011; Dombrovski et al., 2010, 2011; Gujral et al., 2014, 2016; Richard-Devantoy, Szanto, et al., 2014; Szanto et al., 2015), data from the most recent publication with the largest number of participants were used (Gujral et al., 2016).

3 | RESULTS

Table S1 summarizes the 14 studies included in this systematic review. Thirteen studies used a cross-sectional design and one used a longitudinal design (Naifeh et al., 2017). Two studies did not include a nonsuicidal group (Burton, Vella, Weller, & Twamley, 2011; Minzenberg et al., 2015c). Sample size ranged from seven to 9,893 participants per group, with a median of 31 participants. Mean age of participants ranged from 21.1 to 71.4 years of age, with a median age of 66.8. Percentage of female participants ranged from 2% to 77%, with a median of 47%. Thirteen studies included participants with a psychiatric diagnosis. The most common psychiatric diagnoses were depression in seven studies (Clark et al., 2011; Dombrovski et al., 2010, 2011; Gujral et al., 2014, 2016; Richard-Devantoy, Szanto, et al., 2014; Szanto et al., 2015), schizophrenia or schizoaffective disorders in three studies (Delaney et al., 2012; Minzenberg et al., 2015b, 2015c), psychotic mood disorder in one study (Minzenberg et al., 2015a), a variety of psychiatric disorders in one study (Burton et al., 2011), and unspecified psychiatric diagnoses in one study (Naifeh et al., 2017).

Aggregate effect size differences between attempters and ideators, as well as ideators and nonsuicidal individuals, are presented in Table 1. Individual scores used to calculate the aggregate effect sizes are outlined in Table S2.

In general, mostly negligible to small effect size differences were observed comparing attempters to ideators. Attempters differed most from ideators on two subdomains of executive functions: inhibition and decision making, with medium effect sizes observed. Similarly, negligible to small effect size differences were observed comparing ideators to nonsuicidal individuals, with ideators performing better on measures of intelligence and memory. Ideators differed most from nonsuicidal participants on measures of processing speed. A domain-by-domain description of these findings is presented below.

3.1 | Global cognitive functioning

Global cognitive functioning was assessed in seven studies using an overlapping sample of older adults (Clark et al., 2011; Dombrovski et al., 2010, 2011; Gujral et al., 2014, 2016; Richard-Devantoy, Szanto, et al., 2014; Szanto et al., 2015). Two measures were used to assess global cognitive functioning: the Mini-Mental Status Examination (MMSE) and the Dementia Rating Scale (DRS). Examining the results reported by the most recent study (Gujral et al., 2016) revealed a negligible effect size difference between attempters and ideators and a small effect size difference between ideators and nonsuicidal participants on both the MMSE and DRS.

3.2 | Intelligence

Intelligence was assessed in six studies (Burton et al., 2011; Delaney et al., 2012; Minzenberg et al., 2015a, 2015b, 2015c; Szanto et al., 2015), of which four (Delaney et al., 2012; Minzenberg et al., 2015a, 2015b; Szanto et al., 2015) included nonsuicidal individuals. Full-scale intelligence was assessed using two measures: the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III), and the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II). Premorbid IQ was assessed using the American National Adult Reading Test (ANART) and the Wechsler Test of Adult Reading (WTAR). Negligible effect size differences were observed comparing attempters to ideators across both measures of intelligence. Negligible to small effect size differences were observed comparing ideators to nonsuicidal individuals, with ideators performing better than nonsuicidal individuals.

3.3 | Executive functions

Executive functions were assessed in eight studies (Burton et al., 2011; Clark et al., 2011; Dombrovski et al., 2011; Gujral et al., 2014, 2016; Minzenberg et al., 2015c; Richard-Devantoy, Szanto, et al., 2014; Saffer & Klonsky, 2016), of which all but two (Burton et al., 2011; Minzenberg et al., 2015c) included nonsuicidal individuals. Executive functions were assessed using 13 measures, including the Behaviour Rating Inventory of Executive Function—Adult Version (BRIEF-A), the Cambridge Gambling Task (CGT), and the Intra Dimensional/Extra Dimensional (IDED) subtests from the Cambridge Neuropsychological Test Automated Battery (CANTAB), the Animals and FAS subtests from the Controlled Oral Word Association Test (COWAT), the

TABLE 1 Median effect size differences between suicide ideators and nonsuicidal participants and suicide attempters and suicide ideators

	Nonsuicidal vs. ideators			Ideators vs. attempters		
Neurocognitive domain	Number of samples[a]	Number of effect sizes	Hedges' *g* (range)	Number of samples[a]	Number of effect sizes	Hedges' *g* (range)
Global cognitive functioning	1	2	−.42 (−.44 to −.39)	1	2	−.14 (−.27 to −.01)
Intelligence						
Full-scale IQ	3	3	.26 (.03 to .83)	4	4	−.02 (−.36 to .21)
Premorbid IQ	1	1	.03 (N/A)	2	2	−.17 (−.56 to .22)
Executive functions						
Global executive functions	2	2	−.44 (−.74 to −.13)	2	2	−.25 (−.29 to −.21)
Cognitive flexibility	2	2	−.11 (−.40 to .18)	3	4	.22 (−.13 to .66)
Decision making	2	3	−.05 (−.49 to .00)	2	3	−.49 (−.64 to −.15)
Inhibition	1	1	−.28 (N/A)	3	4	−.50 (−.78 to −.25)
Verbal fluency	0	0	N/A	1	2	−.21 (N/A)
Processing speed	1	2	−.81 (N/A)	2	3	.20 (.20 to .37)
Memory	1	3	.31 (N/A)	1	3	−.19 (N/A)
Working memory	1	2	.29 (N/A)	1	2	−.23 (N/A)
Attention	2	2	−.16 (−.38 to .07)	2	2	−.17 (−.38 to .04)

[a]As most samples completed measures of more than one neurocognitive domain, the total number of samples exceeds the number of samples examined in the systematic review.

Delay = Go Computerized Test, the Inhibition and Inhibition/Switching conditions on the Color-Word Interference Test (CWIT) from the Delis-Kaplan Executive Functions System (D-KEFS), the Executive Interview (EXIT-25), the Frontal Systems Behaviour Scale (FrSBe), the Probabilistic Reversal Learning Task (PRLT), the Stroop Test (Stroop), Part B of the Trail Making Test (TMT), and the Wisconsin Card Sorting Test (WCST).

Differences across global and subdomains of executive functions revealed mostly negligible to small effect size differences between attempters and ideators as well as between ideators and nonsuicidal individuals. The largest effect size differences between attempters and ideators were observed on measures of decision making and inhibition, with medium effect sizes reported. The largest effect size difference between ideators and nonsuicidal individuals was observed on measures of global executive functions.

3.4 | Processing speed

Processing speed was assessed in two studies (Burton et al., 2011; Richard-Devantoy, Szanto, et al., 2014) using two measures: the Color-Word Interference Test (CWIT) from the Delis-Kaplan Executive Functions System (D-KEFS) and Part A of the Trail Making Test (TMT). Overall, attempters performed better than ideators, with a small effect size observed. In contrast, a large effect size difference was observed comparing ideators and nonsuicidal individuals, with ideators exhibiting worse performance.

3.5 | Memory

Memory was assessed in one study (Delaney et al., 2012). General memory was assessed using three measures: the Paired Associates Learning (PAL) subtest of the CANTAB and the Logical Memory I and II subtests of the Wechsler Memory Scale, Third Edition (WMS-III). Working memory was assessed using two measures: the Spatial Working Memory (SWM) subtest of the CANTAB and the Letter-Number subtest of the WMS-III. Across measures of general and working memory, negligible to small effect sizes differences were observed comparing attempters to ideators. Small effect size differences were observed comparing ideators to nonsuicidal individuals, with ideators exhibiting better performance.

3.6 | Attention

Attention was measured in two studies (Minzenberg et al., 2015a, 2015b) using one measure: the AX version of the Continuous Performance Task (AX-CPT). Negligible effect size differences were observed comparing attempters to ideators and ideators to nonsuicidal individuals.

3.7 | Longitudinal study

One study (Naifeh et al., 2017) used a longitudinal design to examine whether neurocognitive abilities predicted future suicide-related outcomes such as suicide ideation, suicide attempts, and death by suicide. Using a large sample of Army soldiers (N = 11,545), Naifeh et al. (2017) assessed neurocognitive functioning using five subtests in the Army's Automated Neuropsychological Metrics (Version 4) Traumatic Brain Injury battery (ANAM4™ TBI). A factor analysis of the scores on these subtests revealed that four of the tests loaded onto a single factor representing general neurocognition. A second factor was also observed and interpreted to represent mathematical abilities. A series of logistic regression analyses determined that poorer performance on the general neurocognitive factor as well as the mathematical abilities factor prospectively predicted suicide ideation, suicide attempts, and suicide death in both univariate and multivariate models, with small effect sizes reported.

4 | DISCUSSION

The goal of this systematic review was to examine neurocognitive differences between suicide attempters and ideators, as well as between ideators and nonsuicidal individuals. We identified 14 studies comparing attempters to ideators on a range of neurocognitive abilities. Sample characteristics (e.g., age, gender, psychiatric diagnosis) varied widely between studies and, as neurocognitive domains were examined across one to four studies, findings should be regarded as suggestive rather than definitive.

In general, neurocognitive differences between attempters and ideators were negligible to small, with the exception of two subdomains of executive functions: decision making and inhibition. Interestingly, neither of these domains distinguished ideators from nonsuicidal individuals. Instead, ideators differed most from nonsuicidal individuals on measures of processing speed, global executive functions, and global cognitive functioning. A more detailed description of the findings is provided below.

Global cognitive functioning was observed to negligibly differ between attempters and ideators, and differ slightly between ideators and nonsuicidal individuals. Two measures were used in the studies examining global cognitive functioning: the MMSE and DRS. Interestingly, these two measures yielded similar findings when comparing ideators to nonsuicidal individuals, but disparate findings when comparing attempters to ideators. Previous research findings suggest that these two measures might measure overlapping but independent constructs (Freidl, Schmidt, Stronegger, Fazekas, & Reinhart, 1996; Freidl et al., 2002;

Rajji et al., 2009). A possible explanation for this is that the MMSE is thought to devote more items to assessing memory and attentional abilities (40%) than the DRS (17%; Strauss et al., 2006). Given the findings observed in this review, one interpretation is that the differences observed between attempters and ideators on the DRS and MMSE might reflect greater memory and attention-related impairment among attempters relative to ideators.

Global cognitive functioning was also examined longitudinally in a large sample of Army soldiers (Naifeh et al., 2017). The study found that global cognitive functioning prospectively predicted suicide attempts, death by suicide, and suicide ideation, with small-medium effect sizes observed. Of note, global cognitive functioning most strongly predicted death by suicide, over and above sociodemographic characteristics, history of psychiatric diagnoses, and mathematical ability. These results suggest that global cognitive functioning might represent a unique factor for predicting death by suicide. Furthermore, the weaker prospective relationship between global cognitive functioning, suicide attempts, and suicide ideation observed aligns with negligible differences between attempters and ideators observed in the cross-sectional findings in this review.

Regarding intelligence, ideators obtained better scores on both full-scale and premorbid intelligence measures than nonsuicidal individuals, with negligible to small effect sizes observed. Negligible effect size differences were also obtained between attempters and ideators, with attempters exhibiting worse performance. It is unclear how best to interpret these findings. One interpretation is that intelligence is unrelated to both suicide ideation and suicide attempts. A second interpretation is that given that both high (Voracek, 2004, 2006) and low (Abel & Kruger, 2005; Gunnell, Magnusson, & Rasmussen, 2005) intelligence have been associated with increased risk for suicide, it is possible that intelligence might act as a moderator of other risk factors (e.g., acquired capability for suicide) to suicide. A third interpretation is that more severe cognitive impairment could prevent individuals from thinking about suicide given that thinking about suicide requires several cognitive abilities (e.g., self-awareness, time perspective, planning). Given that intelligence was examined primarily in samples of individuals with psychotic disorders, and the profound impact psychotic disorders have on neurocognitive functions, it is therefore possible that less severe cognitive functioning is associated with suicidal ideation.

The results observed by this review on measures of executive functions help contextualize findings reported by earlier studies. For example, Richard-Devantoy, Berlim, et al. (2014) found that attempters exhibited moderate impairment on a decision-making measure (the Iowa Gambling Task [IGT]) compared to patient controls ($g = -.47$). Our study found a similar difference ($g = -.49$) between attempters and ideators, but a negligible difference ($g = -.05$) between ideators and nonsuicidal individuals. Thus, our results are not only consistent with Richard-Devantoy, Berlim, et al. (2014) but also suggest the IGT's relevance for suicidality might be in distinguishing attempters from ideators. The results observed in this review also suggest that the differences observed by Richard-Devantoy, Berlim, et al. (2014) on a task of inhibition (the Stroop test; $g = -.37$) are likely to be largely accounted for by differences between attempters and ideators ($g = -.50$ in our study) and to a lesser degree by differences between ideators and nonsuicidal individuals ($g = -.28$).

Processing speed was observed to differ considerably between ideators and nonsuicidal individuals and slightly between attempters and ideators, with attempters performing better on these measures. One interpretation is that processing speed is more closely related to history of suicide ideation than suicide attempts. However, given that both studies used psychiatric samples of participants diagnosed primarily with depression, it is possible that differences between ideators and nonsuicidal individuals are better accounted for by the presence and/or severity of depression, a relationship supported by meta-analytic findings (McDermott & Ebmeier, 2009). This explanation would also account for the slight differences observed on measures of processing speed between suicide ideators and attempters, given the aforementioned relationship of depression to suicide ideation and suicide attempts (Kessler et al., 1999; May & Klonsky, 2016).

Memory differences were observed between attempters and ideators as well as between ideators and nonsuicidal individuals, with ideators performing better than nonsuicidal individuals. As only one study examined memory differences between attempters and ideators, it is unclear how to interpret these findings. One interpretation is that increased memory abilities are associated with suicide ideation, not suicide attempts. Indeed, the participants in the study were primarily diagnosed with a psychotic disorder and therefore might experience profound cognitive impairments that would prevent them from thinking about suicide. Indeed, previous research examining neurocognitive functioning in psychotic samples observed that individuals with a history of both suicide ideation and suicide attempts outperform nonsuicidal individuals on memory measures (Kim, Jayathilake, & Meltzer, 2003; Nangle et al., 2006). Furthermore, meta-analytic findings reported by Richard-Devantoy et al. (2015) and Richard-Devantoy, Szanto, et al. (2014) suggest that these findings might extend beyond psychotic disorders, as suicide attempters with mood disorders were observed to exhibit slightly better short-term and working memory abilities than patient controls.

Regarding attentional abilities, mixed results were obtained comparing attempters to ideators, and ideators to nonsuicidal individuals on the single measure of attention. As many factors limit the interpretation of these findings, it remains unclear whether attentional abilities might be related to suicide ideation, suicide attempts, or both.

4.1 | Limitations of existing literature and its interpretation

Key limitations constrain the inferences that can be made about neurocognitive differences among suicide attempters, ideators, and nonsuicidal individuals. First, and most importantly, the number of studies examining neurocognitive differences between attempters and ideators is relatively small. Specifically, of the 144 published studies that used neuropsychological measures with suicide attempters, only 14 directly compared attempters with ideators, of which seven used an overlapping sample. The small number of studies identified precluded our ability to perform meta-analytic calculations and therefore limits the reliability of our findings and their generalizability to other populations. Including a group of ideators in addition to attempters, patient, and healthy control groups in future research could greatly advance our understanding of the role neurocognitive abilities might have in predisposing individuals thinking about suicide to act on their thoughts.

Second, any given neuropsychological measure has only been examined at most a few times in studies comparing attempters to ideators. Although different neuropsychological measures purport to measure the same neurocognitive ability, an increasing body of work suggests that less overlap exists between such measures than previously assumed (Toplak, Sorge, Benoit, West, & Stanovich, 2010; Toplak, West, & Stanovich, 2013). This may be partly due to neurocognitive abilities representing complex and multifaceted constructs that are being incompletely measured by any single neuropsychological measure. To directly address this issue, future studies should use neuropsychological measures utilized in previous studies to allow comparison and aggregation of findings. Furthermore, studies could also include more than one measure for each neurocognitive ability to more completely measure these constructs and help determine when observed differences can be attributed to a particular ability or to a particular measure of that ability.

Third, features of the studies included in this review complicate the interpretation of the results. For example, only one study used a prospective design (Naifeh et al., 2017). The use of nonprospective designs limits our ability to make causal inferences about the relationship between neurocognitive abilities and suicide attempts. Specifically, without knowing the temporal sequence of events, results obtained comparing attempters and ideators could represent either predisposing factors for suicide attempts (i.e., risk factors), the result of suicide attempts, or both. It is therefore crucial that future research use prospective designs to examine whether neurocognitive differences abilities precede suicide attempts as well as whether neuropsychological measures can predict suicide attempts.

Fourth, a large number of the studies in this review used very small samples. For example, in several studies attempter and ideator groups included <10 participants per group, and only half of the 14 studies included 30 or more participants per group. The use of such small sample sizes greatly reduces the precision of effect size estimates and increases the chances of both false-negative and false-positive findings. Progress in this area will require recruiting larger samples of participants.

Fifth, sample characteristics varied greatly between the studies included. For example, seven studies used an overlapping sample of older adults aged 60 or older while three studies (Minzenberg et al., 2015a, 2015b, 2015c) focused on young adults in their early to mid-twenties. Given the changes in cognition that occur with normal aging (Craik & Bialystok, 2006), it is possible that the relationship of neurocognitive abilities to suicide ideation and suicide attempts might change over the course of the lifespan. Additionally, participants received medications in some studies, whereas participants in other studies did not. The severity of psychopathology also varied between studies, in that several studies utilized acute inpatient samples while others focused on outpatients in remission. Furthermore, psychiatric diagnoses ranged from depressive disorders, to psychotic mood disorders, to schizophrenia. Previous systematic reviews observed (Bredemeier & Miller, 2015) differences in neurocognitive functioning according to psychiatric diagnosis, with attempters exhibiting more impaired neurocognitive functioning than patient controls. However, in populations diagnosed with psychotic disorders, studies have reported that suicide attempters appear to exhibit better neurocognitive functioning than patient controls (Kim et al., 2003; Nangle et al., 2006). Future research should further evaluate and report potential moderators of the relationship between neurocognitive abilities and history of suicide attempts.

Sixth, methods for assessing suicide attempts and suicide ideation were inconsistent across studies. For example, history of suicide attempt and suicide ideation was assessed using a variety of methods, including structured interviews, unstructured interviews, self-report measures, medical record reviews, and reviewing information obtained from the treatment team and the participant's family. Researchers responsible for determining history of suicide attempts and suicide ideation ranged in their educational attainment, and included psychiatrists, doctoral-level clinicians, and

master's-level clinicians. It is therefore possible that some studies failed to include participants with a history of suicide attempts and suicide ideation, or that participants were misclassified as attempters or ideators, thereby altering the results of the studies.

Seventh, dichotomous measurement of suicide ideation and attempts status is likely to obscure that (a) neither construct is unidimensional and (b) individuals with histories of frequent and severe suicide ideation or suicide attempts are likely to be different from individuals with a less frequent or severe history of ideation and attempts. For example, the number of suicide attempts ranged from one to four in studies reporting this information, and research suggests that individuals with a history of multiple suicide attempts differ from individuals with a single suicide attempt in several important ways, including being more likely to have comorbid health risks, more severe psychopathology, and a greater risk for future suicide attempts (Michaelis et al., 2003; Rosenberg et al., 2005; Rudd, Joiner, & Rajab, 1996). Given the lack of information about frequency and severity of suicide ideation and attempts, it is therefore possible that reported findings obscure important differences in neurocognitive functioning between mild and severe ideators as well as between single and multiple attempters. Recruiting larger samples of ideators and attempters and examining differences within these groups will advance our understanding of the relationship of these variables to neurocognitive functioning.

Eighth, recency of suicide attempts varied both across and within studies. For example, although some studies focused exclusively on participants with a nonrecent suicide attempt, other studies only included participants with a recent history of suicide attempt, ranging from attempts in the past 2-week period to the past year. Furthermore, most studies included participants with both a nonrecent and recent history of suicide attempts, with one study including participants with a history of suicide attempts occurring prior to the past 12 months, within the past 12 months, and within the past 2 weeks. As recent suicide attempters have been found to self-report more severe neurocognitive impairment than nonrecent suicide attempters (Saffer & Klonsky, 2016), it is possible that using such mixed groups of nonrecent and recent suicide attempters is likely to result in distorted findings. As more studies are conducted in this field, future research should examine whether neurocognitive abilities differ based on the recency of suicide attempts. Finally, it is possible that analyses resulting in null findings and/or nonstatistically significant results were not published (also known as the "file drawer" problem; Rosenthal, 1979) and that the results observed in this review therefore exaggerate the true differences between attempters and ideators as well as ideators and nonsuicidal individuals.

5 | CONCLUSIONS

The results of this review suggest that attempters are largely similar to ideators on a range of neurocognitive abilities, with the exception of two subdomains of executive functions: inhibition and decision making. However, the small number of studies addressing this issue, and the methodological variation and limitations among these studies, preclude definitive conclusions about the relationship of neurocognitive abilities to suicide ideation and suicide attempts. To significantly advance understanding in this important area of research, future studies should (a) separately consider neurocognitive predictors of ideation versus attempts among ideators, (b) use larger sample sizes, (c) use the most validated and precise measures of neurocognitive functioning available, and (d) examine longitudinal prediction of suicidality outcomes in addition to the more commonly utilized cross-sectional design.

CONFLICTS OF INTEREST

The authors do not have any conflicts of interest to disclose.

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