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Review article

Suicidal behaviour and cognition: A systematic review with special focus on prefrontal deficits

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ABSTRACT

Background: Suicide is a major health concern worldwide, thus, identifying risk factors would enable a more comprehensive understanding and prevention of this behaviour. Neuropsychological alterations could lead to difficulties in interpreting and managing life events resulting in a higher risk of suicide.
Method: A systematic literature search from 2000 to 2020 was performed in Medline (Pubmed), Web of Science, SciELO Citation Index, PsycInfo, PsycArticles and Cochrane Library databases regarding studies comparing cognition of attempters versus non-attempters that share same psychiatric diagnosis.
Results: 1.885 patients diagnosed with an Affective Disorder (n = 1512) and Schizophrenia/ Schizoaffective Disorder (n = 373) were included. In general comparison, attention was found to be clearly dysfunctional. Regarding diagnosis, patients with Schizophrenia and previous history of suicidal behaviour showed a poorer performance in executive function. Patients with current symptoms of an Affective Disorder and a previous history of suicidal attempt had poorer performance in attention and executive function. Similarly, euthymic affective patients with history of suicidal behaviour had worse decision-making, attention and executive function performance compared to euthymic non-attempters.
Limitations: The number of papers included in this review is limited to the few studies using non-attempter clinically-matched control group and therefore results regarding diagnosis, symptomatology and time of the attempt are modest and contradictory.
Conclusions: Patients who have attempted suicide have a poorer neuropsychological functioning than non-attempters with a similar psychiatric disorder in attention and executive function. These alterations increase vulnerability for suicide.

1. Introduction

Suicidal behaviour is a major health concern that represents a leading factor of death and disability, causing 800.000 casualties per year in the world (WHO, 2018). Age and gender (Conejero et al., 2016; Gonzalez-Pinto et al., 2006; Oostervink et al., 2009; Rossom et al., 2017), history of childhood adversity (Björkenstam et al., 2017; López et al., 2001; Martin et al., 2016), chronic pain (Racine, 2018), acute mental disorder (Haw and Hawton, 2015) –especially with mixed-symptoms (González-Pinto et al., 2011) –, poor treatment adherence (González-Pinto et al., 2006) and drug abuse (González-Pinto et al., 2010, 2007; Racine, 2018) are associated with a higher risk for suicide. Yet, the strongest risk factor is having a prior history of suicide attempt (Ayuso-Mateos et al., 2012; Coryell et al., 2016; Leadholm et al., 2014; Sanchez-Gistau et al., 2013), which is 10–20 times more frequent than suicide (WHO, 2018) and approximately 40% of people who committed suicide had made a previous attempt (Cavanagh et al., 2003). However, some individuals are more prone to attempt suicide than others under

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similar circumstances, which suggests an interplay between contextual and vulnerability factors (Mann, 2003). Although suicide rates have increased in recent years (WHO, 2018), suicidal behaviour can be prevented with effective interventions (Trueland, 2014). Therefore, it is important that risk factors associated with suicide are clearly identified to establish a more comprehensive approach and design targeted interventions.

Cognitive deficits may be a relevant aspect when assessing the risk for suicide as neuropsychological alterations have been described in suicide attempters when compared with healthy controls, which may lead to difficulties in interpreting and managing life events resulting in an increased vulnerability to suicide (Lara et al., 2015; Richard-Devantoy et al., 2014; Szanto, 2017). Patients with a history of suicidal behaviour have a poor performance on attention, memory, cognitive inhibition, verbal fluency, problem-solving abilities and executive function in comparison with healthy controls (Leadholm et al., 2014; Mann, 2003; Coryell et al., 2016; Ayuso-Mateos et al., 2012; González-Pinto et al., 2010; Racine, 2018; Richard-Devantoy et al., 2014).

Similarly, cognitive deficits have also been found in patients with a mental disorder but no history of suicide (MacQueen and Memedovich, 2017; Nakagome, 2017; Solé et al., 2017). This highlights the need to explore whether cognitive alterations in adult suicide attempters with a mental disorder are linked either to their diagnosis or the suicidal behaviour. For that purpose, studies involving non-attempter patients as a control group can provide meaningful insights and systematic reviews are needed to gather data about the wide range of neuropsychological domains explored in the literature with different assessment tools. Previous reviews that have delved into this subject in adult population and using control patients are scarce and yet heterogenous regarding the cognitive dimensions studied, the instruments used for neuropsychological assessment and the results obtained. In the systematic review and meta-analysis of Richard-Devantoy et al. (2012) suicidal affective patients had an executive dysfuction. Later, they (Richard-Devantoy et al., 2014) found that performance on decision-making and verbal fluency was lower in patients with a suicide attempt but in contrast, they did not find differences between groups in executive function and attention. Same authors (Richard-Devantoy et al., 2016) in a specific review and meta-analysis on decision-making in unipolar and bipolar disorder found that patients with history of suicide had alterations in this neurocognitive dimension. In the review of Jollant et al. (2011) authors describe deficits on decision-making, problem-solving, verbal fluency and attention but control groups are composed indistinctively by healthy and non-suicidal patients. A recent qualitative systematic review of Huber et al. (2019) found a poorer cognitive performance of suicide attempters, especially in cognitive control when comparing to control patients. However, these authors did not distinguish between the specific psychiatric condition in each study which could be interfering with the results obtained.

1.1. Aims of the study

In order to shed light on the role of neuropsychological functions as a predictive factor of suicidal behaviour, this systematic review gathers updated and homogenized data about deficits in several neurocognitive domains (Executive function, decision-making, attention, constructional praxis and working memory) of patients with a mental disorder and suicide attempts in comparison to non-attempters with the same mental disorder. Taking into account the clinical features of suicidal patients, that is, to compare the cognitive performance of suicidal patients that share the same diagnosis may help to distinguish which of the cognitive alterations are more present and, therefore, possibly linked to a higher risk for suicide in each disorder. For further insights on the neuropsychological performance, results are also categorized according to current psychiatric symptoms and time of the attempt.

2. Materials and methods

2.1. Literature search

A systematic literature search, from 2000 to 2020 was performed on March 30th 2020 using Medline (Pubmed), Web of Science, SciELO Citation Index, PyscInfo, PsycArticles and Cochrane Library. Medical subject heading (MESH) terms and free-terms 'suicide', 'suicidal behaviour' and 'suicidal behaviour' were combined with the terms 'executive function', 'working memory', 'prefrontal dysfunction', 'cognitive control', 'executive performance' and the following terms related to specific neuropsychological tests: 'Iowa Gambling Test', 'IGT', 'Wisconsin Card Sorting Test', 'WCST', 'Controlled Oral Word Association Test', 'COWAT', 'Weschler Adult Intelligence Test', 'WAIS', 'Stroop Colour-Word Test', 'SCWT', 'Cognitive Performance Test', 'CPT', 'Trail Making Test' and 'TMT'. The tests included have been selected for being classical measures used in neuropsychological assessment and which can provide evidence for the functioning of several dimensions of cognition.

The exact searching strategy used was:

(SUICIDE OR "SUICIDAL BEHAVIOUR" OR "SUICIDAL BEHAVIOUR") AND ("EXECUTIVE FUNCTION" OR "WORKING MEMORY" OR "PREFRONTAL DYSFUNCTION" OR "COGNITIVE CONTROL" OR "EXECUTIVE PERFORMANCE" OR "IOWA GAMBLING TEST" OR "IGT" OR "WISCONSIN CARD SORTING TEST" OR "WCST" OR "CONTROLLED ORAL WORD ASSOCIATION TEST" OR "COWAT" OR "WESCHLER ADULT INTELLIGENCE TEST" OR "WAIS" OR "SCWT" OR "STROOP COLOUR-WORD TEST" OR "STROOP COLOUR-WORD TEST" OR "CPT" OR "COGNITIVE PERFORMANCE TEST" OR "TMT" OR "TRAIL MAKING TEST").

2.2. Eligibility criteria

After screening, records that met the following inclusion criteria were included in this review: 1) published in English or Spanish language, 2) performed at least one of the following neuropsychological tests: 'Iowa Gambling Test', 'Wisconsin Card Sorting Test', 'Controlled Oral Word Association Test', 'Weschler Adult Intelligence Test' (any of the subtests), 'Stroop Colour-Word Test', Cognitive Performance Test', and 'Trail Making Test', 3) compared suicide attempters versus non-attempters, 4) involved patients over 18 years old to discard neurodevelopment effects of cognitive functioning and 5) involved patients in both groups diagnosed with the same mental disorder according to the Diagnostic and Statistical Manual of Mental Disorder in its different versions depending on the date of publication of the records. Conference and meeting abstracts, reviews, meta-analyses and pilot studies were excluded.

2.3. Data collection and extraction

PRISMA-P (Moher et al., 2015) checklist and flow-chart were used to ensure the quality of this systematic review. The quality of the studies included was assessed independently by 4 reviewers using the online Critical Appraisal Tools of the Basque Office for Health Technology Assessment (López de Argumedo et al., 2017). This tool allows researchers to collect and extract summarized data of each of the studies (Data extracted: Authors, year of publication, diagnosis, current symptomatology, time of attempt, neuropsychological test used and results) and rates the quality of papers as poor, medium or high according to a comprehensive checklist about the objective of the study, research question, methodological aspects (estimation of sample size, diagnostic criteria, inclusion/exclusion criteria of participants, reliable instruments for measurement, control of confounding factors, minimization of possible bias), results, conclusions, external validity and conflict of interest statement. In this review, only medium and high-quality papers were included. Any disagreement between reviewers was

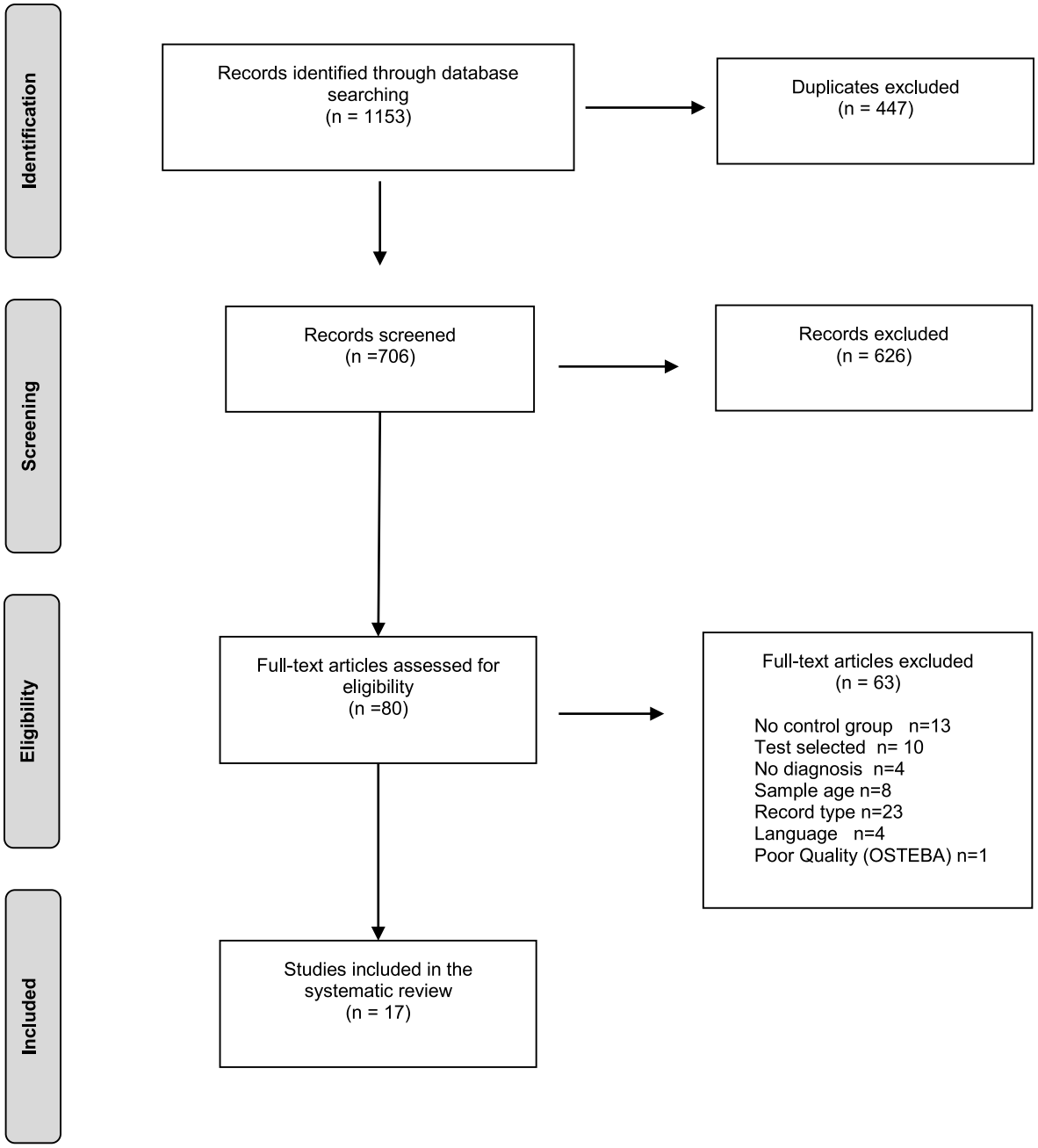

Fig. 1. PRISMA flow chart.

solved by discussion.

3. Results

Of the 1153 papers identified, 17 studies met the inclusion criteria and were selected for this review. A total of 63 full-text articles were excluded: 13 for not having a control group (patients with the same diagnosis but no suicidal behaviour), 11 for using different neuropsychological tests from those established as eligibility criteria, 4 did not provide any data on diagnosis, 22 were excluded for record type (conference abstract, meeting abstract, revision, pilot study), 4 were excluded for the language of publication and 1 was excluded for scoring low quality according to the online Critical Appraisal Tools of the Basque Office for Health Technology Assessment (Fig. 1). According to this criteria, 14 studies included were high-quality and 3 medium quality.

1.885 patients diagnosed with a mental illness comprise the total sample of this review, of whom 840 had attempted suicide and 1.045 had never attempted suicide. Out of the 17 studies in this review, 11 found neuropsychological deficits in a sample of 685 attempters compared to 814 non-attempters (n = 1499). Other 6 studies, comprising 155 attempters and 231 non-attempters (n = 386), did not find these differences.

Regarding the clinical profile, out of the 17 studies selected, 4 (Adan et al., 2017; Kocatürk et al., 2015; Nangle et al., 2006; Verma et al., 2016) assessed 373 patients that had been diagnosed with Schizophrenia or Schizoaffective Disorder. The rest of papers assessed the neuropsychological functioning of 1512 patients with an affective disorder. Concerning the time of the suicide attempt, only 3 studies (Deisenhammer et al., 2018; King et al., 2000; Richard-Devantoy et al., 2012) are based on recent suicide attempts, whereas the rest 14 studies focussed on lifetime history of previous suicide behaviour. Table 1

Table 1
Main characteristics and results of articles included in the review.

Study	Sample	Suicide AttemptersAge m (sd) Gender (% female)	Control PatientsAge m (sd)Gender (% female)	Diagnosis	Neuropsychological Tests	Results in Cognitive Domains	Quality of the study
Adan et al., 2017	n = 50	n = 24 36.21 (6.95) 0%	n = 26 35.92 (8.63) 0%	Dual Schizophrenia Dual Schizoaffective disorder (DSM-IV-TR)	TMT-B WAIS-III Block Design WAIS-III Digits WSCT IGT	SA < NSA Executive Function. Decision-Making. SA = NSA Attention Constructional praxis Working memory	High
Deisenhammer et al., 2018	n = 52	n = 21 37.2 (11.7) 76%	n = 31 42.5 (11.7) 71%	Depressive patients (ICD-10: F3 or F43)	IGT	SA = NSA Decision-Making	Medium
Gilbert et al., 2011	n = 67	n = 28 43.7 (10.7) 50%	n = 39 41.1 (12) 41%	Bipolar I Disorder Bipolar II Disorder (DSM-IV)	Stroop TMT-A / TMT-B WAIS-III Digits WCST IGT	SA = NSA Attention Working memory Executive Functions Decision-Making	High
Gorlyn et al., 2013	n = 72	n = 26 35.04 (11.97) 34.6%	n = 46 37.76 (10.68) 67.4%	Major Depression Episode (DSM-IV)	IGT	SA = NSA Decision-Making	High
Ho et al., 2018	n = 70	n = 34 41.8 (1.4) 91.18%	n = 36 44.3 (1.2) 55.56%	Major Depression Disorder (DSM-V)	IGT	SA = NSA Decision-Making	High
Jollant et al., 2013	n = 232	n = 151 39.9 (12.1) 36.42%	n = 81 38.2 (11.3) 38.27%	Affective Disorders DSM-IV	IGT	SA < NSA Decision-Making	High
Keilp et al., 2008	n = 178	High-lethality n = 42 39.2 (11.2)† Low-lethality n = 53 34.3 (10.9)†	n = 83 41.2 (12.5)	Major Depression Disorder (DSM-IV)	Stroop CPT	HL SA < NSA. Attention	High
Keilp et al., 2013	n = 152	n = 72 35.7 (11.6) 63.9%	n = 80 40.1 (11.9) 52.5%	Major Depressive Episode (DSM-IV)	Stroop TMT-A / TMT-B WAIS-III Digits CPT WCST	SA < NSA Attention	High
Keilp et al., 2014	n = 161	n = 80 42 (9.1) 93.8%	n = 81 44.6 (7.7) 84%	Major Depressive Episode (DSM-IV)	Stroop CPT WSCT	SA < NSA Attention Executive Function	High
King et al., 2000	47	n = 18 66.67 (10.13) 55.6%	n = 29 64.24 (10.97) 68.97%	Major Depression Disorder (DSM-III-R)	TMT-B WAIS Block Design WSCT	SA = NSA Attention Constructional praxis Executive Function	High
Kocatürk et al., 2015	70	n = 27 38.11(8.39) 22.2%	n = 43 39.28(11.03) 41.9%	Schizophrenia Disorder (DSM-IV-TR)	Stroop WSCT	SA < NSA Executive Function	Medium
Malloy-Diniz et al., 2009	39	n = 18 41.0 (13.8) 66.7%	n = 21 40.8 (12.6) 52.4%	Bipolar Disorder I (DSM-IV)	CPT II Stroop IGT WSCT	SA < NSA Decision-Making	High
McGirr et al., 2012	63	n = 20 Low-lethality n = 20 66.80 (8.15) 50% High-lethality n = 14 68.86 (7.53) 50%	n = 29 70.30 (9.03) 65.5%	Major Depression Episode without psychotic features (DSM-IV)	WCST	HL SA < NSA Executive Function	High
Nangle et al., 2006	n = 78	n = 28 42.0 (10.0) 32.14%	n = 50 48.1 (8.1) 22%	Squizophrenia or Schizoaffective Disorder (DSM-IV)	TMT WAIS-III Block Design CPT	SA > NSA Attention	High
Olié et al., 2015	n = 339	High-lethality n = 41† 70.73% Low-lethality n = 84† 67.05%	n = 214† 67.05%	Bipolar I Disorder Bipolar II Disorder (DSM-IV)	TMT Stroop	LL < NSA HL < NSA Attention	High
Richard-Devantoy et al., 2012	n = 40	n = 20 77.1 (7.2) 65%	n = 20 75.9 (6.7) 60%	Major Depressive Episode (DSM-IV)	TMT Stroop	SA < NSA Attention	High
Verma et al., 2016	n = 175	n = 39 34.10 (7.67)†	n = 136 32.78 (7.75)†	Schizophrenia or Schizoaffective Disorder (DSM-IV-TR)	TMT	SA < NSA Attention	Medium

† Data not available
SA: Suicide Attempters
NSA: Non-Suicide Attempters
HL: High-lethality attempt

LL: Low-lethality attempt
<: Worse performance than
>: Better performance than.

provides the main characteristics and results of the studies included in the review.

For practical reasons, the results obtained were classified into five neuropsychological domains as follow: Executive function, decision-making, attention, constructional praxis and working memory. As some of the test included measure different dimensions and could be classified into different dimensions, the criteria used for the categorization of results was made according to the most common objective of the authors using those measures and in a way that enabled results comparison. Specifically, executive function was measured with Wisconsin Card Sorting Test (WCST). Decision-making was considered an independent dimension of executive function as the studies included in this review assessed it using specific assessment tools and Iowa Gambling Test measures were reported. Attention was measured with Trail Making Test (TMT), Stroop colour Word Test (SCWT) and Continuous Performance Test (CPT) scores. *Although Stroop Intereference and TMT-B scores could be also classified into executive function dimension this was not the objective of the majority of the studies.* Constructional praxis and working memory were measured using Weschler Adult Intelligence Scale (WAIS) Block Design subtest and Digit subtest respectively (Table 2).

3.1. Executive function

4 studies revealed that patients with a history of suicide attempt had a poorer performance in executive function as compared to non-attempters diagnosed with the same mental disorder. Adan et al. (2017) explored this cognitive dimension in a sample of 24 men who had attempted suicide in any time of their lifetime and 26 non-attempters, all diagnosed with dual Schizophrenia or a Schizoaffective Disorder, but abstinent for at least three months. Attempters obtained significantly lower scores in the variables Categories Completed ($F_{(1,47)} = 8.013$; $p < 0.01$; $\eta_p^2 = 0.146$; power = 0.792), Trials to First Success" ($F_{(1,47)} = 4.969$; $p < 0.05$; $\eta_p^2 = 0.096$; power = 0.598) and Global Score ($F_{(1,47)} = 7.940$; $p < 0.01$; $\eta_p^2 = 0.145$; power = 0.788) of Wisconsin Card Sorting Test (WCST). In another study, Kocatürk et al. (2015) compared the executive function of 70 patients with Schizophrenia, 27 with a previous suicide attempt and 43 non-attempters. WCST Total Score was higher in non-attempter group ($p < 0.05$) indicating a better performance in executive function and the performance in this variable was found to be a predictor for suicide risk (OR = 1.077; IC = 95%; CI = 1.009–1.150). Keilp et al. (2014) found that WCST Error score was significantly higher ($p = 0.02$) in 80 past suicide attempters ($X = -0.55$, SD = 0.87) than in 81 non-attempters ($X = -0.24$,

Table 2
Performance on neuropsychological domain.

Neuropsychological Domain	Neuropsychological Tests	Results	
Executive function	WSCT	**No differences** Affective disorders King et al., 2000 Gilbert et al., 2011 Keilp et al., 2013	**SA <NSA** Affective disorders Keilp et al., 2014 McGirr et al., 2012 Schizophrenia Adan et al., 2017 Kocatürk et al., 2015
Decision-making	IGT	**No differences** Affective disorders Ho et al., 2018 Gilbert et al., 2011 Gorlyn et al., 2013 Deisenhammer et al., 2018	**SA<NSA** Affective disorders Jollant et al., 2013 Malloy-Diniz et al., 2009 Schizophrenia Adan et al., 2017
Attention	TMT SCWT CPT	**No differences** Affective disorders Malloy-Diniz et al., 2009 Gilbert et al., 2011 King et al., 2000 Schizophrenia Adan et al., 2017 Kocatürk et al., 2015	**SA<NSA** Affective disorders Keilp et al., 2008 Keilp et al., 2013 Keilp et al., 2014 Olié et al., 2015 Richard-Devantoy et al., 2012 Schizophrenia Verma et al., 2016 **SA>NSA** Schizophrenia Nangle et al., 2006
Constructional praxis	WAIS Block Desing subtest	**No differences** Affective disorders King et al., 2000 Schizophrenia Adan et al., 2017 Nangle et al., 2006	
Working memory	WAIS Digits subtest	**No differences** Affective disorders Gilbert et al., 2011 Keilp et al., 2013 Schizophrenia Adan et al., 2017	

SA: Suicide Attempters.
NSA: Non-Suicide Attempters.
<: Worse performance than.
>: Better performance than.

SD = 0.77) with a past history of Major Depression. The study conducted by McGirr et al. (2012) also assessed this domain in 63 old (>60 years) depressed patients with (n = 34) and without (n = 29) a history of suicide attempts. For the statistical analyses, attempters were classified as low-lethality (n = 20) and high-lethality (n = 14) suicide attempters. High-lethality attempters (X = 30.8, SD = 23.70) scored lower on Conceptual Level Responses of WCST in comparison with depressed non-attempters (X = 48.36, SD = 23.42) (p = 0.033). In contrast, the studies of King et al. (2000), Gilbert et al. (2011), Keilp et al. (2013) and Malloy-Diniz et al. (2009) yielded no significant differences. Although studies which found executive deficits in suicide attempters used a slightly bigger sample in their studies (n = 344) compared to the studies with contrary results (n = 315), results remain contradictory and there is no enough information to confirm a possible executive dysfunction.

3.2. Decision-making

Out of 7 studies assessing decision-making, 3 describe a worse performance of suicide attempters than non-attempters with same psychiatric disorder. In the study by Jollant et al. (2013) euthymic patients with a history of affective disorder but no prior history of suicidal behaviour (n = 81) scored higher on Iowa Gambling Test (IGT) Total Net Score (p = 0.003) than clinically similar patients with previous suicide attempts (n = 151). Thus, patients with a history of mood disorder and suicidal behaviour showed poorer decision-making skills. Deficits in this domain were also reported in suicidal attempters in a study by Malloy-Diniz et al. (2009) which included 18 attempters and 21 non-attempters diagnosed with Bipolar disorder. Attempters scored lower on measures of IGT Block 3 (U = −2.819; p < 0.01), Block 4 (U = −2.448; p < 0.05), Block 5 (U = −2.121; p < 0.05) and Net Score (U = −2.665; p < 0.01). Similarly, Adan et al. (Adan et al., 2017) reported lower scores in Block3 ($F_{(1,47)}$ = 7.790; p < 0.01; η_p^2 = 0.142; power = 0.781), Block4 ($F_{(1,47)}$ = 5.636; p < 0.05; η_p^2 = 0.103; power = 0.651), Block5 ($F_{(1,47)}$ = 10.457; p < 0.01; η_p^2 = 0.182; power = 0.886) and Total Score($F_{(1,47)}$ = 11.249; p < 0.01; η_p^2 = 0.193; power = 0.907) on IGT in the group of patients with a suicide attempt. However, the studies conducted by Ho et al. (2018), Gilbert et al. (2011), Gorlyn et al. (2013) and Deisenhammer et al. (2018) did not find any differences in decision-making ability between groups. Interestingly in the later study, authors report less risky decisions under uncertainty, a specific type of decision-making measured by CGT, in non-suicidal patients. Nevertheless, this specific measure of decision-making is not included for the purpose of this review.

3.3. Attention

Attention was measured by several authors using Trail Making Test (TMT) Part A and B, Stroop Colour-Word Test (SCWT) and Cognitive Performance Test (CPT). Of the 17 studies included in this review, 13 explored this dimension with the instruments mentioned above and only 5 reported no significant differences (Adan et al., 2017; Gilbert et al., 2011; King et al., 2000; Kocatürk et al., 2015; Malloy-Diniz et al., 2009). The other 7 studies showed that attention is altered in suicide attempters with a psychiatric disorder in comparison with non-attempters with a similar psychiatric condition.

Keilp et al. (2008) recruited 178 patients to examine potential Attention deficits in currently depressed patients with and without a history of suicide. This sample included 95 subjects who had a previous suicidal behaviour (53 who had made low-lethality attempts and 42 high-lethality attempters) and 83 depressed non-attempters. Sustained attention was evaluated using the CPT, but comparisons of *d'* scores and secondary outcomes failed to yield significant differences. Attention interference was measured using an adaptation of Stroop Test. The results obtained revealed more interference in depressed high-lethality attempters patients (X = −0.89; SD = 1.3) in comparison to non-attempters with the same diagnosis (X = −0.29; SD = 1.1) (p < 0.001). Same authors (Keilp et al., 2013) conducted further studies to explore attention in patients with a current Major Depressive Episode. Stroop interference was found to be significantly higher (p = 0.03) in patients who had attempted suicide (X = −0.54, SD = 1.31) in comparison to non-attempters (X = −0.11, SD = 1.11). In a later paper, same authors (Keilp et al., 2014) reported a lower composite score of the Attention domain in past suicide attempters (X = −0.32, SD = 0.92) compared to non-attempters with same disorder (X = 0.08, SD = 0.68) (p = 0.002). Indeed, attempters (X = −0.25, SD = 1.04) performed worse in CPT *d'* score than non-attempters (X = 0.07, SD = 0.84) (p = 0.04) and results for Stroop Interference showed worse outcomes in suicide attempters (X = −0.39, SD = 1.31) than non-attempters (X = 0.11, SD = 0.93) (p = 0.008). Similarly, in a study conducted by Olié et al. (2015) on 339 euthymic bipolar patients with and without a history of suicide attempts patients with suicidal behaviour were found to have a poorer performance in attention tasks than clinically-similar non-attempters. Therefore, according to these authors, Stroop Word Reading Score can be a predictor for high-lethality (OR = 1.96 (1.15; 3.34)) and low-lethality (OR = 1.48 (0.95; 2.29)) suicide attempts. Likewise, Richard-Devantoy et al. (2012) found more errors in Stroop Test (U = 118.5; p = 0.03) and in TMT-B (U = 98; p = 0.005) in recent suicide attempters (n = 20) compared to non-attempter currently depressed elder patients (n = 20). Also, Verma et al. (2016) assessed attention in 175 patients diagnosed with Schizophrenia or a Schizoaffective Disorder using TMT. Results indicate that patients with lifetime suicide intent had a poorer performance in TMT-A (t = 1.965, p = 0.026) and TMT-B (X^2_{173} = 2.282, p = 0.012) when compared to non-attempters, who took more time to complete both tasks. Interestingly, Nangle et al. (2006) reported a significantly better ability to control and shift attention in Schizophrenic patients with a previous history of suicidal behaviour (n = 28) measured with TMT Part-B compared to never-attempters (n = 50) with the same diagnosis (t = 2.06; p < 0.05).

3.4. Constructional praxis and working memory

Weschler Adult Intelligence Test (WAIS) Block Design subtest was used by Adan et al. (2017), Nangle et al. (2006), and King et al. (2000) to assess constructional praxis but there was no difference between groups. Same happened with the WAIS Digit subtest for measuring working memory in the studies conducted by Adan et al. (2017), Gilbert et al. (2011) and Keilp et al. (2013). Therefore, results indicate that these two domains may not be altered in patients who have attempted suicide.

3.5. Diagnosis, time of the attempt and current psychiatric symptoms

3.5.1. Schizophrenia

Patients diagnosed with Schizophrenia and previous history of suicidal behaviour showed a poorer performance in executive function (Adan et al., 2017; Kocatürk et al., 2015) compared to patients with Schizophrenia who had never attempted suicide. Contradictory results were found regarding attention as attempters have been reported to outperform non-attempters (Nangle et al., 2006) and vice versa (Verma et al., 2016) (Table 3).

3.5.2. Affective disorders

In 7 studies (Jollant et al., 2013; Keilp et al., 2014, 2013, 2008; McGirr et al., 2012; Olié et al., 2015; Richard-Devantoy et al., 2012) cognitive performance was reported to be poorer in affective patients with suicide compared to clinically-similar patients without suicidal behaviour, while 5 studies (Deisenhammer et al., 2018; Gilbert et al., 2011; Gorlyn et al., 2013; Ho et al., 2018; King et al., 2000) did not find differences between groups. According to Richard-

Table 3
Sample distribution according to diagnosis, time of suicide attempt and current of symptoms.

Affective disorders $n = 1512$	Recent attempt	59 symptomatic
	Past attempt	313 euthymic
		350 symptomatic
	Never attempted	345 euthymic
		445 symptomatic
Schizophrenia $n = 373$	Past attempt	118 symptomatic
	Never attempted	255 symptomatic

Devantoy et al. (2012), currently symptomatic patients who had recently attempted suicide had a poorer performance in attention compared to non-attempters. However, other authors found no differences in attention (King et al., 2000), executive function (King et al., 2000; Malloy-Diniz et al., 2009) and decision-making (Deisenhammer et al., 2018) in clinically-matched non-attempters.

On the other hand, currently symptomatic patients with a history of suicide attempt had poorer outcomes in attention (Keilp et al., 2013, 2008) and executive function (McGirr et al., 2012) but exhibited similar decision-making performance (Gorlyn et al., 2013; Ho et al., 2018) when compared to patients with affective symptoms without a history of suicide attempt.

Finally, euthymic patients with history of suicidal behaviour had worse decision-making (Jollant et al., 2013), attention (Keilp et al., 2014; Olié et al., 2015) and executive function (Keilp et al., 2014) compared to euthymic non-attempters. Nonetheless, the study by Gilbert et al. (2011) reported similar cognitive performance in these patients (Table 3).

4. Discussion

The main finding of this review is that patients who have attempted suicide have a poorer neuropsychological functioning than non-attempters with a similar psychiatric disorder, that is, patients with suicidal behaviour have worse cognition than patients without attempts. Specifically, there is a clear dysfunction in attention and our data also suggests that executive function might be altered in both schizophrenic and affective patients with history of suicidal behaviour. In contrast, contradictory data have been found regarding decision-making, whereas no significant differences have been reported in constructional praxis and working memory.

According to the literature, cognitive functioning is impaired in a high proportion of patients with a mental disorder (Nakagome, 2017; Solé et al., 2017) and numerous studies report neuropsychological alterations in attempters with a mental illness when compared to healthy non-attempters (Ayuso-Mateos et al., 2012; Cavanagh et al., 2003; Coryell et al., 2016; González-Pinto et al., 2010; Leadholm et al., 2014; Mann, 2003; Racine, 2018; Sanchez-Gistau et al., 2013). This raises the question whether these alterations in the cognition of suicide attempters are diagnosis-dependant or specific to suicidal behaviour.

Since cognitive deficits are present both in suicidal behaviour and mental illness, we only included in this review studies comparing attempters and non-attempters with the same psychiatric diagnosis with similar clinical profile. Therefore, the differences observed in cognitive performance would be more attributable to suicidal behaviour than to the mental disorder itself. This finding is remarkable as it suggests that this altered cognitive performance may be a risk factor for suicide. Based on this data, accumulating evidence (Hegedűs et al., 2018; Jollant et al., 2005; Richard-Devantoy et al., 2012) indicates that cognitive deficits play a role in the interplay between vulnerability and contextual factors that lead to suicidal behaviour.

Although the majority of studies in this review describe attention deficits in suicide attempters, contradictory results have been obtained in terms of diagnosis, time of suicide attempts and symptoms. Patients with Schizophrenia and previous suicidal behaviour had a deficit in executive function (Adan et al., 2017; Kocatürk et al., 2015) and attention (Verma et al., 2016). However, in another study (Nangle et al., 2006) these patients had better attention skills than non-attempters which could enable them plan and initiate behaviour directed towards a particular goal (Verma et al., 2016). According to Banjes et al. (2016), suicide attempts are a form of a goal-directed behaviour consciously initiated by individuals in response to their subjective psychological experience and environmental factors. Nevertheless, an altered executive function could explain failures in this goal-directed behaviour.

In relation to affective disorders, contradictory results have been obtained regarding attention in currently-symptomatic patients with a recent suicide attempt (King et al., 2000; Richard-Devantoy et al., 2012) which could be explained by the limited number of studies included in this category. Patients with current symptoms and a history of suicidal attempt had poorer performance in attention (Keilp et al., 2013, 2008) and executive function (McGirr et al., 2012) when compared to clinically-matched non-attempters. This implies that cognitive alterations may persist long after the crisis, and may be a risk factor for re-attempts. Thus, deficits in attention and executive function could impair the regulation of emotions, thought and actions, which can lead to suicidal behaviour (Bredemeier and Miller, 2015). Besides, currently euthymic patients with past history of suicidal behaviour show a more deficient decision-making (Jollant et al., 2013), attention (Keilp et al., 2014; Olié et al., 2015) and executive function (Keilp et al., 2014) compared to currently euthymic non-attempters.

In conclusion, attention and executive function are altered in both affective and schizophrenic past suicide attempters. Dysfunction in these domains interfere with the ability to process and interpret information to respond to situational demands. Attention and executive functions encompass multiple cognitive processes that orchestrate thought and behaviour, such as planning, task switching, error detection, cognitive inhibition, and decision-making (Gläscher et al., 2012; Miller and Cohen, 2001). These processes can be influenced by the emotional state of the patient, altering their performance in case of great psychological distress (Lerner et al., 2015; Phelps et al., 2014). Failures in these processes can lead patients to consider suicide as the only possible solution to an unbearable pain and stress (Richard-Devantoy et al., 2014). In addition, cognitive alterations may also increase the difficulties in interpersonal relationships which is a classical trigger of suicidal crisis (Jollant et al., 2007).

This result reinforces the idea that the neuropsychological alterations implicated in suicidal behaviour accompany the patient over time, even in asymptomatic periods, but this finding also leaves room to neuropsychological remediation to be explored as a therapeutic tool.

Limitations

Only studies published in English or Spanish between years 2000 and 2020 were included in this review and grey literature was excluded.

Due to the scarcity of studies that involve non-attempter clinically-matched control group, the number of articles and sample of patients of this systematic review is limited. Thus, further studies are needed to clarify the cognitive domains that are altered in subjects with suicidal behaviour. More specifically, although we did not obtain significant results for working memory and constructional praxis, these domains should be explored more in depth in order to determine their role in suicidal behaviour. Regarding executive function results were contradictory, therefore it is necessary to confirm these findings in future investigations. Another limitation of this review is the neuropsychological battery defined as eligibility criteria, which had to be reduced to widely-used instruments but, as a result, we discarded heterogeneous data from other tests and cognitive domains. Also, contradictory results regarding the time of suicide attempt and current symptoms indicate that further research is needed in the field.

In conclusion, patients with a mental disorder and history of

suicidal behaviour exhibit cognitive alterations that are not present in patients with the same diagnosis but that have never attempted suicide. Affective and Schizophrenic patients with a past suicide attempt have executive function and attention alterations. These results suggest that patients with a history of suicide attempt may have a different cognitive profile from that of non-attempter patients with the same diagnosis and that these alterations may persist during the course of the disease, both in times of stability and during symptomatic phases, even if suicidal behaviour is not recent.

Cognition plays an important role in suicidal behaviour and is a potential vulnerability marker that could be taken into account for a comprehensive suicide risk evaluation. Therefore, future interventions should include neuropsychological assessment and cognitive remediation as a possible tool for reducing suicide attempts.

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