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Forms of confabulation: Dissociations and associations

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ABSTRACT

Confabulation denotes the emergence of memories of experiences and events which never took place. Whether there are distinct forms with distinct mechanisms is still debated. In this study, we explored 4 forms of confabulation and their mechanisms in 29 amnesic patients. Patients performed tests of explicit memory, executive functions, and two test of orbitofrontal reality filtering (memory selection and extinction capacity in a reversal learning task) previously shown to be strongly associated with confabulations that patients act upon and disorientation. Results indicated the following associations: (1) Intrusions in a verbal memory test (simple provoked confabulations) dissociated from all other forms of confabulation and were not associated with any specific cognitive measure. (2) Momentary confabulations, defined as confabulatory responses to questions and measured with a confabulation questionnaire, were associated with impaired mental flexibility, a tendency to fill gaps in memory, and with one measure of reality filtering. Momentary confabulations, therefore, may emanate from diverse causes. (3) Behaviourally spontaneous confabulation, characterized by confabulations that the patients act upon and disorientation, was strongly associated with failure in the two reality filtering tasks. Behaviourally spontaneous confabulation may be seen as a specific instance of momentary confabulations with a distinct mechanism. (4) A patient producing fantastic confabulations with nonsensical, illogical content had wide-spread cognitive dysfunction and failed in the reality filtering tasks. The results support the presence of truly or partially dissociable types of confabulation with different mechanisms.

1. Introduction

Confabulation describes the emergence of memories of events and experiences which never happened (Wernicke, 1900). Diverse forms have been described, usually as a dichotomy between "momentary" (also called "out-of-embarrassment" or "classic compensatory") and "fantastic" confabulations or between provoked and spontaneous confabulations (Berlyne, 1972; Bonhoeffer, 1901; Kopelman, 1987; Schnider, von Däniken, & Gutbrod, 1996b). Based on an analysis of the different descriptions and own data, Schnider (2008) recently proposed to distinguish four forms of confabulations:

(1) Intrusions in memory tests, previously also called (simple) provoked confabulations (Kopelman, 1987; Schnider et al., 1996b). (2) Momentary confabulations (the most frequently reported form), that is, false recollections verbally expressed in response to questions or other situations inciting a comment—hence Bonhoeffer's denomination as "momentary" (Berlyne, 1972; Bonhoeffer, 1901). They have also been named "out-of-embarassement" (Bonhoeffer, 1904; Van der Horst, 1932) or "classic compensatory" (Flament, 1957) confabulations, implying that they serve to hide a gap in memory. Another denomination has been "provoked confabulations" (Kopelman, 1987) because they are typically elicited by questions (Dalla Barba, 1993b; Gilboa et al., 2006; La Corte, Serra, Attali, Boisse, & Dalla Barba, 2010; Moscovitch & Melo, 1997). However, occasional patients may also produce them relatively spontaneously (Pick, 1905). They may occur in many diseases and have relatively little anatomic specificity, although there is a certain preponderance of anterior inferior brain lesions (Schnider, 2008). Most studies on confabulations concern this form, implicitly assuming that they reflect a common disorder. (3) Behaviourally spontaneous confabulation, a disorder reflecting confusion of reality: the patients produce confabulations in discussions (thus, they produce momentary confabulations) but – specifically – they also act in agreement with their false ideas, at least intermittently, and they are disoriented (Schnider, 2003; Schnider et al., 1996b). These confabulations may thus be conceived as a special instance of momentary confabulations (they occur in discussions) but with unequivocal signs of reality confusion. Focal lesions involve the posterior medial orbitofrontal cortex (OFC, Brodmann's area 13)

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or structures directly connected with it (Gilboa & Moscovitch, 2002; Schnider, Gutbrod, Hess, & Schroth, 1996a; Schnider & Ptak, 1999). (4) Fantastic confabulations, that is, the narration of non-sensical and implausible experiences that are incompatible with common notions of reality. This form has been described in severe psychosis, dementia, and acute confusional states (Berlyne, 1972; Bonhoeffer, 1901; Damasio, Graff Radford, Eslinger, Damasio, & Kassel, 1985; Gundogar & Demirci, 2006; Kraepelin, 1887/88).

Among these forms, only behaviourally spontaneous confabulation has received an experimentally validated explanation: a failure of orbitofrontal reality filtering. The specifics of this function have been elucidated in experimental studies with patients (Nahum, Ptak, Leemann, & Schnider, 2009; Ptak & Schnider, 1999; Schnider & Ptak, 1999; Schnider et al., 1996b; Schnider, Ptak, von Däniken, & Remonda, 2000a; Schnider, von Däniken, & Gutbrod, 1996c) plus electrophysiological, imaging and pharmacological studies with healthy subjects. Reality filtering describes a memory control process necessary to maintain thinking and behaviour in phase with reality (Schnider, 2003, 2008). It depends on orbitofrontal area 13 and connected subcortical structures (Schnider & Ptak, 1999; Schnider, Treyer, & Buck, 2000b; Treyer, Buck, & Schnider, 2003), is electrocortically expressed at 200–300 ms after evocation of a memory (Schnider, Valenza, Morand, & Michel, 2002; Wahlen, Nahum, Gabriel, & Schnider, 2011) and is under dopaminergic modulation (Pihan, Gutbrod, Baas, & Schnider, 2004; Schnider, Guggisberg, Nahum, Gabriel, & Morand, 2010). Its underlying physiological process likely corresponds to extinction capacity: the ability to learn when previously valid anticipations no longer apply, or, more generally, when an anticipation does not apply to current reality (Nahum et al., 2009) and behaviour needs to be adapted (Nahum, Simon, Lazeyras, Sander, & Schnider, 2011b). Extinction capacity is independent from other forms of response inhibition (Rosenkilde, 1979). Its failure not only induces patients to act according to ideas that are out of phase with reality (a hospitalized patient may insist on attending an imagined business meeting) but is also strongly associated with disorientation (Nahum et al., 2009; Schnider et al., 1996c).

While orbitofrontal reality filtering is the only mechanism with an experimentally verified biological basis that has been validated for behaviourally spontaneous and disorientation, it is far from being the only theory of confabulation. It competes with the following hypotheses: (1) The gap-filling account which holds that confabulations emanate from a desire to fill gaps in memory to avoid embarrassment (Bonhoeffer, 1901; Pick, 1905). The account is related to the motivation hypothesis which stipulates that confabulations reflect a desire to embellish the situation of disease and handicap (Conway & Tacci, 1996; Flament, 1957; Fotopoulou, Solms, & Turnbull, 2004; Metcalf, Langdon, & Coltheart, 2010). An argument in favour of this idea has been that confabulations often have a positive emotional flavour (Fotopoulou et al., 2008b). However, confabulations with dark content have also been documented (Bajo, Fleminger, & Kopelman, 2010; Korsakoff, 1891). Also, confabulators do not have a general tendency to fill gaps in memory: We found that – at least behaviourally spontaneous – confabulators did not have an increased tendency to confabulate in response to questions about non-existent items for which they had a mandatory gap in memory (Where is Premola? Who is Princess Lolita?) (Schnider, 2003; Schnider et al., 1996b). (2) The executive hypothesis, which proposes that confabulations arise from the combination of amnesia with dysexecutive syndrome (Kapur & Coughlan, 1980; Stuss, Alexander, Lieberman, & Levine, 1978). Indeed, in unselected groups of brain-damaged subjects, the severity of executive failures, either alone (Moscovitch & Melo, 1997) or in combination with amnesia (Cunningham, Pliskin, Cassisi, Tsang, & Rao, 1997), was found to be associated with momentary confabulations. However, in patients matched regarding the severity of amnesia, executive dysfunction did not distinguish between behaviourally spontaneous confabulators and other amnesics (Nahum et al., 2009; Schnider & Ptak, 1999; Schnider, et al., 1996b). (3) Monitoring hypotheses: Differing in focus (e.g., monitoring of content, context, or source of memories) and anatomical predictions, the models hold that confabulations emanate from impaired processes involved in the evocation and monitoring of memories (Burgess & Shallice, 1996; Gilboa et al., 2006; Johnson, 1991; Johnson & Raye, 1998; Moscovitch, 1989, 1995; Moscovitch & Melo, 1997). While the source memory account has received negative results in a multiple case study (the confabulating patient did not differ from non-confabulating patients in source memory tasks (Johnson, O'Connor, & Cantor, 1997), the 'strategic retrieval account' (Gilboa et al., 2006; Moscovitch, 1989, 1995; Moscovitch & Melo, 1997) has received supportive evidence. This model proposes that confabulations arise from the activation of a faulty memory followed by deficient monitoring of the recovered memory. Confabulating patients, classified according to the presence or absence of either momentary confabulations (Moscovitch & Melo, 1997) or inappropriate acts (Gilboa et al., 2006) provided more erroneous details when asked about personal experiences and historical events relating to specific cue words (Moscovitch & Melo, 1997) or when reciting details of fairy tales and bible stories (Gilboa et al., 2006). This theory, notably the production of confabulations in semantic memory retrieval (cue words, bible stories), has been proposed to explain not only momentary, but also behaviourally spontaneous confabulations. (4) Temporal hypotheses, which attribute confabulations to a disturbed sense of time and temporal relations in memory (Dalla Barba, 2002; Dalla Barba, Cappelletti, Signorini, & Denes, 1997; Talland, 1961; Van der Horst, 1932). These authors have not proposed specific experiments to test the hypothesis.

The reality filter hypothesis (Schnider, 2003, 2008) is compatible with the main ideas of both the monitoring and temporal hypotheses. However, it is derived from experimental findings from patients with behaviourally spontaneous confabulation and disorientation (Nahum et al., 2009; Schnider & Ptak, 1999; Schnider et al., 1996b). Whether it also applies to other forms of confabulation is unknown. The other hypotheses have subsumed multiple or all forms under a common framework, thus assuming that confabulations are a unitary disorder.

In the present study, we explored the associations and dissociations between the 4 proposed forms of confabulation in a series of amnesic subjects and tested how well they were explained by a tendency to fill gaps in memory, executive disturbances, or a failure of reality filtering.

2. Participants and methods

Patients hospitalized for neurorehabilitation after first-ever brain injury were considered for the study if they had an amnesia characterized by a long-delay free recall ≤ 5 in the California verbal learning test (CVLT) (Delis, Kramer, Kaplan, & Ober, 1987) or ≤ 3 in the CERAD Word List Memory task (Welsh et al., 1994) irrespective of lesion type or aetiology. In addition, they had to respond to the following criteria: absence of a confusional state, that is, normal day-night rhythm, ability to participate in the daily rehabilitation program, a digit span of ≥ 5; absence of a severe language or visual impairment preventing performance of the tasks. In order to verify face recognition, as required for one experimental task, patients also had to correctly recognize a face in serially presented pairs of faces (Nahum et al., 2009).

Twenty-nine patients (6 females, 23 males; age, 55.2 ± 15.7 years; education, 13.2 ± 3 years) participated in the study. Ten had already participated in our previous study on extinction capacity (Nahum et al., 2009) which, however, used a different version of this tasks.

Table 1
Patient characteristics.

Pat.	Sex	Age (years)	Etiology	Lesion site	Days after onset	CVLT intrusions	Conf. in the DBCQ	Conf. in the SQ	Total orientation score	BSpC
1	M	63	ACoA	Left OFC	30	3	N/A	0	8	X
2	M	39	Hypoxia		63	1	N/A	0	11	X
3	M	55	Hypoxia		32	6	N/A	4	11	X
4	M	57	WKS	Mamillary bodies bilateral; prefrontal and OFC hypometabolism	60	0	7	0	9	X
5	F	61	ACoA	Left OFC, left paramedian frontal, right ACC, right anterior corpus callosum	50	4	15	1	5	X
6	M	49	WKS	Cerebral atrophy	75	2	1	0	11	X
7	F	74	ACoA	Left OFC, left ACC	90	5	12	2	12	X
8	M	38	ACoA	Right temporal, caudate bilateral, pallidum bilateral	240	9	16	N/A	5	X
9	M	79	Ischemic stroke	Right frontal, right parietal	54	N/A	11	N/A	13	X
10	F	39	Limbic encephalitis	Medial temporal bilateral, posterior OFC and caudate bilaterally	31	7	8	N/A	8	X
11	M	34	Hypoxia		70	1	21	5	11	
12	M	67	ACoA (spasms)	Right dorsolateral prefrontal	25	7	N/A	0	18	
13	M	63	ACoA	Left OFC	60	1	N/A	0	17	
14	M	70	Hypoxia		52	2	N/A	0	19	
15	M	53	TBI	OFC bilateral, right temporal	104	0	N/A	0	13	
16	M	58	Hypoxia		416	20	N/A	0	17	
17	F	77	Ischemic stroke	Left medial temporal	15	1	N/A	0	16	
18	M	59	Hypoxia		45	1	2	3	16	
19	M	38	ACoA	Left (orbito)frontal	70	1	4	0	16	
20	M	69	Ischemic stroke	Paramedian thalamic bilateral	120	4	4	0	16	
21	M	68	Hypoxia		30	0	6	0	13	
22	M	19	TBI	Left Insula, left frontal, diffuse white matter	80	7	1	0	20	
23	M	35	ACoA	Right OFC, right ventral striatum, right fronto-polar	70	0	1	0	18	
24	F	72	TBI	Frontal bilateral, corpus callosum	45	0	N/A	0	19	
25	M	72	Ischemic stroke	Left medio-temporo-occipital lobe	50	1	3	0	15	
26	M	38	PICA aneurysm rupture	Hydrocephalus	70	3	3	0	18	
27	M	52	WKS	Cerebral atrophy	80	5	7	0	17	
28	F	65	ACoA	Right frontal, caudate bilateral	180	5	4	0	17	
29	M	38	Arnold Chiari malformation	Hydrocephalus	81	N/A	1	N/A	19	

Abbreviations: ACoA, anterior communicating artery aneurysm rupture; PICA, posterior inferior cerebellar artery; CVLT, California verbal learning test (Delis et al., 1987); DBCQ, Dalla Barba's (1993b) confabulation questionnaire; SQ, semantic questionnaire (Schnider et al., 1996b); BSpC, behaviorally spontaneous confabulation; ACC, anterior cingulum cortex; OFC, orbitofrontal cortex; TBI, traumatic brain injury; WKS, Wernicke–Korsakoff syndrome; N/A = data not available.

Aetiologies and location of lesions in the patients are indicated in Table 1. All patients gave informed consent to participate in the study. The Ethical Committee of the University Hospital of Geneva approved the study.

2.1. Measures of confabulations

The patients underwent tests for the presence of the 4 forms of confabulation (Schnider, 2008) as described in the following. Patients might thus produce one or several forms of confabulation or not confabulate at all.

2.1.1. Intrusions (simple provoked confabulations)

Intrusions (simple provoked confabulations) were measured as the total number of intrusions in the CVLT, i.e., the total number of false words produced when recalling the word list. Healthy participants normally produce very few intrusions (1 ± 1.7, median 0.5; Ilmberger, unpublished data).

2.1.2. Momentary confabulations

Momentary confabulations were measured as the total number of confabulations in Dalla Barba's (1993b) confabulation questionnaire (DBCQ). This questionnaire contains subtests with questions concerning personal and general semantic memory, episodic memory, orientation for space and time, and semantic and episodic memory questions to which the appropriate response is "I don't know". Healthy subjects normally produce no confabulation in any part of the DBCQ (La Corte et al., 2010).

2.1.3. Behaviourally spontaneous confabulation and disorientation

Ten patients were classified as behaviourally spontaneous confabulators according to criteria used in previous studies: presence of confabulations in discussions, that is, production of momentary confabulations, which, however, the patients act upon or which they use to justify currently inappropriate acts. Additionally, patients are disoriented (Schnider, 2003, 2008; Schnider et al., 1996b). Spontaneous confabulations and false acts were qualitatively evaluated through clinical observations. Five patients repeatedly tried to leave the unit to go to work; one patient thought he had to take the plane and tried to leave the unit to go to the airport; one patient had the false belief that he had to arrange the funeral of his recently deceased wife and daughter (both of whom regularly visited him at the hospital); one patient repeatedly thought she would receive guests for dinner and prepared for these occasions; one patient tried to leave the unit in the false belief that he actually lived at home and had just come to the hospital for therapies.

Disorientation was tested with a 20-item questionnaire adapted for a hospitalized population (Von Cramon & Säring, 1982). It covers 5 questions for each of 4 domains of orientation: (1) orientation to person: name, age, profession, citizenship, eye colour; (2) orientation to place: city, state, name of institution, floor, hospital room; (3) orientation to situation: reason for being here, types of treatment, sources of support, name of a person on the ward, party covering the costs of the hospital stay; (4) orientation to time: day of the week, date, month, year, time. A correctly oriented subject will give at least four correct answers for domains (1) to (3) and at least three correct answers for domain (4). Healthy subjects give ≥ 16 correct responses. Orientation scores of each patient are provided in Table 1.

2.1.4. Fantastic confabulation

One patient (patient no. 11) was classified as a fantastic confabulator. This 34-year-old man had postanoxic encephalopathy after a cardiac arrest due to probable heroin use. For weeks he told bizarre stories about him having extraordinary spy missions. He maintained that he had been at home the day before when a helicopter with armed soldiers landed in his garden and tried to kill him because he was a spy on an important mission at the hospital. He was apathetic and mostly stayed in his bedroom, often in his bed. He occasionally tried to leave the unit without explaining why. Thus, he did not correspond to the definition of a behaviourally spontaneous confabulator in that he did not clearly act on his confabulations, unless his attempts to leave the unit were motivated by his fantastic ideas (Schnider, 2008). Table 2 shows the neuropsychological results of this patient documenting severe and wide-ranging memory and executive dysfunction. The results from this patient were excluded from the statistical comparisons between behaviourally spontaneous confabulators and other patients.

2.2. General testing

While delayed free recall in the CERAD Word List Memory task (Welsh et al., 1994) was a possible inclusion criterion, all patients eventually performed the CVLT whose result entered the analyses. The CVLT scores of immediate free recall, long delay free recall, correct recognition, susceptibility to proactive interference (difference between the number of correct words recalled on the single trial of list B as compared with the first trial of list A) and retroactive interference (difference between total correct words recalled on the short delay free recall trial compared with total correct words recalled on the fifth trial of list A) and the number of false positive were also included in the statistical analyses.

The following executive tests were applied ≤5 days after the experimental tasks described below: verbal fluency (Thurstone & Thurstone, 1962), figural fluency in Regard's 5-point task (Regard, Strauss, & Knapp, 1982), color-word-interference (Stroop, 1935), and cognitive flexibility in the trail making test (Army Individual Test Battery, 1944). A differential score consisting of time in part B minus time in part A of the trail making test was computed as an indicator of executive control.

Table 2
Neuropsychological results of the fantastic confabulating patient (patient no. 11).

Neuropsychological test	Patient	Percentile
Orientation score (Von Cramon & Säring, 1982)	11	Normal score ≥15
Digit span (Wechsler, 1945)	5	20
Corsi block tapping (Milner, 1971)	5	16
California verbal learning test (Delis et al., 1987)		
Trial 5	4	<1
Sum trials	18	<1
Long delay free recall	0	<1
Recognition, correct	10	<1
Recognition, false positives	8	<1
Doors and People test (Baddeley et al., 1994)		
Doors test part A	5	<1
Pyramids and palm trees test (Howard & Patterson, 1992)	47	
Boston Naming Test (Kaplan et al., 1983)	15	<1
Phonological fluency (Thurstone & Thurstone, 1962)		
Total number of words	1	<1
Total number of errors	2	
Semantic fluency (Thurstone & Thurstone, 1962)		
Total number of errors	8	<1
Total number of words	0	
Design fluency (Regard et al., 1982)		
Total number of designs	8	<1
Total number of errors	2	
Stroop test, interference condition (Perret, 1974)		
Seconds	76	10
Errors	0	
Trail making test (Army Individual Test Battery, 1944)		
Part A		
Seconds	85	<1
Errors	0	
Part B		
Seconds	405	<1
Errors	0	

2.3. Experimental tasks

The following tasks were applied on the same day as orientation testing.

2.3.1. Gap-filling

To test the tendency to fill gaps in memory, a semantic questionnaire (SQ) was used that contained 15 questions about existing and 15 questions about non-existing items from three categories: famous personalities (existing item: "Who is prince Charles?", non-existing item: "Who is princess Lolita?"), places (existing: "Where is Manchester?", non-existing: "Where is Bleumont?"), and relatively rare words (existing: "What is an oboe?", non-existing: "What is a watercove?"). As subjects have a mandatory gap in memory for the non-existent items, the number of responses to non-existent items was used to test the tendency for gap-filling (Schnider et al., 1996b).

This questionnaire was also used as a measure of (semantic) momentary confabulations: all explanations for non-existent items, other than "I do no know", were considered confabulations.

2.3.2. Reality filtering—Memory selection

The two following experimental tasks had been previously shown to be highly predictive of behaviourally spontaneous confabulation and to strongly correlate with orientation (Nahum et al., 2009; Schnider et al., 1996c).

The memory selection task measures the abilty to distinguish between memories that relate to ongoing reality and memories that do not (Schnider et al., 1996b, 1996c). Fig. 1A presents the design. It has two runs of a continuous recognition test, composed of the same meaningful line drawings (Snodgrass & Vanderwart, 1980). The only difference between the runs is that pictures are presented in different order. Participants are asked to indicate picture recurrences only within the ongoing run. The first run assesses pure information storage, calculated as: Hits—false positives. In the second run, which is made 45–60 min later, participants again have to indicate picture recurrences within the run and to disregard familiarity with items from the previous run. Thus, the second run requires the ability to distinguish between items' previous occurrence in the currently ongoing rather than the previous first run. Confusion with the first run is calculated as temporal context confusion, TCC = FP2/Hits2—FP1/Hits1 where Hits1,2 is the number of correctly recognized picture repetitions (maximum, 40), FP1,2 is the number of false positive responses in runs 1,2 (max. 80). In our previous studies, healthy subjects and non-confabulating patients had TCC <0.3, while behaviourally spontaneous confabulators had TCC ≥0.3 (Schnider et al., 1996b). TCC strongly correlated with orientation in amnesic patients (Schnider et al., 1996c)

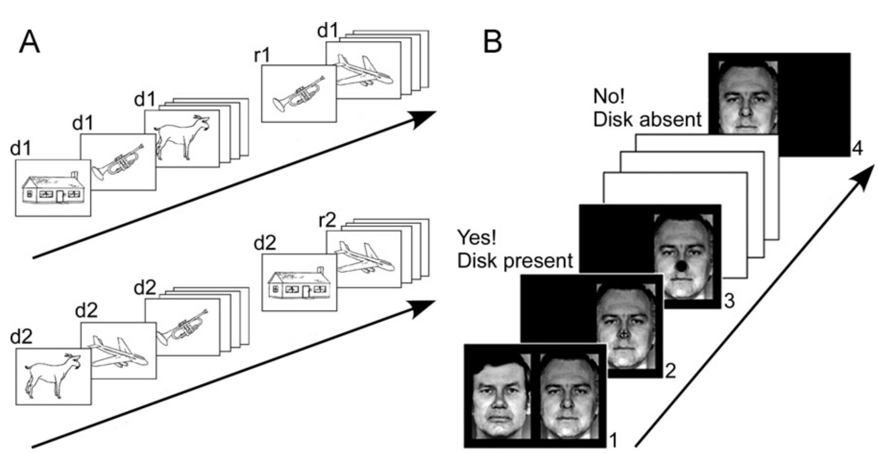

Fig. 1. Reality filtering tasks. (A) Memory selection task composed of two runs of a continuous recognition task. In both runs, subjects have to indicate picture recurrences only within the ongoing run. The two runs are composed of the same pictures; the only difference is that they are arranged in different order. $d1,2$ = distracters of run 1 or 2, that is, items that are presented for the first run within the ongoing run; $r1,2$ = repetitions within the ongoing run. (B) Reversal learning task to test extinction capacity. Trials start with the presentation of two neutral faces (step 1). The faces remain on screen until participant's response, then the chosen face receives a fixation cross on its nose and the non chosen face disappears (step 2). After 1500 ms, feedback is provided, either by appearance of a disk on the nose of the chosen face, indicating a correct choice (step 3), or by the absence of the disk (step 4, extinction trials).

and paralleled the individual clinical course of behaviourally spontaneous confabulation (Schnider et al., 2000a).

2.3.3. Reality filtering—Extinction capacity

A similar reversal learning task as in previous studies was used (Nahum et al., 2009; Nahum, Ptak, Leemann, Lalive, & Schnider, 2010). Behaviourally spontaneous confabulators remain convinced about their plans and ideas although reality never confirms them. Thus, they fail to learn from the absence of anticipated events, a failure akin to deficient extinction capacity (Nahum et al., 2009; Ouyang & Thomas, 2005). The task measures the ability to learn the association between two stimuli and – most importantly – the ability to learn when one stimulus no longer predicts the occurrence of the other. Fig. 1B depicts the design. Participants repeatedly saw the same pair of faces on a computer monitor and were asked to predict which one of the two faces would have a black disk on its nose. Participants were informed that the disk would normally reappear on the same face. Occasionally, however, it would be absent because it had switched to the other face. Following such trials, which we called extinction trials and which occurred after four to six correct choices, the subject should choose the alternate face. If the participant made an unmotivated error by abandoning the face that had had the target stimulus in the previous trial, the counter of correct choices was set back to zero. Participants were asked to make their choices by pointing to the chosen face on the basis of the previous feedback and to restrain from guessing; responses were typed in the computer by the experimenter.

Two measures were calculated: (1) Association learning error rate, that is, the unmotivated abandonment of the face that had had the disk on its nose in the previous trial; (2) post-extinction error rate, that is, the continued choice of the same face despite absence of the target outcome on its nose in the previous trial (extinction trial). Patients made 2 blocks of 60 trials each, which normally lasted about 6 min and which were separated by a 4 min break.

2.3.4. Reality filtering—Combined score

Both TCC and post-extinction error rate are normally between 0 and 0.3, abnormal values typically go up to 0.8 (Nahum et al., 2009; Schnider et al., 1996b). We therefore also calculated a combined reality filtering score by adding the two scores. This score is purely arithmetic with no inherent biological validity; TCC represents a surrogate marker of reality confusion, while post-extinction errors presumably reflect the underlying physiological mechanism behind reality confusion (Nahum et al., 2009; Schnider et al., 1996b).

2.4. Data analysis

2.4.1. Relation between the different forms of confabulation

To determine the relation between the four different forms of confabulation, we calculated Pearson correlations between the forms of confabulation for which continuous measures exist (total number of intrusions; total number of confabulations in the DBCQ and in the SQ), while group comparisons using the Mann–Whitney *U*-Test were made where patients were classified according to defined, non-continuous criteria (behaviourally spontaneous confabulation).

2.4.2. Mechanisms of confabulation and disorientation

To test for significant predictors of the different forms of confabulation and disorientation, we calculated Pearson correlations and applied stepwise regression models with the demographic data, the scores in the experimental tasks and neuropsychological tests (Table 4) as the independent variables. Where patients could be classified as "confabulators" and "non-confabulators" of the respective confabulation type (intrusions, behaviourally spontaneous confabulators), stepwise discriminant function analysis with the same variables as above was performed (forward selection; criterion for entering, $F \geq 4$).

Table 3
Confabulations produced by the participants. "Confabulations" denotes the total number of confabulations in the respective category: mean ± standard deviation (median). "Confabulators" denotes the number of patients producing more confabulations than the cut-off (highest accepted value) of the respective category per number of patients tested.

Type	Confabulations	Cut-off	"Confabulators"
Intrusions	3.6 ± 4.2 (2)	4	9/27
DBCQ, total	6.8 ± 5.7 (4)	0	19/19
DBCQ, episodic	6.1 ± 4.6 (4)	0	18/19
DBCQ, semantic	0.8 ± 1.6 (0)	0	5/19
SQ	0.6 ± 1.4 (0)	0	5/25
Behaviourally spontaneous confabulators		Behaviour yes/no	10/29

3. Results

3.1. Relation between the different forms of confabulation

Table 3 indicates the number of confabulations produced by the patients.

3.1.1. Intrusions versus momentary confabulations

Fig. 2 indicates that the total number of intrusions did not correlate with the total number of confabulations in the DBCQ ($R=0.22$, $P=0.39$, Fig. 2A) or the SQ ($R=-0.14$, $P=0.94$, Fig. 2B). There was a double dissociation between the two types of confabulation. The fantastic confabulator (patient 11, grey squares in Fig. 2) produced the highest number of confabulations in the questionnaires but only one intrusion in the CVLT, while several patients (patients 12, 16, 22, Table 1) who produced no or very few momentary confabulations produced massive intrusions.

3.1.2. Intrusions versus behaviourally spontaneous confabulation

The number of intrusions in the CVLT did not distinguish the group of behaviourally spontaneous confabulators (black dots in Fig. 2) from the other patients (empty circles in Fig. 2;

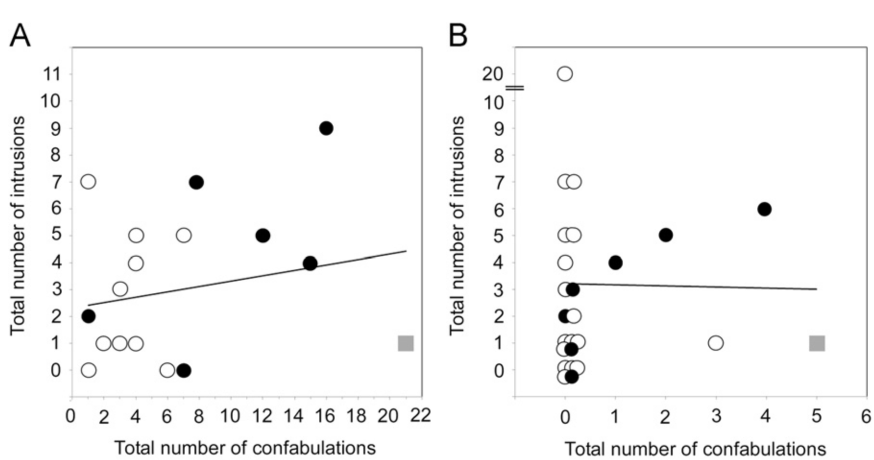

Fig. 2. Associations of intrusions (simple provoked confabulations). (A) Correlation between intrusions in the CVLT and confabulations in the DBCQ; (B) Correlation between intrusions in the CVLT and confabulations in the SQ. Black dots depict behaviourally spontaneous confabulators and empty circles the other patients. The grey square depicts the fantastic confabulator. CVLT, California verbal learning test (Delis et al., 1987); DBCQ, Dalla Barba's (1993b) confabulation questionnaire; SQ, semantic questionnaire (Schnider et al., 1996b).

Mann–Whitney U-Test, $U=56{,}5$ $P=0.21$). There was a double dissociation between these types of confabulation. Two behaviourally spontaneous confabulators produced one or no intrusion (patients 2 and 4, Table 1), while several patients (patients 12, 16, 22, Table 1) who were not behaviourally spontaneous confabulators, produced many intrusions.

3.1.3. Momentary confabulations versus behaviourally spontaneous confabulation

The total number of momentary confabulations in the DBCQ distinguished the group of behaviourally spontaneous confabulators from the other patients involved in the study (behaviourally spontaneous confabulators, 10 ± 5.2; other amnesics, 5 ± 5.3; Mann–Whitney U-Test, $U=17.5$, $P=0.04$). A finer analysis revealed that the patient groups only differed on confabulations in the episodic part of the DBCQ (behaviourally spontaneous confabulators, 8.7 ± 4.6; other amnesics, 4.5 ± 4.1; $U=18.5$, $P=0.047$), but not in the semantic part (behaviourally spontaneous confabulators, 1.3 ± 1.9; other amnesics, 0.5 ± 1.4; U-Test, $U=30.5$, $P=0.33$). When items testing orientation were not included in the analysis, the difference was not significant anymore (behaviourally spontaneous confabulators, 4.3 ± 4.2; other amnesics, 1.7 ± 4.2; $U=23$, $P=0.11$). The number of confabulations in the SQ did not distinguish the group of behaviourally spontaneous confabulators from the other patients involved in the study (behaviourally spontaneous confabulators, 1 ± 1.15; other amnesics, 0.4 ± 1.3; $U=45$, $P=0.28$). There was a double dissociation between the two types of confabulation: the fantastic confabulator (patient 11) and another patient (patient 27) produced many momentary confabulations but did not act according to them, while one behaviourally spontaneous confabulator (patient 6) produced only one momentary confabulation.

3.1.4. Fantastic confabulation versus the other forms of confabulation

Patient 11's production of intrusions was in the normal range ($n=1$), while he produced the highest number of momentary confabulations in the DBCQ (16 in the episodic domain and 5 in the semantic domain).

3.2. Mechanisms of confabulation

3.2.1. Intrusions (simple provoked confabulations)

A stepwise regression analysis with the number of intrusions in the CVLT as the dependent variable and demographic variables, the measures obtained in general testing, and performance in the reversal learning (post-extinction error rate, associative learning error rate) and memory selection tasks (item recognition, TCC), and total orientation score was performed (measures listed in Table 4). None of these variables had a significant association with the number of intrusions.

A stepwise discriminant function analysis distinguishing between patients producing a normal (≤ 4; 18 patients) or abnormal (>4; 9 patients) number of intrusions (Schnider et al., 1996b), including all variables listed in Table 4, detected no significant discriminator.

3.2.2. Momentary confabulations

There was a strong correlation between the DBCQ and the SQ ($R=0.69$; $P=0.004$), which remained significant when the semantic questions of the DBCQ were excluded from analysis ($R=0.59$; $P=0.02$). Likewise, confabulations in the episodic and the semantic part of the DBCQ correlated ($R=0.54$, $P=0.02$). Table 5 gives the detailed associations of the subcategories of the DBCQ and the SQ. The total number of confabulations in the DBCQ and in the SQ

Table 4
Correlations or comparisons between the different forms of confabulation and the scores of the neuropsychological evaluation and experimental tasks. U value obtained with the Mann Whitney test; R indicates Pearson's correlation coefficient. *denotes statistical significance at $P<0.05$; ** $P<0.01$; ***$P<0.001$. Significant scores in the stepwise regression analyses are indicated in bold. Abbreviations: BspC, behaviourally spontaneous confabulation; conf., confabulations; CVLT, California verbal learning test; DBCQ, Dalla Barba's confabulation questionnaire; TMT, trail making test; SQ, semantic questionnaire.

Forms of confabulation Tests	Provoked conf. (Intrusions) R value	Momentary conf. (DBCQ) R value	BSpC (patients 1–10 versus other patients) U value	Disorientation (questionnaire) R value	Fantastic conf. (patient 11)
Orientation	−.02	−.70**	4.5***		Impaired
Memory selection					
Item recognition	.16	−.21	83	.29	Impaired
TCC	.22	.69**	21***	**−.80*** **	Impaired
Reversal learning					
Association error rate	0.05	0.17	47.5*	−0.35	Preserved
Post-extinction error rate	−.04	.44	**11*** **	**−.79*** **	Impaired
Combined Reality filter score	.08	.62**	4***	−.88***	Impaired
TMT (time)					
Part A	−.26	.14	66.5	−.23	Impaired
Part B	−.4	.82***	22	−.58**	Impaired
Part B–Part A	−.37	**.86*** **	15.5*	−.60**	Impaired
Fluency (correct resp.)					
Phonological	.08	−.31	64.5	.28	Impaired
Semantic	.14	−.24	75	.26	Impaired
Non-verbal	.14	−.33	62.5	.2	Impaired
Digit span	−.24	−.22	79	.29	Preserved
Stroop (interference condition)					
Time	−.09	−.06	76	.04	Impaired
Error	.14	.08	66.5	−.16	Preserved
CVLT					
Immediate Free recall	.01	−.11	42.5	.46*	Impaired
Delayed free recall	.09	−.23	**22.5** **	**.57** *	Impaired
Proactive interference	−.19	.03	63	−.19	Impaired
Retroactive interference	.001	.16	68	−.11	Impaired
Recognition	−.1	.21	55	.14	Impaired
False positives	−.02	.12	51.5	−.39*	Impaired
SQ	−.01	.69**	45	−.32	Impaired

Table 5
Correlations of the number of confabulations in the DBCQ (total test, episodic domain, semantic domain) and in the semantic questionnaire with the scores of the neuropsychological evaluation and experimental tasks. Abbreviations: see Table 4.

Tests	DBCQ total	DBCQ episodic domain	DBCQ semantic domain	SQ
Orientation	−.70**	−.74***	−.34	−.32
Memory selection				
Item recognition	−.21	−.21	−.19	−.32
TCC	.69**	.69**	.45	.43*
Reversal learning				
Association error rate	.17	.14	.22	.19
Post-extinction error rate	.44	.46*	.22	.19
Combined Reality filter score	.62**	.62**	0.37	0.32
TMT (time)				
Part A	0.14	0.07	0.27	0.09
Part B	.82***	.80**	.72**	.61**
Part B–Part A	**.86*****	**.84*****	**.73****	**.70****
Fluency (correct resp.)				
Phonological	−.31	−.27	−.32	−.34
Semantic	−.24	−.24	−.14	−.31
Non-verbal	−.33	−.32	−.22	−.27
Digit span	−.22	−.33	.16	−.19
Stroop (interference condition)				
Time	−.06	−.05	−.07	−.04
Error	.08	.11	−.04	.04
CVLT				
Immediate Free recall	−.11	−.13	−.01	−.24
Delayed free recall	−.23	−.22	−.24	−.39
Proactive interference	.03	.09	−.18	.17
Retroactive interference	.16	.16	.09	.02
Recognition	.21	.23	.1	.11
False positives	.12	.13	.04	−.10

correlated strongly with the differential time in the trail making test (TMT B–A), but also with orientation and TCC, but not post-extinction errors. Stepwise regression analyses with the total number of confabulations in the DBCQ and in the SQ as the dependent variables and including the same independent variables as above (Table 4) retained TMT B-A as the sole significant variable. The slower the patients were in performing part B, the higher the number of confabulations was in the SQ ($F(1, 16)=15.7$, $P=0.001$) and in the DBCQ ($F(1, 17)=29.4$, $P=0.0002$). This variable explained 46% of the variance in the SQ and 70% in the DBCQ. Similar analyses limited to the episodic part ($F(1, 17)=22.3$, $P=0.0006$) and semantic part ($F(1, 17)=21.1$, $P=0.0007$) also retained only TMT B–A.

A finer analysis (Table 5) showed that while the correlation with TMT B–A was significant both for the episodic and semantic part of the DBCQ as well as the SQ, the correlation with orientation and TCC was limited to the episodic part. (Confabulations to "I don't know" questions were not analysed separately as they were extremely rare.)

As the SQ also measures a tendency to fill gaps in memory, an additional stepwise regression was performed with confabulations in the DBCQ as the dependent variable and adding confabulations in the SQ to the list of independent variables. The number of confabulations in the SQ ($F(1, 10)=39.4$, $P<0.001$) and the number of errors in the figural fluency task ($F(1, 10)=10.1$, $P=0.009$) were selected at first and second step. These predictor variables explained together 87% of the variance. A stepwise regression regarding the predictors of confabulations only in the episodic domain of the DBCQ selected the number of confabulations in the SQ ($F(1, 10)=24.3$, $P<0.001$) and the number of errors in the figural fluency task ($F(1, 10)=6.7$, $P=0.03$).

3.2.3. *Behaviourally spontaneous confabulation*

A group comparison including the same independent variables (see Table 4) showed that behaviourally spontaneous confabulators differed from the other amnesics both regarding post-extinction errors (confabulators, 74 ± 17%; other amnesics 24 ± 24%; Mann–Whitney *U*-Test, $U=11$, $P=0.0001$) and TCC score (confabulators, 0.52 ± 0.22; other amnesics, 0.18 ± 0.16; $U=21$, $P=0.0006$). In addition, they also differed on the orientation score (confabulators, 9.3 ± 2.8; other amnesics, 16.6 ± 2.3; $U=4.5$, $P<0.001$).

A stepwise discriminant function analysis was performed to determine which combination of the neuropsychological variables (same list of independent variables as above) would best classify the patients as behaviourally spontaneous confabulator (the grouping variable). Orientation came out as the only significant discriminator in an initial analysis ($F(1, 27)=56$; Wilks' $\lambda=1.0$; $P<0.0001$). It correctly classified 93% of patients (90% of confabulators, 95% of other amnesics). As orientation shares its main mechanism with behaviourally spontaneous confabulation and can be considered a continuous measure of the same disorder – impaired Reality Filtering (Nahum et al., 2009; Schnider et al., 1996c) – a second analysis excluding orientation was performed. This analysis selected post-extinction error rate at the first step ($F(1, 26)=25.7$; Wilks' $\lambda=0.69$; $P<0.001$) and the long delayed free recall ($F(1, 26)=7.2$; Wilks' $\lambda=0.44$; $P=0.012$) at second step as the best discriminators between behaviourally spontaneous confabulating patients and other patients. While TCC was highly significant on its own, it provided no additional predictive value beyond the post-extinction error rate. The final model using these 2 variables accurately assigned 100% of the patients with behaviourally spontaneous confabulation and 89% of the other patients to the correct group (93% of the patients correctly classified).

When post-extinction error rate and TCC were replaced by their combined score (reality filtering score), the analysis selected the combined reality filtering score ($F(1, 26)=32.3$; Wilks' $\lambda=0.69$; $P<0.0001$) at first step and the long delayed free recall ($F(1, 26)=7.2$; Wilks' $\lambda=0.36$; $P=0.045$) at second step. The two variables accurately assigned 90% of the patients (90% of the confabulators; 89% of the other patients).

3.2.4. *Disorientation*

Orientation did not significantly correlate with intrusions ($R=-0.02$; $P=0.91$) or with confabulations in the SQ ($R=-0.32$; $P=0.11$) but correlated with the total number of confabulations in the DBCQ ($R=-0.7$; $P=0.001$). When the items testing orientation in the DBCQ were excluded, the correlation was reduced but remained significant ($R=-0.58$; $P=0.009$). On a finer scale, orientation correlated only with the number of confabulations in the episodic part of the DBCQ ($R=-0.74$; $P<0.001$) but not in the semantic part ($R=-0.34$; $P=0.15$; Table 5).

Orientation clearly separated behaviourally spontaneous confabulators from other amnesics (Mann–Whitney *U*-Test, $U=4.5$, $P<0.001$; Fig. 3).

As to the mechanisms, orientation strongly correlated with TCC ($R=-0.80$; $P<0.0001$) (Fig. 3A and B) and with post-extinction error rate in the reversal learning task ($R=-0.79$; $P<0.0001$). Fig. 3C shows that the combined reality filtering score (post-extinction error rate+TCC) improved the strong association with orientation ($R=-0.89$, $P<0.0001$).

A stepwise regression analysis including the same independent variables as in the previous analyses (list in Table 4) indicated that the best model to predict total orientation score comprised post-extinction error rate ($F(1, 14)=20.58$, $P<0.001$), which explained 60% of the total orientation score, then TCC ($F(1, 14)=8.6$; $P=0.01$) and long delayed free recall ($F(1, 14)=5.6$, $P=0.03$), which accounted, respectively, for 15% and 5% additional unique variance of orientation.

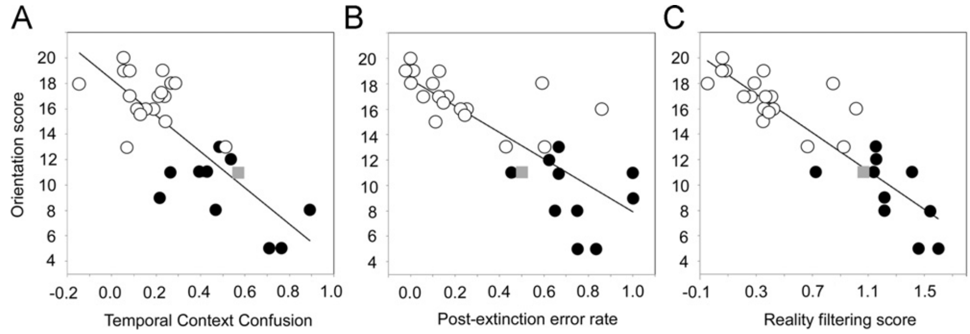

Fig. 3. Correlation of orientation, (A) with TCC, (B) with post-extinction rate, and (C) with the combined reality filtering score (TCC + post-extinction rate). Black dots depict behaviourally spontaneous confabulators and empty circles the other patients. The grey square depicts the fantastic confabulator. TCC, temporal context confusion.

Post-extinction error rate and TCC correlated with each other in the whole group of participants ($R=0.59$; $P=0.001$).

3.2.5. *Fantastic confabulations*

Patient 9, the only patient with fantastic confabulations (grey square in Fig. 3), had a similar total orientation score (11/20), memory selection score (TCC, 0.57) and post-extinction error rate (50%) as the behaviourally spontaneous confabulators (orientation score, 9.3 ± 2.8; TCC $= 0.52 \pm 0.22$; post-extinction error rate $= 74 \pm 17\%$). In addition, he had very severe memory and executive failures (Table 2).

4. Discussion

This study confirms dissociation between some forms of confabulation and associations between others. Intrusions (simple provoked confabulations) dissociated from all other forms. Momentary confabulations, behaviourally spontaneous confabulation (with disorientation), and fantastic confabulation shared some elements with each other. Deficient reality filtering was strongly predictive of behaviourally spontaneous confabulation and disorientation, and was one of three predictors of momentary confabulations. The results call for a more fine grained classification of confabulations than proposed by simple dichotomies (Bonhoeffer, 1901; Kopelman, 1987) and they are incompatible with the interpretation of confabulation as a unique entity varying only in severity (DeLuca & Cicerone, 1991; Fischer, Alexander, D′Esposito, & Otto, 1995).

The term provoked confabulations was originally proposed to describe a mode of evocation (Pick, 1905) but recently received the connotation of false productions in memory tests (Kopelman, 1987), in particular intrusions in verbal recall (Schnider et al., 1996b), which is the measure used in the present study. In healthy subjects, intrusions can be promoted by interference at encoding, suggesting that a weak memory trace may be a prerequisite for the occurrence of intrusions (Dalla Barba et al., 2002). Overall, intrusions are more frequent in brain-damaged than healthy subjects, irrespective of lesion site (Borsutzky, Fujiwara, Brand, & Markowitsch, 2008; Schnider, 2008), and correlate with general memory and executive failures (Cunningham et al., 1997). Within a sample of patients with comparable memory deficit, however, they do not correlate with the severity of other cognitive failures (Schnider et al., 1996b), a finding confirmed in the present study. On the contrary, a previous study (Schnider et al., 1996b) found an association with relatively better performance in memory and fluency tests, indicating that intrusions reflect a particularly strong effort to retrieve more information from memory than actually available. While the present study does not specifically support this notion, it shows that intrusions provoked by the request to recall a word list dissociate from false answers provoked by questions or a discussion, that is, momentary confabulations. Thus, "provoked confabulations" appears to be an expression with little value in terms of underlying mechanism. It is necessary to specify the type of provoked confabulations, namely, "intrusions" (or simple provoked confabulations) or "momentary confabulations" in order to acknowledge the dissociation between the two. Similar to previous observations, intrusions had no association with behaviourally spontaneous confabulation (Schnider et al., 1996b) or disorientation.

The present study did not reveal a universal mechanism for momentary confabulations, a result compatible with the clinical observation that these confabulations may occur at different stages of diverse memory disorders due to varying lesions, although they are particularly frequent after anterior inferior brain lesions (Gilboa & Moscovitch, 2002; Schnider, 2008). The term "momentary confabulations" was originally proposed for statements and remarks that patients made – spontaneously or provoked by questions – to fill gaps in memory in order to avoid embarrassment in a discussion or upon questioning (Bonhoeffer, 1901). More recently, it was proposed to describe an "invariably provoked" form of false autobiographical memory recollection referring to the recent past and composed of "true memory displaced in time" (Berlyne, 1972). With regards to the classification of confabulations proposed here, momentary confabulations might also be considered "verbal expressions of false memories", in comparison to "false acts based on false memories", which characterize behaviourally spontaneous confabulations. The use of questionnaires to explore it is relatively recent (Dalla Barba, 1993a). Other authors analysed the recall of personal and semantic events in response to cue words (Moscovitch & Melo, 1997) or the detailed recall of tales and bible stories (Attali, De Anna, Dubois, & Dalla Barba, 2009; Gilboa et al., 2006).

The present study reveals associations between momentary confabulations and diverse cognitive measures. First, total confabulations in the 2 questionnaires and confabulations in the episodic and semantic subcategories correlated with the differential time of the trail making test (part B–part A, TMT B–A), an indicator of task switching ability (Sanchez-Cubillo et al., 2009). Earlier studies testing patient groups which were not matched with regards to the severity of amnesia also indicated an association between executive failures and momentary confabulations (Cunningham et al., 1997; Fischer et al., 1995; Moscovitch & Melo, 1997). Thus, a certain proportion of momentary confabulations are associated with executive failures, such as, impaired mental flexibility. Second, our data provide some empirical support for an age-old proposition, namely, that momentary confabulations may reflect a tendency to fill gaps in memory (Bonhoeffer, 1901; Pick, 1905): confabulations in the SQ, which contains items for which subjects have a mandatory gap in memory, significantly correlated with false responses in the DBCQ, even when the semantic part of the latter was excluded from analysis. The observation does not allow one to decide whether this tendency results from an urge to avoid embarrassment (Bonhoeffer, 1901), possibly reflecting personality traits (Williams & Rupp, 1938), from an attempt to embellish an uncomfortable state of illness (Flament, 1957; Fotopoulou et al., 2008a, 2008b) or, as Pick (1921) suggested, from an unconscious physiological process by which lacunes in memory are automatically filled similarly to the filling of the blind spot in vision. A tendency to fill gaps in memory might also be facilitated by deficient monitoring processes of memory retrieval, which are at the heart of diverse hypotheses of confabulation (Burgess & Shallice, 1996; Gilboa et al., 2006; Johnson & Raye, 1998; Moscovitch & Melo, 1997). Thus, a certain proportion of momentary confabulations appear to reflect a tendency, conscious or not, to fill gaps in memory. Third, momentary confabulations in the DBCQ were associated with disorientation and, accordingly, one of the measures of reality filtering, increased TCC. This association, however, only held for the episodic part of the DBCQ and when items of orientation contained in the DBCQ remained in the analysis. The result is compatible with the clinical fact that behaviourally spontaneous confabulators produce confabulations in response to questions about their recent doings or plans, that is, they produce momentary confabulations. In the present study, behaviourally spontaneous confabulators produced more momentary confabulations than other amnesics. This result may reflect the fact that our patients were hospitalized after a first-time brain damage at the time of study, thus mostly including severely impaired subjects. Results might differ in patients with chronic degenerative (Joray, Herrmann, Mulligan, & Schnider, 2004) or psychiatric disorders. The finding also gives support to temporal hypotheses of momentary confabulations (Dalla Barba, 2002; Dalla Barba et al., 1997; Talland, 1961; Van der Horst, 1932), although none of these proposals was substantiated by experimental data. However, insofar as TCC can be considered a measure relevant for the temporal hypotheses, our present data indicate that this mechanism only holds for a limited proportion of patients with momentary confabulations, namely, those with additional signs of reality confusion: inappropriate acts and disorientation.

A challenge for future studies will be to develop experimental approaches to further dissect momentary confabulations. It is likely that significant semantic confabulations have a different mechanism than episodic ones. For example, even patients with extremely severe reality confusion and confabulations need not make any confabulation in the semantic domain (Nahum et al., 2010). While the present study pointed to three partial mechanisms, a more fine grained analysis of different instances of momentary confabulations according to the mode of evocation (provoked, spontaneous), the memory domain concerned (episodic, semantic), or accompanying specific cognitive disorders might allow better characterization of sub-forms with possibly distinct mechanisms.

The present study reproduces previous observations on behaviourally spontaneous confabulation (Nahum et al., 2009, 2010; Ptak et al., 2001; Ptak & Schnider, 1999; Schnider & Ptak, 1999; Schnider et al., 1996b, 1996c). It was again strongly associated with disorientation and shared the mechanism with the latter: a failure of reality filtering. Reality filtering, as measured by the extinction capacity task, together with long term memory as measured by delayed free recall, best classified patients as behaviourally spontaneous confabulators. The capacity to suppress the interference of memories that do not pertain to current reality (memory selection task, TCC) was similarly strong in sorting out behaviourally spontaneous confabulators but did not significantly augment the separating power of extinction capacity.

Amnesia is a common feature of behaviourally spontaneous confabulation (Schnider, 2003, 2008; Schnider et al., 1996b). Although all patients of this study were severely amnesic, differences between patients' performance in the CVLT were still large enough to separate behaviourally spontaneous confabulators from the other amnesic patients. This finding may explain why TCC alone, and probably also extinction capacity alone, may not be an entirely reliable predictor of behaviourally spontaneous confabulation when disregarding the severity of amnesia (Gilboa et al., 2006). Trail-making B–A also separated between the groups in a separate analysis (Table 3) but did not further contribute to the separating power of extinction capacity and free recall. In previous group studies, executive dysfunctions did not separate behaviourally spontaneous confabulators from other amnesics (Nahum et al., 2009; Schnider, 1997; Schnider & Ptak, 1999; Schnider et al., 2000a, 1996b) and did not significantly correlate with disorientation (Nahum et al., 2009; Schnider et al., 1996c). Thus, while executive dysfunction is an important variable for the occurrence of momentary confabulations in general, it is a weak predictor of reality confusion in patients matched for the severity of their amnesia.

Both reality filtering measures were significantly associated. Nonetheless, adding the two measures into a combined Reality filter score modestly improved the classification of patients as behaviourally spontaneous confabulators and the prediction of disorientation. Both measures have many similar characteristics: they depend on the orbitofrontal cortex (Nahum, Gabriel, & Schnider, 2011a; Schnider et al., 2000b; Schnider, Treyer, & Buck, 2005) and are cortically expressed by a positive evoked potential over frontal electrodes at 200–300 ms (Nahum et al., 2011a; Schnider, Mohr, Morand, & Michel, 2007; Schnider et al., 2002; Wahlen et al., 2011). We suggest that our memory selection task is a surrogate marker of a memory capacity that is crucial for filtering memories that do not pertain to reality, while the extinction task taps the underlying physiological mechanism of reality filtering (Nahum et al., 2009; Schnider, 2008).

Fantastic confabulation is a rare phenomenon and may reflect the combination of multiple, severe failures of memory and cognitive control (Fig. 4). The present study, albeit having only one patient, shows that fantastic confabulation is independent from intrusions in a memory test (simple provoked confabulations). By contrast, our patient produced more momentary confabulations than the majority of other patients and was severely deficient on most cognitive measures (Table 2). Indeed, the rare fantastic confabulators described in recent years produced unrealistic stories particularly in response to questions (Feinstein, Levine, & Protzner, 2000; Gundogar & Demirci, 2006; Kapur & Coughlan, 1980). But there have also been descriptions of psychotic patients who spontaneously produced the wildest, most abstruse confabulations, with no obvious incitation (Kraepelin, 1887/88). Fantastic confabulations remain a rare phenomenon that appears to betray severe, general cognitive failure.

The present study indicates a complex relationship between the proposed forms of confabulations. Fig. 4 tries to depict it. Intrusions constitute a separate entity, which may at least partly reflect the effort to retrieve memories despite a weak trace (Schnider et al., 1996b). Momentary confabulations are the verbal expression of false memories and may have diverse mechanisms. The present study points to executive dysfunction (TMT B-A), similar to earlier studies (Baddeley & Wilson, 1988; Cunningham et al., 1997; Fischer et al., 1995; Moscovitch & Melo, 1997; Nys et al., 2004), a tendency to fill gaps in memory, as proposed by the early authors (Bonhoeffer, 1901; Flament, 1957; Pick, 1905, 1921), and deficient reality filtering. Other mechanisms may play a role but were not explored in this study: personality traits – e.g., talkativeness, perfectionism, extroversion – (Flament, 1957; Weinstein & Lyerly, 1968; Williams & Rupp, 1938), and deficient memory and source monitoring (Burgess & Shallice, 1996; Gilboa et al., 2006; Johnson, 1991; Johnson & Raye, 1998; Moscovitch, 1989, 1995; Moscovitch & Melo, 1997).

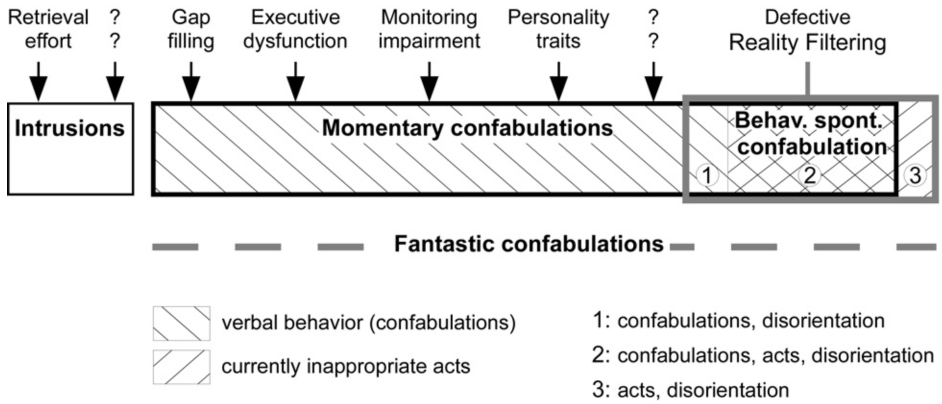

Fig. 4. Relationship between the proposed forms of confabulation and their mechanisms. The grey rectangle describes the scope of disorders emanating from deficient reality filtering. Fantastic confabulations are proposed to emanate from a combination of multiple, severe cognitive failures.

Behaviourally spontaneous confabulation holds a special role as it has a distinct mechanism: deficient reality filtering, as again confirmed in the present study. It overlaps with momentary confabulation: most patients have the combination of momentary, typically episodic confabulations, inappropriate acts, and disorientation, as the patients in the present study (group 2 in Fig. 4). In this case, deficient reality filtering is also the putative cause of the confabulations, which are the patients' honest account of their falsely perceived reality. Occasional patients with impaired reality filtering, as measured with the tasks used in this study, may not act according to their confabulations or too inconsistently to be discovered (group 1 in Fig. 4) (Schnider et al., in press). Other, rare patients, who fail in the reality filtering tasks, are disoriented, act in a way incompatible with their hospitalization, but hardly communicate or respond to questions; they do not confabulate (group 3 in Fig. 4) (Schnider, 2008). Thus, we suggest that deficient reality filtering is one specific cause of momentary confabulations, but that deficient reality filtering may occasionally cause reality confusion that the patients do not express in confabulations or in inappropriate acts.

Orbitofrontal reality filtering is a distinct limbic contribution to memory processing, necessary to keep thought in phase with reality. Studies conducted until now dealt with severely amnesic patients or applied difficult versions of the reality filtering tasks in healthy subjects. Reality filtering may be deficient in active psychosis (Waters, Badcock, Maybery, & Michie, 2003). In healthy subjects, inter-individual differences are considerable, but the behavioural correlate of these differences is unknown (Schnider et al., 2010). More studies, also involving people with lesser degrees of amnesia, will be necessary to understand the full scope of capacities and disorders dependent on orbitofrontal reality filtering.

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