REVIEW ARTICLE

Suicidal behaviour and memory: A systematic review and meta-analysis

STEPHANE RICHARD-DEVANTOY1,2, MARCELO T. BERLIM1 & FABRICE JOLLANT1

1McGill University, Department of Psychiatry & Douglas Mental Health University Institute, McGill Group for Suicide Studies, Montréal, Québec, Canada, and 2Laboratoire de Psychologie des Pays de la Loire EA 4638, Université de Nantes et Angers, France

Abstract

Objectives. Suicidal behaviour results from a complex interplay between stressful events and vulnerability factors, including cognitive deficits. It is not yet clear if memory impairment is part of this specific vulnerability. Therefore, the objective of this study was to examine the association between memory deficits and vulnerability to suicidal acts.

Methods. A literature review was performed using Medline, Embase, and PsycINFO databases. Twenty-four studies (including 2,595 participants) met the selection criteria. Four different types of memory (i.e., working memory, short- and long-term memory, and autobiographical memory) were assessed in at least three different studies.

Results. Autobiographical memory was significantly less specific and more general in patients with a history of suicide attempt relative to those without such a history (Hedges’ g = 0.8 and 0.9, respectively). Long-term memory and working memory were both more impaired in suicide attempters than in patient and healthy controls. Only short-term memory did not differentiate suicide attempters from patient controls.

Conclusions. Memory may play a significant role in the risk of suicidal acts, perhaps by preventing these individuals from using past experiences to solve current problems and to envision the future, and by altering inhibitory processes. More studies are necessary to better clarify these relationships.

Key words: suicidal behaviour, vulnerability, working memory, autobiographical memory, short- and long-term memory

Introduction

What makes a person consider and eventually commit a suicidal act while another person in the same context of stressful life events or major depression, for instance, will never do so? It is now largely thought that the first person may present with vulnerability factors which increase the risk in stressful conditions of experiencing mental pain, hopelessness and suicidal ideas and, in some cases, of acting out (Mann 2003). Neuropsychology may shed light on some aspects of these vulnerability factors.

A growing literature suggests that suicide attempters, in comparison to patient and healthy controls, show several cognitive deficits that may play a significant role in the vulnerability to suicidal acts (Jollant et al. 2011). We recently conducted a meta-analysis of seven different neuropsychological tests (Richard-Devantoy et al. 2013) and suggested that impairment in value-based decision-making and cognitive inhibition, two deficits that show little overlap in suicide attempters (Richard-Devantoy et al. 2013), may be part of this specific vulnerability.

We did not assess memory in this previous study. Yet, memory is a major brain function playing a significant role in what we are and do. Consequently, investigating memory deficits in relation to the vulnerability to suicidal behaviour is particularly relevant. Several studies have been published reporting memory deficits in suicide attempters (see below). However, both positive and negative results have been published, one major limitation of several studies being a small sample size. Also, it is not clear if these deficits may be associated with suicidal behaviour or may be more closely related to co-morbid psychiatric disorders such as major depression. To this aim, we have systematically reviewed the literature on...
memory in suicidal behaviour, and then conducted a meta-analysis.

As no particular memory test has been used in at least three different studies, we had to use a cognitive domain approach (Keefe 1995). Therefore, different tests had to be analysed together in the meta-analysis. Moreover, defining categories of memory is not a straightforward task. Based on previous publications in the field of suicide, we chose to consider the four following types: (1) working memory, (2) short-term memory, (3) long-term memory, and (4) autobiographical memory. Working memory is the function that actively holds multiple pieces of transitory information in mind, where they can be manipulated (Conway et al. 1996; Goldman-Rakic 1996), whereas short-term memory is defined as the capacity for holding a small amount of information in mind in an active, readily available state for a short period of time (Engle et al. 1999; Tetzlaff et al. 2012). In contrast, long-term memory can hold a large amount of information for a long period of time. Finally, autobiographical memory is the system involved in collecting, storing and retrieving episodes from an individual’s life, and comprising a combination of episodic (e.g., personal experiences and specific objects, people and events experienced at particular time and place) and semantic (general knowledge and facts about the world) memory (Williams et al. 1986).

This meta-analysis therefore aimed at clarifying the relationship between each of these four domains and the vulnerability to suicidal behaviour, and disentangling potential deficits associated with suicidal behaviour from those related to comorbid disorders.

Methods and material

Data sources

An English and French systematic literature search of MEDLINE, Embase, and PsycInfo databases was performed for human studies published until 31 June 2013. The Medical Subject Heading (MeSH) term “suicide” was combined with the MeSH terms “Neuropsychology”, “Neuropsychological Tests”, “Executive Function”, “Memory”, “Memory, Long-Term”, “Memory, Short-Term”, “Working Memory”, and “Autobiographical Memory”. An iterative process was used to ensure that all relevant articles were obtained. A further hand search of the bibliographical references of the selected papers and existing reviews was conducted to identify additional potential studies. References were also selected from our research group’s online database (www.bdsuicide.disten.com).

Study selection

Abstract selection was based on the STrengthening the Reporting of OBServational studies in Epidemiology (STROBE) checklist (Von Elm et al. 2008) which describes items that should be included in reports of cohort studies. Abstracts identified through the literature search were independently evaluated by two reviewers (SRD and FJ) and selected by a consensus from all authors.

Studies that met the following inclusion criteria were included in this systematic review: (1) published in an English or French language peer-reviewed journal; (2) including at least one memory task; and (3) including at least one group of patients with a history of suicide attempt. A suicidal attempt was defined as any act carried out with a certain intent to die and different from non-suicidal self-injury (Mann 2003). Full articles were then obtained for final review. The study selection process is shown on a chart flow diagram in Figure 1.

Of the 334 originally identified abstracts, 31 studies met the inclusion criteria for this systematic review (see Table I). The quality of each study was assessed independently by two reviewers (SRD and FJ) using the Crombie criteria adapted by Petticrew et al. (2006).

Then, studies that met the additional inclusion criteria of comparing at least two groups of which one comprised patients with a history of suicide attempts were included in this meta-analysis. Of the 31 studies of the systematic review, 24 studies met this criterion (see Table II).

Although eligible, two studies were not included, because precise means and standard deviations were not available in the papers and could not be obtained directly from the authors (Williams et al. 1986; Taylor et al. 2010).

Data extraction and analyses

A standardized form was used to extract data, which included authors, date of publication, study design, settings, study population, memory tests used, definition of suicidal behaviour, and memory scores (mean and SD). Five variables encompassing four memory domains that have been explored in at least three different studies, were analysed: (1) Working memory, (2) Short-term memory, (3) Long-term memory, (4) General autobiographical memory, and (5) Specific autobiographical memory.

Analyses were performed using Comprehensive Meta-Analyses Version 2.0 (Biostat, Englewood, NJ, USA), and IBM SPSS Version 20 (IBM Corporation, Chicago, IL, USA).
We used a random-effects model as we assumed that the true effect sizes had likely varied between the included studies (Riley et al. 2011). Pooled Hedges’ $g$ effect sizes for the subjects’ neuropsychological

Three groups were compared: suicide attempters (patients with a history of suicide attempt), patient controls (i.e., patients with no personal history of suicidal act but with a history of mental disorders) and healthy controls. When two groups of suicide attempters were reported in one study (e.g. low vs. high lethality acts (McGirr et al. 2011; Keilp et al. 2013)), the combined means and standard deviations were calculated to obtain a global group, using the following formula:

$$
\mu_{X\times Y} = \frac{N_X \mu_X + N_Y \mu_Y}{N_X + N_Y}
$$

$$
\sigma_{X\times Y} = \sqrt{\frac{N_X \sigma_X^2 + N_Y \sigma_Y^2}{N_X + N_Y} + \frac{N_X N_Y}{(N_X + N_Y)^2} (\mu_X - \mu_Y)^2}
$$

We used a random-effects model as we assumed that the true effect sizes had likely varied between the included studies (Riley et al. 2011). Pooled Hedges’ $g$ effect sizes for the subjects’ neuropsychological
| Authors                          | Study type and population                                                                 | Medication | Definition                     | Source of information | Period assessed | Memory measure | Results                                                                 |
|---------------------------------|-------------------------------------------------------------------------------------------|------------|--------------------------------|-----------------------|-----------------|----------------|-------------------------------------------------------------------------|
| *Autobiographical memory*       |                                                                                            |            |                                |                       |                 |                |                                                                          |
| Pettersen et al., 2010          | Cross-sectional study - In and Outpatients with diagnosis of schizophrenia or schizoaffective disorder (n = 32) | Yesa       | Suicide attempt                 | ISST                  | Lifetime        | AMT            | - SA < PC: Worse specific autobiographical memories.                    |
| Norway                          |                                                                                            |            |                                |                       |                 |                | - SA > PC: More over-general autobiographical memories.                  |
|                                 |                                                                                            |            |                                |                       |                 |                | - SA > PC: A higher level of current suicidal ideation.                 |
| Maurex et al. 2010              | Cross-sectional study - SA inpatients with a borderline personality disorder (n = 47; mean age: 30.5 y.o.; men: 0%) | Yesabc     | ≥2 suicide attempts            | SASII                 | Previous 6 month | AMT            | - SA < HC: Worse specific autobiographical memories.                    |
| Sweden                          |                                                                                            |            |                                |                       |                 |                | - SA < HC: More over-general autobiographical memories.                  |
| Taylor et al. 2010              | Cross-sectional study - Outpatients with a schizophrenia spectrum disorders                | Yesa       | Suicide attempt                 | SBQ-R                 | Lifetime        | AMT            | - SA > PC: More specific autobiographical memories for both negative and positive cues |
| England                         |                                                                                            |            |                                |                       |                 |                |                                                                          |
| Crane et al. 2009               | Cross-sectional study - Inpatients SA with a major depressive disorder (n = 49; mean age: 36.6 y.o.; men: 34.7%) | NA         | ≥1 suicide attempts            | NA                    | Recent          | AMT            | - A significant association between (earlier) age of onset of childhood sexual abuse and increased over-general autobiographical memories. |
| England                         |                                                                                            |            |                                |                       |                 |                | - SA < PC: Worse specific autobiographical memories.                     |
| Arie et al. 2008                | Cross-sectional study - Inpatients with a psychiatric diagnosis (borderline personality disorder, anorexia nervosa, conduct disorder, mood disorder) | Yesabc     | Suicide attempt                 | SRC                   | Recent          | AMT            | - SA > PC, HC: More over-general autobiographical memories.             |
| Israel                          |                                                                                            |            |                                |                       |                 |                | - Association between generalized autobiographical memory, poor inter-personal problem solving and suicide attempter status. |

(Continued)
| Authors          | Study type and population                                                                 | Medication | Definition                        | Source of information | Period assessed     | Memory measure | Results                                                                 |
|------------------|-------------------------------------------------------------------------------------------|------------|----------------------------------|-----------------------|--------------------|----------------|------------------------------------------------------------------------|
| Rasmussen et al. 2008 (Rasmussen et al. 2008) Scotland | - Cross-sectional study<br>- Inpatients with a psychiatric diagnosis<br> ($n=40$; mean age 38 y.o.;<br> men: 42.5%)<br>  ○ First time SA ($n=17$)<br>  ○ Repetitive self-harmers SA ($n=23$) | NA         | Deliberate-Self Harm (DHS)       | SPS                   | Recent history of SA | AMT            | - More over-general autobiographical memories for positive cues only in repetitive DSH vs. first-timers DSH. |
| Sinclair et al. 2007 (Sinclair et al. 2007) England | - Cross-sectional study<br>- Inpatients SA with a current depressive episode ($n=68$; mean age: 37.3 y.o.;<br> men: 29%) | NA         | Deliberate-Self Harm (DHS)       | -Hospital data sources<br>-Clinical notes | Lifetime | AMT            | - Association between low memory specificity and DSH<br>- Low specificity memory mediates the association between childhood abuse and recent DSH<br>- No between differences<br>- Only those formerly depressed people with a history of suicidal ideation shifted in MEPs performance before and after a mood-induction procedure. |
| Williams and al. 2005 (Williams et al. 2005)         | - Cross-sectional study<br>- Outpatients with a history of major depressive disorder<br> ($n=19$; mean age: 42.9 y.o.;<br> men: 26.3%)<br>  ○ PC ($n=15$; mean age: 43.6 y.o.; men: 40%)<br>  - Healthy Controls ($n=22$; mean age: 49.6 y.o.; men: 40%) | NA         | Suicide ideation                 | BBSw                  | Lifetime | AMT            | - SA < HC: Worse specific autobiographical memories.<br>- SA > PC: More over-general autobiographical memories.<br>- No significant correlations between autobiographical memory and problem solving in SA or HC.<br>- Association between over-general autobiographical memories and fewer parasuicide acts. |
| Kaviani et al. 2005 (Kaviani et al. 2005) Iran        | - Cross-sectional study<br>- SA inpatients with a current depressive episode ($n=20$; mean age: 28.05 y.o.;<br> men: 40%)<br>  - Healthy Controls ($n=20$; mean age: 27.65 y.o.; men: 40%) | NA         | Suicide attempt                  | -Clinical notes       | Recent              | AMT            | - SA < HC: Worse specific autobiographical memories.<br>- SA > PC: More over-general autobiographical memories.<br>- No significant correlations between autobiographical memory and problem solving in SA or HC.<br>- Association between over-general autobiographical memories and fewer parasuicide acts. |
| Startup et al. 2001 (Startup et al. 2001) Wales       | - Cross-sectional study<br>- SA with a borderline personality disorder<br> ($n=23$; mean age: 31.1 y.o.;<br> men: 21.7%) | NA         | Suicide attempt                  | PHI                   | Recent (Previous 4 month) | AMT            | - SA < PC, HC: Worse specific autobiographical memories.<br>- SA > PC, HC: More over-general autobiographical memories.<br>- Significant correlations between autobiographical memory and problem solving in SA. |
| Pollock et al. 2001 (Pollock et al. 2001) Wales       | - Cross-sectional study<br>- Out- and Inpatients with a psychiatric diagnosis<br> ($n=24$; age range: 21 to 72 y.o.;<br> men: 42%)<br>  ○ PC ($n=24$; age range: 21 to 72 y.o.;<br> men: 42%)<br>  - Healthy Controls ($n=24$; age range: 21 to 72 y.o.; men: 42%) | NA         | Suicide attempt                  | NA                    | First-time suicide attempt | AMT            | - SA < PC, HC: Worse specific autobiographical memories.<br>- SA > PC, HC: More over-general autobiographical memories.<br>- Significant correlations between autobiographical memory and problem solving in SA. |
Table I. (Continued)

| Authors | Study type and population | Medication | Definition | Source of information | Period assessed | Memory measure | Results |
|---------|----------------------------|------------|------------|-----------------------|----------------|----------------|---------|
| Williams and al. 1996 (Williams et al. 1996) Wales | - Cross-sectional study - SA inpatients with a psychiatric diagnosis (major depressive disorder, minor depression, or no psychiatric diagnosis; \( n = 24; \) mean age: 34 y.o.; men: 33%) | NA | Suicide attempt | NA | Lifetime | AMT | - SA < PC, HC: Worse specific autobiographical memories. - SA > PC, HC: More over-general autobiographical memories. |
| Evans et al. 1992 (Evans et al. 1992) England | - Cross-sectional study - Inpatients with diagnosis of depressive disorder (\( n = 24 \)) \( \circ \) SA (\( n = 12; \) mean age: 38 y.o.; men: 50%) \( \circ \) PC (\( n = 12; \) mean age: 37 y.o.; men: 50%) | NA | Suicide attempt | NA | Recent history of SA | AMT | - SA < PC: Wors specific autobiographical memories. - SA > PC: More over-general autobiographical memories. - SA < PC: Fewer and less effective problem-solving strategies. |
| Williams and al. 1986 (Williams et al. 1986) England | - Cross-sectional study - Out- and Inpatients \( \circ \) SA with a psychiatric diagnosis, mainly MDD (\( n = 25; \) men: 32%) \( \circ \) PC (\( n = 25; \) men: 32%) \( \circ \) Healthy Controls (\( n = 25; \) men: 32%) | NA | Suicide attempt | NA | Recent history of SA | AMT | - SA < PC: worse specific autobiographical memory for positive cues only. |
| Working Memory Jollant et al. 2013 (Jollant et al. 2013) France | - Cross-sectional study - Normothymic patients with a mood disorder: \( \circ \) SA (\( n = 109; \) mean age: 36.4 y.o.; men: 36.1%) \( \circ \) PC (\( n = 59; \) mean age: 38.2 y.o.; men: 58.3%) \( \circ \) Healthy Controls (\( n = 61; \) mean age: 37.2 y.o.; men: 50%) | Yes<sup>b,c</sup> | Suicide attempt | SCID | Lifetime | Verbal working memory | - HC, AC < SA |

(Continued)
| Authors                  | Study type and population                                                                 | Medication | Definition                      | Source of information          | Period assessed | Memory measure | Results                                      |
|-------------------------|------------------------------------------------------------------------------------------|------------|---------------------------------|-------------------------------|----------------|----------------|----------------------------------------------|
| Keilp et al. 2013       | - Cross-sectional study                                                                    | NA         | Suicide attempt                 | - Colombia                     | Lifetime        | N-Back test     | SA > PC, HC: Worse performances.            |
| (Keilp et al. 2013) USA | - Patients with a current major depressive episode:                                        |            |                                 | Suicide History Scale          |                |                |                                              |
|                         |  o SA (n = 72; mean age: 35.7 y.o.; men: 36.1%)                                             |            |                                 | - SSI                         |                |                |                                              |
|                         |  o PC (n = 80; mean age: 40.1 y.o.; men: 47.5%)                                              |            |                                 |                               |                |                |                                              |
|                         | - Healthy Controls (n = 56; mean age: 31.5 y.o.; men: 50%)                                  |            |                                 |                               |                |                |                                              |
| Delaney et al. 2012     | - Cross-sectional study                                                                    | Yes<sup>a,b,c</sup> | Suicide attempt                 | SCID                          | Lifetime        | WMS-III        | - No-between group differences              |
| (Delaney et al. 2012) Ireland | - Outpatients (n = 310; aged from 18 to 65 years) with diagnosis of schizophrenia,          |            |                                 | Suicide ideations             | Current        | Letter-Number Sequencing task               |
|                         |  o Multiple SA (n = 37)                                                                    |            |                                 |                               |                | SWM            |                                              |
|                         |  o Single SA (n = 48)                                                                      |            |                                 |                               |                |                |                                              |
|                         |  o SI (n = 63)                                                                             |            |                                 |                               |                |                |                                              |
|                         |  o PC (n = 172)                                                                            |            |                                 |                               |                |                |                                              |
| Raust et al. 2007       | - Cross-sectional study                                                                    | Yes<sup>a,b,c</sup> | Suicide attempt                 | Recent history of SA           | N-Back Test     | Lifetime        | SA > HC: Worse performances                 |
| (Raust et al. 2007) France | - Inpatients with a bipolar or schizophrenia disorder:                                     |            |                                 |                               | (1, 2, and 3 back) |                |                                              |
|                         |  o SA (n = 30; mean age: 40 y.o.; men: 40%)                                                |            |                                 |                               |                |                |                                              |
|                         |  o Healthy Controls (n = 39; mean age: 44.6 y.o.; men: 54%)                                 |            |                                 |                               |                |                |                                              |
| Richard-Devantoy et al. 2012 | - Cross-sectional study                                                                    | Yes<sup>b,c</sup> | Suicide attempt                 | SSI                           | Lifetime        | Dual task of Baddeley | HC > SA                                      |
| (Richard-Devantoy et al. 2012) France | - Patients with a current major depressive episode:                                      |            |                                 |                               |                |                |                                              |
|                         |  o SA (n = 20; mean age: 77.1 y.o.; men: 35%)                                             |            |                                 |                               |                |                |                                              |
|                         |  o PC (n = 20; mean age: 75.9 y.o.; men: 40%)                                             |            |                                 |                               |                |                |                                              |
|                         |  o Healthy Controls (n = 20; mean age: 75.2 y.o.; men: 40%)                                |            |                                 |                               |                |                |                                              |
| Yen et al., 2008        | - Cross selected study                                                                     | Yes<sup>d</sup> | Suicide attempt                 | VASA                          | Previous year and current | WMS-III        | - No-between group differences              |
| (Yen et al. 2008) Taiwan | - Outpatients with a bipolar I disorder:                                                   |            |                                 |                               |                | working memory index |                                              |
|                         |  o SA/SI (n = 9; mean age: 34.8 y.o.; men: 66.7%)                                          |            |                                 |                               |                |                |                                              |
|                         |  o PC (n = 87; mean age: 41.4 y.o.; men 50.6%)                                            |            |                                 |                               |                |                |                                              |
| Authors                  | Study type and population                                                                 | Medication | Definition          | Source of information | Period assessed | Memory measure       | Results                          |
|-------------------------|------------------------------------------------------------------------------------------|------------|---------------------|-----------------------|-----------------|----------------------|----------------------------------|
| Westheide et al., 2008  | - Inpatients with a unipolar disorder:                                                     | No (14     | Suicide attempt     | SIS                   | In the last      | VLMT trial 1           | - No-between group differences   |
| Germany                 |   - SA with SI (n = 14; mean age: 34.3 y.o.)                                                 | patients)  |                     |                       | 3 month          |                      |
|                         |   - SA with no SI (n = 15; mean age: 40.4 y.o.)                                               |            | Suicide ideations   | SSI                   | Current          |                      |
|                         |   - Healthy Controls (n = 29; mean age: 39 y.o.)                                               |            |                     |                       |                 |
| Nangle et al., 2006     | - Cross-sectional study                                                                    | Yes        | Suicide attempt     | SCID                  | Lifetime         | N-Back Test (1 back or 2 back) | - No-between group differences. |
| Ireland                 |   - Outpatients with a diagnosis of schizophrenia                                           |            |                     |                       |                 |
|                         |     - SA (n = 28; mean age: 42 y.o.; men: 67.8%)                                               |            |                     |                       |                 |
|                         |     - PC (n = 50; mean age: 48.1 y.o.; men: 78%)                                               |            |                     |                       |                 |
|                         |   - Healthy Controls (n = 29; mean age: 39 y.o.)                                               |            |                     |                       |                 |
| Kim et al., 2003        | - Cross-sectional study                                                                    | No         | Suicide attempt     | SADS                  | Lifetime         | CTT                  | - SA > PC: Better performances.  |
| USA                     |   - In and Outpatients with schizophrenia (n = 333; mean age: 35.2 y.o. (18-65 years); men: 78%) |            |                     |                       |                 |
|                         |     - SA (n = 200; mean age: 35 y.o.; men: 78.5%)                                              |            |                     |                       |                 |
|                         |     - PC (n = 133; mean age: 35.4 y.o.; men: 77.4%)                                            |            |                     |                       |                 |
|                         |   - Patients tested n = 151; n = 93 SA, n = 58 PC.                                             |            |                     |                       |                 |
| Potkin et al., 2003     | - Prospective clinical trial (2 years)                                                      | Yes        | Suicide attempt     | CGI-SS                | Last 3 years     | Letter-Number Span     | - No-between group differences   |
| USA                     |   - Inpatients or outpatients (n = 188; mean age: 36.3 y.o.; men: 68%) with schizophrenia (n = 93) or schizoaffective disorders (n = 95): |            |                     |                       |                 |
|                         |     - SA (n = 69)                                                                              |            |                     |                       |                 |
|                         |     - PC (n = 52)                                                                              |            |                     |                       |                 |
| Short-Term Memory       | - Cross-sectional study                                                                      | Yes        | Suicide attempt     | SCID                  | Lifetime         | Verbal working memory  | - HC, AC < SA memory               |
| Jollant et al., 2013    |   - Normothymic patients with a mood disorder:                                               |            |                     |                       |                 |
| France                  |     - SA (n = 109; mean age: 36.4 y.o.; men: 36.1%)                                            |            |                     |                       |                 |
|                         |     - PC (n = 59; mean age: 38.2 y.o.; men: 58.3%)                                            |            |                     |                       |                 |
|                         |     - Healthy Controls (n = 61; mean age: 37.2 y.o.; men: 50%)                                |            |                     |                       |                 |

(Continued)
| Authors | Study type and population | Medication | Definition | Source of information | Period assessed | Memory measure | Results |
|---------|---------------------------|------------|------------|-----------------------|-----------------|----------------|---------|
| Keilp et al. 2013 (Keilp et al. 2013) USA | - Cross-sectional study - Patients with a current major depressive episode: ○ SA (n = 72; mean age: 35.7 y.o.; men: 36.1%) ○ PC (n = 80; mean age: 40.1 y.o.; men: 47.5%) - Healthy Controls (n = 56; mean age: 31.5 y.o.; men: 50%) | No | Suicide attempt | Colombia Suicide History Scale SSI | Lifetime | Buschke Selective Reminding Test | - SA > PC, HC: Worse performances |
| Gujral et al. 2013 (Gujral et al. 2012) USA | - Cross-sectional study - In and outpatients with a major depressive episode (Unipolar disorder): ○ SA (n = 83; mean age: 69.4 y.o.; 49% F) ○ SI (n = 43; mean age: 69.9 y.o.; 47% F) ○ PC (n = 54; mean age: 70.7 y.o.; 67% F) - Healthy Controls (n = 48; mean age: 69.1 y.o.; 48% F) | Yes | Suicide attempt | BLS | Lifetime | DRS-Memory | - No-between group differences |
| Delaney et al. 2012 (Delaney et al. 2012) Ireland | - Cross-sectional study - Outpatients (n = 310; aged from 18 to 65 years) with diagnosis of schizophrenia, schizoaffective disorder or schizophreniaform disorder: ○ Multiple SA (n = 37) ○ Single SA (n = 48) ○ SI (n = 63) ○ PC (n = 172) | Yes ab,c | Suicide attempt (lifetime) Suicide ideations (current) | SCID | Lifetime and current | WMS-III PAL | - No-between group differences except for better performances in SI vs. PC |
| Richard-Devantoy et al. 2012 (Richard-Devantoy et al. 2012) France | - Cross-sectional study - Inpatients with a major depressive episode: ○ SA (n = 20; mean age: 77.1 y.o.; 65% F) ○ PC (n = 20; mean age: 75.9 y.o.; 60% F) - Healthy Controls (n = 20; mean age: 75.2 y.o.; 60% F) | Yes ab,c | Suicide attempt | SSI | Lifetime Recent history of SA | Dual task of Baddeley | - HC > SA |

(Continued)
| Authors                          | Study type and population                                                                 | Medication | Definition      | Source of information | Period assessed | Memory measure | Results                                           |
|---------------------------------|------------------------------------------------------------------------------------------|------------|----------------|------------------------|----------------|----------------|---------------------------------------------------|
| McGirr et al. 2012 (McGirr et al. 2012) USA | Cross-sectional study  
- Inpatients with a major depressive episode (unipolar disorder):  
  ○ High-lethality SA (n = 14; mean age: 68.8 y.o.; men 50%)  
  ○ Low-lethality SA (n = 20; mean age: 66.8 y.o.; men: 50%)  
  ○ PC (n = 29; mean age: 70.2 y.o.; men: 36.7%)  
- Healthy Controls (n = 30; mean age: 69.7 y.o.; men: 53.3%) | Yes         | Suicide attempt | BLS SIS               | Lifetime         | DRS-Memory     | No-between group differences                     |
| Barrett et al., 2011 (Barrett et al. 2011) Norway | Cross-sectional study  
- Inpatients or outpatients (n = 174; aged from 18 to 65 years) with diagnosis of schizophrenia (n = 137), schizoaffective disorder (n = 26) or schizophreniform disorder (n = 11)  
  ○ SA (n = 53; mean age: 32.3 y.o.; men: 42%)  
  ○ PC (n = 121; mean age: 31.6 y.o.; men: 65%) | Yes<sup>a,b,c,d</sup> | Suicide attempt | SCID 1 IDS-C       | Lifetime         | CVLT-II       | No-between group differences                     |
| Martino et al. 2010 (Martino et al. 2010) Argentina | Cross-sectional study  
- Outpatients with a bipolar I and II disorder:  
  ○ SA (n = 22; mean age: 42.1 y.o.; men: 21.5%)  
  ○ PC (n = 63; mean age: 39.2 y.o.; men: 39.4%)  
- Healthy Controls (n = 34; mean age: 40 y.o.; men: 35.3%) | Yes<sup>d</sup> | Suicide attempt | -Semi-structured interview | Lifetime | Memory Battery of Signoret | No-between group differences  
  - HC > SA, PC                                    |
| Malloy-Diniz et al., 2009 (Malloy-Diniz et al. 2009) Brazil | Cross-sectional study  
- Outpatients with a bipolar I disorder:  
  ○ SA (n = 18; mean age: 41 y.o.; men: 33.3%)  
  ○ PC (n = 20; mean age: 75.9 y.o.; men: 47.6%)  
- Healthy Controls (n = 50; mean age: 36.9 y.o.; men: 34%) | Yes<sup>d</sup> | Suicide attempt | -Semi-structured interview -Medical records | Lifetime | RAVLT immediate recall | No-between group differences  
  - HC > SA, PC                                    |
| Authors                  | Study type and population                                                                 | Medication | Definition                          | Source of information | Period assessed        | Memory measure | Results                        |
|-------------------------|--------------------------------------------------------------------------------------------|------------|-------------------------------------|-----------------------|------------------------|----------------|--------------------------------|
| Yen et al., 2008        | Cross selected study: Outpatients with a bipolar I disorder:                                 | Yes<sup>d</sup> | Suicide attempt                      | VASA                  | Previous year and current | WMS-III        | - No-between group differences|
| (Yen et al. 2008)       | - SA/SI (n = 9; mean age: 34.8 y.o.; men: 66.7%)                                              |            |                                     |                       |                        | immediate      | index                          |
|                         | - PC (n = 87; mean age: 41.4 y.o.; men: 50.6%)                                                 |            |                                     |                       |                        | index          |                                |
| Westheide et al., 2008  | CROSS SELECTED STUDY: Inpatients with a unipolar disorder:                                   | No (14 patients) | Suicide attempt                      | SIS                   | In the last 3 month    | VLMT trial 1-5 | - No-between group differences |
| (Westheide et al. 2008) | - SA with SI (n = 14; mean age: 34.3 y.o.)                                                   | Yes<sup>b,c</sup> | Suicide ideations                    | SSI                   | Current               |                |                                |
|                         | - SA with no SI (n = 15; mean age: 40.4 y.o.)                                                 |            |                                     |                       |                        |                |                                |
|                         | - Healthy Controls (n = 29; mean age: 39 y.o.)                                                 |            |                                     |                       |                        |                |                                |
| Dombrovski et al. 2008  | In and outpatients with a major depressive episode (Unipolar disorder):                     | Yes<sup>b,c</sup> | Suicide attempt                      | SSI                   | In the last 3 month    | DRS-memory       | - SA/SI < PC: Worse performances |
| (Dombrovski et al. 2008) | - SA/SI (n = 32; mean age: 70.2 y.o.; men: 47%; 100% hospitalized)                           |            |                                     |                       |                        | Current         |                                |
|                         | - PC (n = 32; mean age: 71.5 y.o.; men: 48%; 47% hospitalized)                                |            |                                     |                       |                        |                |                                |
| Nangle et al., 2006     | Cross-sectional study: Outpatients with a diagnosis of schizophrenia                         | Yes<sup>a</sup> | Suicide attempt                      | SCID                  | Lifetime               | N-Back Test (0-Back) | - SA > PC: Better performances |
| (Nangle et al. 2006)    | - SA (n = 28; mean age: 42 y.o.; men: 67.8%)                                                  |            |                                     |                       |                        |                 |                                |
|                         | - PC (n = 50; mean age: 48.1 y.o.; men: 78%)                                                   |            |                                     |                       |                        |                 |                                |
| Kim et al., 2003        | Cross-sectional study; Inpatients and outpatients                                            | No         | Suicide attempt                      | SADS                  | Lifetime               | VLL Immediate recall | - SA > PC: Better performances |
| (Kim et al. 2003)       | - Schizophrenia (n = 333; mean age: 35.2 y.o. (18-65 years); men: 78%)                       |            |                                     |                       |                        |                 |                                |
|                         | - SA (n = 200; mean age: 35 y.o.; men: 78.5%)                                                  |            |                                     |                       |                        |                 |                                |
|                         | - PC (n = 133; mean age: 35.4 y.o.; men: 77.4%)                                                |            |                                     |                       |                        |                 |                                |

*Patients tested n = 151: n = 93 SA, n = 58 PC.*
Table I. (Continued)

| Authors                      | Study type and population                                                                 | Medication | Definition                        | Source of information | Period assessed | Memory measure          | Results                                      |
|------------------------------|--------------------------------------------------------------------------------------------|------------|-----------------------------------|-----------------------|-----------------|--------------------------|---------------------------------------------|
| Potkin et al., 2003          | Prospective clinical trial (2 years)                                                         | Yes*       | Suicide attempt                    | CGI-SS                | Last 3 years      | RAVLT Immediate recall   | - No-between group differences              |
| (Potkin et al. 2003)         | Inpatients or outpatients (n=188; mean age: 36.3 y.o.; men: 68%) with diagnosis of schizophrenia (n=93) or schizoaffective disorder (n=95): |            | Suicide ideations                  | ISST                  | Current          |                          |                                             |
|                              | - SA (n=69)                                                                                |            |                                   |                       |                 |                          |                                             |
|                              | - PC (n=52)                                                                                |            |                                   |                       |                 |                          |                                             |
| Keilp et al., 2001           | Cross-sectional study                                                                      | No         | - Suicide attempt (history)        | Colombia Suicide     | Lifetime         | WMS-III Buschke Selective Reminding Test (total recall and delayed recall) | - HLSA<HC                                   |
| (Keilp et al. 2001)          | Inpatients and outpatients with a current major depressive episode (n=50, 38 unipolar disorders, 12 bipolar disorders): |            | - Intensity (mild and severe)      | Suicide History Scale | Lifetime         |                          | - HLSA< LLSA, PC, HC                       |
|                              | - High-lethality SA (n=15; mean age: 42.5 y.o.; men: 40%)                                   |            |                                   | - SSI                |                 |                          |                                             |
|                              | - Low-lethality SA (n=14; mean age: 34 y.o.; men: 36%)                                       |            |                                   |                      |                 |                          |                                             |
|                              | - PC (n=21; mean age: 41 y.o.; men: 57%)                                                    |            |                                   |                      |                 |                          |                                             |
|                              | - Healthy Controls (n=22; mean age: 41 y.o.; men: 64%)                                       |            |                                   |                      |                 |                          |                                             |
| Keilp et al. 2013            | Cross-sectional study                                                                      | No         | Suicide attempt                    | Colombia Suicide     | Lifetime         | Buschke Selective Reminding Test                      | - SA > PC, HC: Worse performances          |
| (Keilp et al. 2013)          | Patients with a current major depressive episode:                                           |            |                                   | History Scale        |                 |                          |                                             |
|                              | - SA (n=72; mean age: 35.7 y.o.; men: 36.1%)                                                |            |                                   | - SSI                |                 |                          |                                             |
|                              | - PC (n=80; mean age: 40.1 y.o.; men: 47.5%)                                                |            |                                   |                      |                 |                          |                                             |
|                              | - Healthy Controls (n=56; mean age: 31.5 y.o.; men: 50%)                                     |            |                                   |                      |                 |                          |                                             |
| Martino et al. 2010          | Cross-sectional study                                                                      | Yes*       | Suicide attempt                    | Semi-structured      | Lifetime         | Memory Battery of Signoret                             | - No-between group differences              |
| (Martino et al. 2010)        | Outpatients with a bipolar I and II disorder:                                               |            |                                   | interview            |                 |                          | - HC > SA, PC                             |
|                              | - SA (n=22; mean age: 42.1 y.o.; men: 21.5%)                                                |            |                                   |                      |                 |                          |                                             |
|                              | - PC (n=63; mean age: 39.2 y.o.; men: 39.4%)                                                |            |                                   |                      |                 |                          |                                             |
|                              | - Healthy Controls (n=34; mean age: 40 y.o.; men: 35.3%)                                     |            |                                   |                      |                 |                          |                                             |

(Continued)
### Table I. (Continued)

| Authors                        | Study type and population | Medication | Suicidal behaviour         | Source of information | Period assessed | Memory measure | Results                                      |
|--------------------------------|---------------------------|------------|----------------------------|-----------------------|-----------------|----------------|----------------------------------------------|
| Westheide et al., 2008 (Westheide et al. 2008) Germany | Cross selected study - Inpatients with a unipolar disorder:  
  - SA with SI ($n = 14$; mean age: 34.3 y.o.)  
  - SA with no SI ($n = 15$; mean age: 40.4 y.o.)  
  - Healthy Controls ($n = 29$; mean age: 39 y.o.) | No (14 patients) Yes | Suicide attempt          | SIS                  | In the last 3 month | VLMT trial 7 | - No-between group differences |
| Nangle et al., 2006 (Nangle et al. 2006) Ireland | Cross-sectional study - Outpatients with a diagnosis of schizophrenia  
  - SA ($n = 28$; mean age: 42 y.o.; men: 67.8%)  
  - PC ($n = 50$; mean age: 48.1 y.o.; men: 78%) | Yes | SSI Suicide attempt | SCID | Lifetime | WMS-III | - No-between group differences |
| Potkin et al., 2003 (Potkin et al. 2003) USA | Prospective clinical trial (2 years) - Inpatients or outpatients ($n = 188$; mean age: 36.3 y.o.; men: 68%) with diagnosis of schizophrenia ($n = 93$) or schizoaffective disorder ($n = 95$):  
  - SA ($n = 69$)  
  - PC ($n = 52$) | Yes | Suicide attempt | CGI-SS | Last 3 years | RAVLT delayed recall | - SA > PC: Better performances |
| Kim et al., 2003 (Kim et al. 2003) USA | Cross-sectional study; Inpatients and outpatients  
  - Schizophrenia ($n = 333$; mean age: 35.2 y.o. (18-65 years); men: 78%)  
  - SA ($n = 200$; mean age: 35 y.o.; men: 78.5%)  
  - PC ($n = 133$; mean age: 35.4 y.o.; men: 77.4%) | No | Suicide attempt | SADS | Lifetime | VLL Delayed recall | - SA > PC: Better performances |

*Patients tested $n = 151$: $n = 93$ SA, $n = 58$ PC.*
| Authors       | Study type and population                                                                 | Medication | Definition               | Source of information    | Period assessed | Memory measure | Results          |
|---------------|------------------------------------------------------------------------------------------|------------|--------------------------|--------------------------|-----------------|----------------|-----------------|
| Keilp et al., 2001 (Keilp et al. 2001) USA | - Cross-sectional study<br>- Inpatients and outpatients with a current major depressive episode (n = 50, 38 unipolar disorders, 12 bipolar disorders):  ○ High-lethality SA (n = 15; mean age: 42.5 y.o.; men: 40%)  ○ Low-lethality SA (n = 14; mean age: 34 y.o.; men: 36%)  ○ PC (n = 21; mean age: 41 y.o.; men: 57%)  - Healthy Controls (n = 22; mean age: 41 y.o.; men: 64%) | No          | - Suicide attempt (history)  - Intensity (mild and severe) | - Colombia Suicide History Scale  - SSI | Lifetime | WMS-III Buschke Selective Reminding | - HLA-SA < HC  - HLA-SA < LSSA, PC, HC |

AMT, Autobiographical Memory Test (Williams et al. 1986); BBSw, Beck Scale for Suicide Ideation; BLS, Beck Lethality Scale; CANTAB, Cambridge Automated Test Battery; CANTAB Spatial Working Memory (SWM) subtest; CGI-SS, Clinical Global Impression of Severity of Suicidality; CTT, Consonant Trigram Test; CVLT-II, California Verbal Learning Task; DRS, Dementia-Rating Scale; IDS-C, Inventory of Depressive Symptoms–Clinician rated; ISST, InterSePT Scale for Suicidal Thinking (Lindenmayer et al. 2003); PAL, Paired Associate Learned; PHI, Parasuicidal History Interview; RAVLT, Rey Auditory Verbal Learning Test; SADS, Schedule for Affective and Schizophrenia Disorder; SASII, Suicide Attempt Self-Injury Interview; SBQ-R, Revised Suicidal Behaviours Questionnaire (Osman et al. 2001); SCID, Structured Clinical Interview for DSM-IV Axis I disorders; SPS, Suicide Probability Scale; SRC, Suicide Risk Scale (Putchik et al. 1989); SSI, Suicide Intent Scale; VASA, Violence and Suicide Assessment Scale; VLL, Verbal List Learning; VLMT, Verbaler Lern- und Merkfähigkeitstest; WMS-III Letter-Number Sequencing task; WMS-III, Wechsler Memory Scale 3rd Edition.

SA, Suicide attempters (i.e. patients with a history of suicide attempt); PC, Patient Controls (i.e. patients with no history of suicide attempt).

NA, Non-Available.

*Antipsychotic medication. *Antidepressant medication. *Anxiolytic medication. *Mood Stabilizers (lithium, valproic acid, or carbamazepine).
Table II. Studies included in the meta-analysis.

| Study                  | N  | Age± SD (years) | Males (%) | Depression score± SD|  | N  | Age± SD (years) | Males (%) | Depression score± SD|  | N  | Age± SD (years) | Males (%) | Memory type                  |
|------------------------|----|-----------------|-----------|---------------------|  |    |               |           |                     |  |    |               |           |                                |
| Arie et al. 2008       | 25 | 16.5 ± 2.5      | 44        | *                   |  | 25 | 16.5 ± 2.5      | 40        | *                   |  | 25 | 16.6 ± 2.3      | 48        | Autobiographical memory       |
| Barrett et al. 1990    | 53 | 32.3 ± 10.2     | 42        | 2.8 ± 1.6a          |  | 121| 31.6 ± 9.6      | 65        | 2.5 ± 1.4a          |  | 8  | 28.0 ± 100      | 100       | Short-term memory             |
| Delanay et al. 2012    | 48 | 70.2 ± 9        | *         | *                   |  | 172| 71.5 ± 7.1      | 38        | 20.3 ± 3.4b         |  | 12 | 37 ± 50         | *         | Short-term memory, working memory |
| Dombrowski et al. 2008 | 32 | 38              | 50        | *                   |  | 12 | 37 ± 50         | *         | AutoBiographical memory   |  | 8  | 37 ± 50         | *         | Short-term memory             |
| Evans et al. 1992      | 12 | 38              | 50        | *                   |  | 12 | 37 ± 50         | *         | AutoBiographical memory   |  | 8  | 37 ± 50         | *         | Short-term memory             |
| Gurj et al. 2013       | 83 | 69.4 ± 8.8      | 51        | 22.7 ± 5.8b         |  | 54 | 70.7 ± 8.4      | 33        | 18.7 ± 3.9b         |  | 8  | 37 ± 50         | *         | AutoBiographical memory       |
| Jollent et al. 2013    | 151| 39.9 ± 12.1     | 36.4      | *                   |  | 81 | 38.2 ± 11.3     | 38.3      | *                   |  | 144| 37.2 ± 11.1     | 50        | Short-term memory, working memory |
| Kaviani et al. 2005    | 20 | 28.05           | 40        | 36.3                |  | 20 | 27.6 ± 40       | *         | AutoBiographical memory   |  | 58 | 36.9 ± 9.8      | 33.3      | Short-term memory             |
| Keilp et al. 2001      | 29 | 38.5 ± 10.6     | 37.8      | 29.3 ± 5.2b         |  | 21 | 41 ± 10.9       | 57.1      | 27.5 ± 6.4b         |  | 22 | 41.2 ± 16.8     | 63.6      | Short and long term memory, working memory |
| Keilp et al. 2013      | 72 | 35.7 ± 11.6     | 36        | 25.7 ± 7.3b         |  | 80 | 40.1 ± 11.9     | 47.5      | 25.6 ± 7.4b         |  | 56 | 31.5 ± 11.1     | 50        | Short and long term memory, working memory |
| Kim et al. 2003        | 93 | *               | *         | *                   |  | 8  | 37 ± 50         | *         | Short-term memory, working memory   |  | 8  | 37 ± 50         | *         | Short-term memory             |
| Malloy-Diniz et al. 2009 | 18 | 41 ± 13.3       | 33.3      | 9.6 ± 5.1c          |  | 21 | 40.8 ± 12.6     | 47.6      | 8.0 ± 4.3c          |  | 50 | 36.9 ± 9.8      | 33.3      | Short and long term memory     |
| Martino et al. 2010    | 22 | 42.1 ± 10.6     | 21.5      | 2.4 ± 1.0b          |  | 63 | 39.2 ± 10.8     | 39.4      | 2.0 ± 2.0b          |  | 34 | 40.1 ± 12.9     | 35.3      | Short and long term memory     |
| Maurex et al. 2010     | 47 | 30.5 ± 8.1      | 0         | 28.8 ± 16.1d        |  | 50 | 48.1 ± 8.1     | 78        | *                   |  | 30 | 25.5 ± 10       | 0         | Short-term memory              |
| McGirr et al. 2011     | 34 | 67.8 ± 7.8      50 | 22.3 ± 5.2b | 29 | 70.3 ± 9.0 | 34.4 | 19.85 ± 3.6b | 30 | 69.7 ± 6.8 | 53.3 | Short-term memory          |
| Nangle et al. 2006     | 28 | 42 ± 10         | 68        | *                   |  | 50 | 48.1 ± 8.1     | 78        | *                   |  | 16 | 39.4 ± 12.7     | 62.5      | Short and long term memory, working memory |
| Petterson et al. 2010  | 16 | 32.3 ± 9        | 75        | 5.88 ± 3.9a         |  | 16 | 39.4 ± 12.7     | 62.5      | 5.06 ± 2.8a         |  | 24 | 42 *           | 17.7 ± 9.6 | AutoBiographical memory        |
| Pollock et al. 2001    | 24 | 42             | 29.2 ± 9.2c | 24 | *           | 42 | 17.7 ± 9.6     | 24 | *           | 42 | AutoBiographical memory        |
| Potkin et al. 2003     | 69 | *              | *         | *                   |  | 52 | *              | *         | *                   |  | 69 | *              | *         | Working memory                  |
| Raust et al. 2007      | 30 | 39.8 ± 13.6     | 40        | 3.6 ± 2.8d          |  | 39 | 44.6 ± 12.4     | 54        | *                   |  | 39 | 39 ± 10.9       | *         | Short and long term memory, working memory |
| Richard-Devantoy et al. | 20 | 71.7 ± 7.2     | 45        | 27.7 ± 3.5a         |  | 20 | 75.9 ± 6.7     | 40        | 28.3 ± 2.4a         |  | 20 | 75.2 ± 3.4      | 40        | Short-term memory, working memory |
| Westheide et al. 2008   | 29 | 37.3 ± 11       | *         | 15 ± 1f             |  | 29 | 39 ± 10.9       | *         | Short and long term memory, working memory |
| Williams et al. 1996   | 24 | 34 ± 12        | 33        | 27.9 ± 10.8c        |  | 24 | 34 ± 12        | 37.5      | 7 ± 4.3c            |  | 24 | 34 ± 12        | 33.3      | Short-term memory              |
| Yen et al. 2008        | 34 | 48 ± 8.3       | 66.7      | *                   |  | 87 | 41.4 ± 12.9     | 50.6      | *                   |  | 87 | 41.4 ± 12.9     | 50.6      | Short and long term memory, working memory |

#Depression scores come from different scales and, therefore, cannot be directly compared across studies: HCSDC: Calgary Depression of Schizophrenia Scale; HAD-D: Hamilton Depression Scale; BDII: Beck Depression Inventory; KABOSS: Karolinska Affective and Borderline Symptoms Scale; POMS: Profile of Mood States.

bMADRS: Montgomery-Asberg Depression Rating Scale.

Data No Available.
Table III. Effects sizes for the contrasts between suicide attempters, patient controls and healthy controls for the 5 memory domain performances. (Hedges et al. 1985). The obtained effect sizes are usually considered small if $<0.3$, moderate if comprised between 0.3 and 0.8, and large if $>0.8$ (Egger et al. 2001).

Heterogeneity was assessed using the $Q$ statistics and the $I^2$ index (Cooper et al. 2009). Values of $P<0.10$ for the former and $>35\%$ for the latter were deemed as indicative of study heterogeneity. Finally, we used Funnel Plots, Rosenthal's Fail-Safe N (Rosenthal 1979) and Egger's Regression Intercept (Egger et al. 1997) to test for the presence of publication bias (Cooper et al. 2009).

**Results**

**Systematic review**

Table I summarizes the 31 studies included in the systematic literature review. The design of all identified studies was cross-sectional, except for one prospective study (Potkin et al. 2003). Ages ranged from 13 to 86 and the rate of men ranged from 0 to 85%. Main co-morbid disorders were mood disorders (both bipolar and depressive disorders) (Williams et al. 1986; Evans et al. 1992; Keilp et al. 2001, 2013; Kaviani et al. 2005; Williams et al. 2005; Sinclair et al. 2007; Dombrovski et al. 2008; Westheide et al. 2008; Yen et al. 2008; Crane et al. 2009; Malloy-Diniz et al. 2009; Martino et al. 2010; Gujral et al. 2012; McGirr et al. 2012; Richard-Devantoy et al. 2012; Jollant et al. 2013), schizophrenia or schizoaffective disorders (Kim et al. 2003; Potkin et al. 2003; Nangle et al. 2006; Pettersen et al. 2010; Taylor et al. 2010; Barrett et al. 2011; Delaney et al. 2012), borderline personality disorder (Startup et al. 2001; Maurex et al. 2010), or various psychiatric disorders (Williams et al. 1996; Pollock et al. 2004; Arie et al. 2008; Rasmussen et al. 2008).

Autobiographical memory was only tested with the Autobiographical Memory Test (AMT; Williams et al. 1986). In the AMT, five positive words (happy, safe, interested, successful, and surprised) and five negative words (sorry, angry, clumsy, hurt (emotional), and lonely) are successively presented to the participant. Subjects are given 1 min to produce a specific personal memory in response to each word. Responses are usually audio-recorded. The specificity of the memories is then determined on the basis of details given to describe the event (Williams et al. 1986).

Working memory was assessed with six different tests (i.e., N-Back Task, Dual-task of Baddeley, CANTAB Spatial Working Memory, Consonant Trigram Test, WMS-III Letter–Number Sequencing task; Wechsler Memory Scale 3rd Edition), short-term memory with 11 different tests (Buscke selective scores and depression ratings were computed (Hedges et al. 1985). The obtained effect sizes are usually considered small if $<0.3$, moderate if comprised between 0.3 and 0.8, and large if $>0.8$ (Egger et al. 2001).
reminding test, Dementia-Rating Scale, Wechsler Memory Scale 3rd Edition immediate memory index, dual task of Baddeley, California Verbal Learning Task-II, memory battery of Signoret, Rey Auditory Verbal Learning Test immediate recall, Paired Associate Learned, Verbal List Learning immediate recall, Verbaler Lern- and Merkfähigkeitstest trial 1-5, N-Back test 0 back), and long-term memory with five different tests (memory battery of Signoret, Verbaler Lern- and Merkfähigkeitstest trial 7, Wechsler Memory Scale 3rd Edition, Rey Auditory Verbal Learning Test delayed recall, and Verbal List Learning delay recall). Overall, main findings were:

1. Among 14 studies, eight reported less specific and more general autobiographical memories in suicide attempters compared to patient (Williams et al. 1986, 1996; Pollock et al. 2004; Kaviani et al. 2005; Arie et al. 2008; Pettersen et al. 2010) and healthy controls (Williams et al. 1996; Pollock et al. 2004; Kaviani et al. 2005, Arie et al. 2008, Maurex et al. 2010), across different age and diagnosis groups. One study in psychosis reported the opposite results (Taylor et al. 2010), and one study reported no between-group difference (Williams et al. 2005). Finally, four studies reported a significant association between poor performance in autobiographical memory and a higher number of suicide attempts (Startup et al. 2001; Sinclair et al. 2007; Rasmussen et al. 2008; Crane et al. 2009), especially in those with an early age of onset of history of childhood abuse (Crane et al. 2009).

2. Among 10 studies on working memory, no difference between suicide attempters and patient controls were found in five studies. Four studies reported worse performances in suicide attempters with mood disorder (Rast et al. 2007; Richard-Devantoy et al. 2012; Jollant et al. 2013; Keilp et al. 2013). One study (Keilp et al. 2013) found high-lethality attempters to outperform low-lethality attempters although it is not clear if this result is a true positive result, if this is related to the high frequency of violent attempters in the low-lethality group, or to a sampling bias. One study reported better performance in suicide attempters with schizophrenia (Kim et al. 2003) relative to patient controls.

3. No between group differences in short-term memory were found in 10 studies, but two studies in schizophrenia found better performances in suicide attempters compared to patient controls (Kim et al. 2003; Nangle et al. 2006) and three studies in mood disorders found worse performance in suicide attempters, especially in high-lethality attempters (Keilp et al. 2001, 2013).

4. Similarly, three studies found no between group differences in long-term memory, but two studies in schizophrenia found better performances in suicide attempters compared to patient controls (Kim et al. 2003; Potkin et al. 2003), and two studies in mood disorders found worse performance in suicide attempters, especially in high-lethality attempters (Keilp et al. 2001, 2013).

Meta-analysis

A total of 24 studies were included (Table II), comprising 2,595 participants, of whom 984 were suicide attempters (mean age = 40.8 ± 10.0 years; 43.5 % males), 942 were patient controls (40.1 ± 9.4 years; 46.9 % males), and 669 were healthy controls (41.8 ± 8.6 years; 44.1 % males). Table III presents the results of the contrasts between the three groups for the five variables, and Table IV provides a summary of the main findings. Detailed information on heterogeneity and publication bias can be found in the Table in the Supplemental Data available online at http://informahealthcare.com/doi/abs/10.3109/15622975.2014.925584.

Suicide attempters vs. patient controls

Suicide attempters had significantly less specific and more general autobiographical memories than patient controls (Figure 2, A & B), all representing high effect sizes. The Fail-Safe N, i.e., the number of unpublished or missing null-findings that would be needed to render the results non-significant, was 18 for the general autobiographical memory and 26 for the specific autobiographical memory. Depression level did not differ between the two groups, thus ruling out depression intensity as a confounding factor.

Besides, suicide attempters had significantly worse performances than patient controls in working memory but not short- and long-term memory (Figure 2, C, D, and E). Heterogeneity exceeded that expected by chance at $P<0.05$ for working memory and short- and long-term memory implying that the variance among the effect sizes was greater than expected by sampling error (table in Supplemental Data available online at http://informahealthcare.com/doi/abs/10.3109/15622975.2014.925584). Three studies
Suicidal behaviour and memory

(Richard-Devantoy et al. 2012; Jollant et al. 2013; Keilp et al. 2013) were likely responsible for the heterogeneity related to working memory. After excluding these studies, the heterogeneity disappeared, and results remained significant. No specific study explained the heterogeneity related to the short-term memory analyses. Between-group difference in long-term memory became significant after excluding the two studies responsible for the heterogeneity (Keilp 2001, 2013). The Funnel Plots were reasonably symmetrical for all types of memory, suggesting a low risk of publication bias. Moreover, the more conservative Egger’s regression intercept suggested no publication bias.

**Suicide attempters vs. healthy controls**

Suicide attempters had significantly more general and less specific autobiographical memories, and worse working memory and short-term memory performance than healthy controls. The Fail-Safe N was, respectively, 63, 171, 142, and 40.

Heterogeneity exceeded that expected by chance for all domains. One study (Maurex et al. 2010) was likely responsible for the heterogeneity related to the general autobiographical memory performance. After excluding this study, results became not significant, and the associated Funnel Plots were reasonably symmetrical. Egger’s regression intercept test suggested no publication bias. Two studies (Williams et al. 1996; Maurex et al. 2010) were likely responsible for the heterogeneity related to the specific autobiographical memory. After excluding these studies, results remained significant. Three studies (Richard-Devantoy et al. 2012; Jollant et al. 2013; Keilp et al. 2013) were likely responsible for the heterogeneity related to the short-term memory performances, and one study (Kim et al. 2003) for the heterogeneity related to the long-term memory performances. After excluding these studies, results remained significant, funnel Plots were reasonably symmetrical. Egger’s regression intercept test suggested no publication bias.

**Patient controls vs. healthy controls**

Patient controls had significantly more general autobiographical memory, and worse working memory, and short- and long-term memory than healthy controls. The Fail-Safe N could not be calculated for general autobiographical memory due to the small number of studies available. It was 8, 77, and 29, respectively, for the other memory domains.

Heterogeneity exceeded that expected by chance for four domains. Two studies (Williams et al. 1996; Maurex et al. 2010) were likely responsible for the heterogeneity related to the specific autobiographical memories performance. After excluding these studies, results became significant. Two studies (Malloy-Diniz et al. 2009; Richard-Devantoy et al. 2012) were likely responsible for the heterogeneity related to short-term memory performance. After excluding these studies, results remained significant. Two studies (Martino et al. 2010; Richard-Devantoy et al. 2012) were likely responsible for heterogeneity related to the long-term memory and the working memory, respectively. After excluding these studies, results remained significant.

**Discussion**

To our knowledge, this is the first meta-analysis on mnesic functions associated with the vulnerability to suicidal behaviour. Overall, three domains (i.e., autobiographical memory reported as being over-general and less specific; long-term memory and working memory) were found to be altered in suicide attempters vs. patient controls, and in patient controls vs. healthy controls suggesting greater alterations in those with a vulnerability to suicidal behaviour than in those with co-morbid disorders but no history of suicidality. One domain (short-term memory) was only altered in the comparison between patient control groups and healthy controls suggesting that impairment in this domain is mostly related to co-morbid disorders (in this case, mainly major depression). Finally, no memory alteration was found to be specifically associated with the vulnerability to suicidal behaviour (i.e., in the contrast between suicide attempters and both patient and healthy control groups, but not between patient and healthy controls).

Some limitations of this meta-analysis need to be highlighted. First, studies included in this review examined various populations in terms of socio-demographic and/or clinical variables. Most studies examined middle-aged samples, although some focused on elderly participants. Some studies were only conducted in males while most included both genders. Diagnoses varied from bipolar disorder, major depressive disorder (or a combination of both subtypes of mood disorder), to schizophrenia and borderline personality disorder. Also, some studies were conducted in patients who were acutely depressed, while others focused on those in remission. Furthermore, participants in some studies were on medica-
Figure 2. Comparison of General (A) and Specific (B) Autobiographical Memories, (C) Working Memory, (D) Short-Term Memory, (E) and Long-Term Memory between Suicide Attempters and Patient Controls.
tion while in other studies they were not. Moreover, it was not possible to separate memory function from low and high lethality suicide attempters, and from violent and non-violent suicide attempters, because too few studies distinguished these groups. Of note, we were able to rule out the effects of several variables (including, for example, the intensity of depressive symptoms, age, and gender). Meta-analyses have often been criticized for combining heterogeneous studies, for their potential of publication bias, and for the inclusion of poor-quality trials. In the present study, however, these concerns were addressed by the objective examination of both publication bias and heterogeneity. An additional limitation is the small number of studies in some analyses, notably on autobiographical memory, and this may have caused an artificially high effect size (Button et al. 2013). One final limitation is the combined analysis of multiple tasks with the assumption that they measure the same core component of cognition. This may partly explain the heterogeneity observed in several contrasts.

Keeping these limitations in mind, our findings suggest that a set of memory deficits may be in play in the suicidal crisis with some deficits being more particularly involved in facilitating the suicidal act. This is notably the case of autobiographical and long-term memory, two types of memory associated with past experiences. Reduced specificity of autobiographical memory may serve an adaptive function (Raes et al. 2006), limiting access to negative affects and distress associated with some recollections (Williams et al. 2007). For instance, over-general memory has been associated with a history of trauma and abuse (Williams et al. 2007), a significant risk factor for suicidal acts. However, a higher tendency for more general memory retrieval at the expense of specificity, combined with decreased long-term memory efficiency, may also prevent these individuals from accessing various stored material acquired with experience. In addition, literature suggests that the neural system implicated in imagining the future overlap with the one involved in episodic memory (Addis et al. 2007). Reduced memory for long-term experiences may therefore impact the ability both to solve problems (Evans et al. 1992; Pollock et al. 2001) and to see beyond a problem to form a long-term perspective. Consequently, this may lead to a feeling of entrapment and hopelessness combined with the continuation of the problem.

One brain structure associated with both long-term memory deficits and suicide diathesis may be the hippocampus. Theory of hippocampal function operates as a single auto-association network to enable rapid associations between any spatial location and a reward, and then to provide for recalling memory from any part (Rolls 2013). Furthermore, future event construction, as discussed above, uniquely engaged the right hippocampus, possibly as a response to the novelty of these events (Addis et al. 2007). Hippocampus is also a major inhibitor of the hypothalamic–pituitary axis that underlies the glucocorticoid stress system. Regarding suicidal behaviour, post-mortem studies revealed several biochemical alterations in the hippocampus of suicide completers (Labonté et al. 2013). Notably, childhood adversity was associated with epigenetic alterations affecting the glucocorticoid receptor expression in hippocampal neurons (McGowan et al. 2009) suggesting developmental impairments. Dysregulation of the glucocorticoid system has been reported in suicide attempters and predicts future suicide (Coryell et al. 2001), a dysfunction that may be related to hippocampal alterations. In turn, deactivation of the hippocampus has been correlated with the release of

---

### Table IV. Summary of findings.

| Memory domains                  | Suicide attempters vs Patient Controls | Suicide Attempters vs Healthy Controls | Patient Controls vs Healthy Controls |
|---------------------------------|---------------------------------------|---------------------------------------|-------------------------------------|
| Alterations specifically associated to suicidal behaviour              |                                       |                                       |                                     |
| Greater alterations in suicidal behaviour than in mood disorder           |                                       |                                       |                                     |
| General autobiographical memory                                          | +++                                   | [++]                                  | +++                                 |
| Specific autobiographical memory                                          | +++                                   | +++                                   | (+++)                               |
| Long term memory                                                           | (+++)                                 | +++                                   | +++                                 |
| Working memory                                                             | ++                                    | +++                                   | +++                                 |
| Alterations specifically related to mood disorder                         |                                       |                                       |                                     |
| Short term memory                                                          | +++                                   | +++                                   | +++                                 |

+ $P<0.05$; ++ $P<0.01$; +++ $P<0.001$.
(+) contrast became significant after excluding studies responsible for heterogeneity.
[+] contrast became non-significant after excluding studies responsible for heterogeneity.
cortisol in response to stress (Pruessner et al. 2008). In vivo, recall of suicide action through scripts was associated with increased activity in the hippocampus of suicide attempters (Reisch et al. 2010) while less activation at rest was found in the right parahippocampal gyrus of suicide attempters compared to patient controls (Reisch et al. 2010; Wagner et al. 2012; Fan et al. 2013). Decreased volume of the right parahippocampal gyrus was additionally found in high- vs. low-lethality suicide attempters with borderline personality disorder (Soloff et al. 2012). Hippocampus may therefore be implicated in several long-term memory deficits and, indirectly, in the high sensitivity to stress in patients at-risk for suicide.

We also found that working memory was altered in suicide attempters compared to patient controls, in both verbal and visual–spatial tasks (Keilp et al. 2013). According to Baddeley (1992), working memory involves executive control and visuospatial skills, which manipulates visual images, and phonological loop, enabling to store and rehearse speech-based information. We have recently shown that, in suicide attempters, working memory deficits were negatively correlated with cognitive inhibition (Richard-Devantoy et al. 2013). Although working memory deficits may also impact decision-making performance (Bechara et al. 1998), we did not confirm this association in suicide attempters (Richard-Devantoy et al. 2013). Thus, deficits in working memory may particularly impact functions implicated in executive control in suicide attempters.

Interestingly, memory in suicide attempters may play an opposite role in major depression and in schizophrenia. In major depression, suicide attempters had greater memory impairment compared to patient controls, whereas the opposite was found in schizophrenia. Similar findings have been reported in other cognitive domains. Suicide attempters with schizophrenia tended to outperform non-attempters in executive functioning, namely attention and verbal fluency (Nangle et al. 2006), and cognitive flexibility (Kim et al. 2003; Nangle et al. 2006), whereas depressed suicide attempters had worse executive performance compared to patients without such a history (Richard-Devantoy et al. 2013). Similarly, low IQ has been associated with suicidal behaviour (Sorberg et al. 2013), but high IQ was associated with suicidal behaviour in psychosis (Batty et al. 2010). Hence, contrary to the transosnographic model of suicidal behaviour favoured so far and supported by clinical and biochemical studies (Mann 2003), neuropsychological studies suggest potentially different mechanisms between mood and psychotic disorders. One hypothesis could be that these improved cognitions increase insight, a significant risk factor for suicide in schizophrenia (Lopez-Morinigo et al. 2012). More investigation is definitely needed to clarify this issue.

Conclusion

Our findings, although limited by several shortcomings, suggest that memory deficits may be a key player in the cognitive vulnerability to suicidal behaviour. More studies are necessary to confirm these initial results, to examine how memory acts in combination with other cognitive domains to increase the risk of suicidal act, and to understand their neural and molecular basis. Ultimately, cognitive deficits may be the target of future interventions aiming at reducing suicide risk.

Acknowledgements

We would like to thank Dr G. Turecki for his support. Dr S. Richard-Devantoy received a fellowship grant from the Canadian Institutes for Health Research (CIHR). Drs F. Jollant and M. Berlim received a “chercheur-boursier clinicien” salary grant from the Fond de Recherche du Québec – Santé (FRQS).

Statement of interest

None to declare.

References

Addis DR, Wong AT, Schacter DL. 2007. Remembering the past and imagining the future: common and distinct neural substrates during event construction and elaboration. Neuropsychologia 45:1363–1377.

Arie M, Apter A, Orbach I, Yefet Y, Zalzman G. 2008. Autobiographical memory, interpersonal problem solving, and suicidal behavior in adolescent inpatients. Comp Psychiatry 49:22–29.

Baddeley A. 1992. Working memory. Science 255:556–559.

Barrett EA, Sundet K, Simonsen C, Agartz I, Lorentzen S, Mehlum L, et al. 2011. Neurocognitive functioning and suicidality in schizophrenia spectrum disorders. Comp Psychiatry 52:156–163.

Batty GD, Whitley E, Deary IJ, Gale CR, Tynelius P, Rasmussen F. 2010. Psychosis alters association between IQ and future risk of attempted suicide: cohort study of 1,109,475 Swedish men. BMJ 340:c2506.

Bechara A, Damasio H, Tranel D, Anderson SW. 1998. Dissociation of working memory from decision making within the human prefrontal cortex. J Neurosci 18:428–437.

Button KS, Ioannidis JP, Mokrysz C, Nosek BA, Flint J, Robinson ES, et al. 2013. Power failure: why small sample size undermines the reliability of neuroscience. Nat Rev Neurosci 14:365–376.

Conway AR, Engle RW. 1996. Individual differences in working memory capacity: more evidence for a general capacity theory. Memory 4:577–590.

Cooper H, Hedges IV, Valentine JC. 2009. The Handbook of Research Synthesis and Meta-Analysis. New York: Russell Sage Foundation Publications.

Coryell W, Schlesser M. 2001. The dexamethasone suppression test and suicide prediction. Am J Psychiatry 158:748–753.

Crane C, Duggan DS. 2009. Overgeneral autobiographical memory and age of onset of childhood sexual abuse in patients with recurrent suicidal behaviour. Br J Clin Psychol 48:93–100.
Suicidal behaviour and memory

Delaney C, Mccrane J, Cummings E, Morris DW, Tropea D, Gill M, et al. 2012. Preserved cognitive function is associated with suicidal ideation and single suicide attempts in schizophrenia. Schizophrenia Research 140:232–236.

Dombrovski AY, Butters MA, Reynolds CF 3rd, Houck PR, Clark L, Mazumdar S, et al. 2008. Cognitive performance in suicidal depressed elderly: preliminary report. Am J Geriatr Psychiatry 16:109–115.

Egger M, Davey Smith G, Altman D. 2001. Systematic Reviews in Health Care: Meta-Analysis in Context. London: BMJ Publishing Group.

Egger M, Davey Smith G, Schneider M, Minder C. 1997. Bias in meta-analysis detected by a simple, graphical test. BMJ 315:629–634.

Engle RW, Tuholski SW, Laughlin JE, Conway AR. 1999. Working memory, short-term memory, and general fluid intelligence: a latent-variable approach. J Exp Psychol Gen 128:309–331.

Evans J, Williams JM, O’Loughlin S, Howells K. 1992. Autobiographical memory and problem-solving strategies of suicide attempters. Psychol Med 22:399–405.

Fan T, Wu X, Yao L, Dong J. 2013. Abnormal baseline brain activity in suicidal and non-suicidal patients with major depressive disorder. Neurosci Lett 534:35–40.

Goldman-Rakic PS. 1996. Regional and cellular fractionation of working memory. Proc Natl Acad Sci USA 93:13473–13480.

Gujral S, Dombrovski AY, Butters M, Clark L, Reynolds CF 3rd, Szanto K. 2012. Impaired executive function in contemplated and attempted suicide in late life. Am J Geriatr Psychiatry 22:811–819.

Hedges LV, Olkin I. 1985. Statistical methods for meta-analysis. London, Academic Press. p. 369.

Jollant F, Guillaume S, Jaussent I, Bechera A, Courret P. 2013. When knowing what to do is not sufficient to make good decisions: deficient use of explicit understanding in remitted patients with histories of suicidal acts. Psychiatry Res.

Jollant F, Lawrence NL, Olie E, Guillaume S, Courret P. 2011. The suicidal mind and brain: a review of neuropsychological and neuroimaging studies. World J Biol Psychiatry 12:319–339.

Kaviani H, Rahimi-Darabad P, Naghavi HR. 2005. Autobiographical memory retrieval and problem-solving deficits of Iranian depressed patients attempting suicide. J Psychopathol Behav Assess 27:39–44.

Keefe RS. 1995. The contribution of neuropsychology to psychiatry. Am J Psychiatry 152:6–15.

Keilp JG, Gorlyn M, Russell M, Oquendo MA, Burke AK, Harkavy-Friedman J, et al. 2013. Neuropsychological function and suicidal behavior: attention control, memory and executive dysfunction in suicide attempt. Psychol Med 43:539–551.

Keilp JG, Sackeim HA, Brodsky BS, Oquendo MA, Malone KM, Mann J. 2001. Neuropsychological dysfunction in depressed suicide attempters. Am J Psychiatry 158:735–741.

Kim C, Jayathilake K, Meltzer F. 2003. Hopelessness, neurocognitive function, and insight in schizophrenia: a relationship to suicidal behavior. Schizophrenia Research 60:71–80.

Labonte B, Suderman M, Maussion G, Lopez JP, Navarro-Sanchez L, Yerko V, et al. 2013. Genome-wide methylation changes in the brains of suicide completers. Am J Psychiatry 170:511–520.

Lindenmayer JP, Czobor P, Alphs L, Nathan AM, Anand R, Islam Z, et al. 2003. The InterSePT scale for suicidal thinking reliability and validity. Schizophr Res 63:161–170.

Lopez-Morinigo JD, Ramos-Rios R, David AS, Dutta R. 2012. Insight in schizophrenia and risk of suicide: a systematic update. Compr Psychiatry 53:313–322.

Malloy-Diniz LF, Neves FS, Abrantes SS, Fuentes D, Correa H. 2009. Suicide behavior and neuropsychological assessment of type I bipolar patients. J Affect Disord 112:231–236.

Malloy-Diniz LF, Neves FS, Abrantes SS, Fuentes D, Correa H. 2009. Suicide behavior and neuropsychological assessment of type I bipolar patients. J Affect Disord 112:231–236.

Mann JJ. 2003. Neurobiology of suicidal behaviour. Nat Rev Neurosci 4:819–828.

Martino DJ, Strejilevich SA, Tovralva T, Manes F. 2010. Decision making in euthymic bipolar I and bipolar II disorders. Psychol Med 1–9.

Maurex L, Leikamer M, Nielsone A, Andersson EE, Asberg M, Ohman A. 2010. Social problem solving, autobiographical memory, trauma, and depression in women with borderline personality disorder and a history of suicide attempts. Br J Clin Psychol 49:327–342.

Mcgirr A, Dombrovski AY, Butters MA, Clark L, Szanto K. 2012. Deterministic learning and attempted suicide among older depressed individuals: cognitive assessment using the Wisconsin Card Sorting Task. J Psychiatri Res 46:226–232.

Megovon PO, Sasaki A, D’ Alessio AC, Dymov S, Labonte B, Szfy M, et al. 2009. Epigenetic regulation of the glucocorticoid receptor in human brain associates with childhood abuse. Nat Neurosci 12:342–348.

Nangle JM, Clarke S, Morris DW, Schwaiger S, Mcghee KA, Keny N, et al. 2006. Neurocognition and suicidal behaviour in an Irish population with major psychotic disorders. Schizophr Res 85:196–200.

Osman A, Bagge CL, Gutierrez PM, Konick LC, Kopper BA, Barrios FX. 2001. The Suicidal Behaviors Questionnaire-Revised (SBQ-R): validation with clinical and nonclinical samples. Assessment 8:443–454.

Pettersen K, Rydningen NN, Christensen TB, Walby FA. 2010. Autobiographical memory and suicide attempts in schizophrenia. Suicide Life Threat Behav 40:369–375.

Petitcres M, Roberts H. 2006. Systematic reviews in the social sciences: a practical guide. Oxford: Blackwell.

Plutchik R, Van Praag H. 1989. The measurement of suicidality, aggressivity and impulsivity. Prog Neuropsychopharmacol Biol Psychiatry 13(Suppl):S23–34.

Pollock LR, Williams JM. 2001. Effective problem solving in suicide attempters depends on specific autobiographical recall. Suicide Life Threat Behav 31:386–396.

Pollock LR, JM. 2004. Problem-solving in suicide attempters. Psychol Med 34:163–167.

Potkin SG, Anand R, Alphs L, Fleming K. 2003. Neurocognitive performance does not correlate with suicidality in schizophrenic and schizoaffective patients at risk for suicide. Schizophr Res 59:59–66.

Pruessner JC, Dedovic K, Khalili-Mahani N, Engert V, Pruessner M, Buss G, et al. 2008. Deactivation of the limbic system during acute psychosocial stress: evidence from positron emission tomography and functional magnetic resonance imaging studies. Bio Psychiatry 63:234–240.

Raes F, Hermans D, Williams JM, Beyers W, Brunfaut E, Eelen P. 2006. Reduced autobiographical memory specificity and rumination in predicting the course of depression. J Abnorm Psychol 115:699–704.

Rasmussen SA, O’Connor RC, Brodie D. 2008. The role of perfectionism and autobiographical memory in a sample of parasite patients: an exploratory study. Crisis 29:64–72.

Raut A, Slama F, Mathieu F, Roy I, Chenu A, Koncke D, et al. 2007. Prefrontal cortex dysfunction in patients with suicidal behavior. Psychol Med 37:411–419.

Reisch T, Seifritz E, Esposito F, Wiest R, Valach L, Michel K. 2010. An fMRI study on mental pain and suicidal behavior. J Affect Disord 126:321–325.

Richard-Devantoy S, Berlin MT, Jollant F. 2013. A meta-analysis of neuropsychological markers of vulnerability to suicidal behavior in mood disorders. Psychol Med: 1–11.
Richard-Devantoy S, Jollant F, Kefi Z, Turecki G, Olie JP, Annweiler C, et al. 2012. Deficit of cognitive inhibition in depressed elderly: a neurocognitive marker of suicidal risk. J Affect Disord 140:193–199.

Richard-Devantoy S, Olie E, Guillaume S, Bechara A, Courret P, Jollant F. 2013. Distinct alterations in value-based decision-making and cognitive control in suicide attempters: toward a dual neurocognitive model. J Affect Disord.

Riley RD, Higgins JP, Deeks JJ. 2011. Interpretation of random effects meta-analyses. Br Med J 342:d549.

Rolls ET. 2013. The mechanisms for pattern completion and pattern separation in the hippocampus. Front Syst Neurosci 7:74.

Rosenthal R. 1979. The file drawer problem and tolerance for null results. Psychol Bull 86:638–641.

Sinclair JM, Crane C, Hawton K, Williams JM. 2007. The role of autobiographical memory specificity in deliberate self-harm: correlates and consequences. J Affect Disord 102:11–18.

Soloff PH, Pruitt P, Sharma M, Radwan J, White R, Dwadkar VA. 2012. Structural brain abnormalities and suicidal behavior in borderline personality disorder. J Psychiatr Res 46:516–525.

Sorberg A, Allebeck P, Melin B, Gunnell D, Hemmingsson T. 2013. Cognitive ability in early adulthood is associated with later suicide and suicide attempt: the role of risk factors over the life course. Psychol Med 43:49–60.

Startup M, Heard H, Swales M, Jones B, Williams JM, Jones RS. 2001. Autobiographical memory and parasuicide in borderline personality disorder. Br J Clin Psychol 40:113–120.

Taylor PJ, Gooding PA, Wood AM, Tarrier N. 2010. Memory specificity as a risk factor for suicidality in non-affective psychosis: the ability to recall specific autobiographical memories is related to greater suicidality. Behav Res Ther 48:1047–1052.

Tetzlaff C, Kolodziejski C, Markelic I, Worgetter F. 2012. Time scales of memory, learning, and plasticity. Biol Cybern 106:715–726.

Von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP, et al. 2008. The Strengthening the Reporting of Observational Studies in Epidemiology [STROBE] statement: guidelines for reporting observational studies. J Clin Epidemiol 61:344–349.

Wagner G, Schultz CC, Koch K, Schachtzabel C, Sauer H, Schlosser RG. 2012. Prefrontal cortical thickness in depressed patients with high-risk for suicidal behavior. J Psychiatr Res 46:1449–1455.

Westheide J, Quednow BB, Kuhn KU, Hoppe C, Cooper-Mahkorn D, Havellek B, et al. 2008. Executive performance of depressed suicide attempters: the role of suicidal ideation. Eur Arch Psychiatry Clin Neurosci 258:414–421.

Williams JM, Barnhofer T, Crane C, Beck AT. 2005. Problem solving deteriorates following mood challenge in formerly depressed patients with a history of suicidal ideation. J Abnorm Psychol 114:421–431.

Williams JM, Barnhofer T, Crane C, Herman D, Raes F, Watkins E, et al. 2007. Autobiographical memory specificity and emotional disorder. Psychol Bull 133:122–148.

Williams JM, Broadbent K. 1986. Autobiographical memory in suicide attempters. J Abnorm Psychol 95:144–149.

Williams JM, Ellis NC, Tyers C, Healy H, Rose G, Macleod AK. 1996. The specificity of autobiographical memory and imageability of the future. Mem Cognit 24:116–125.

Yen CF, Cheng CP, Ko CH, Yen YJ, Huang CF, Chen CS. 2008. Suicidality and its association with insight and neurocognition in taiwanese patients with bipolar I disorder in remission. J Nerv Ment Dis 196:462–467.

Supplementary material available online

Supplementary Table V. Heterogeneity and publications bias