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1 **Emotional specificities of autobiographical memory after breast cancer diagnosis**

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26

27 **Abstract**

28

29 Cancer involves stressful events. One aspect of cognition that is impacted by stress is episodic  
30 autobiographical memory (EAM). EAM is intimately linked to self-representation. Some  
31 studies have revealed impairment of EAM in patients with breast cancer in remission. Yet,  
32 these studies failed to differentiate between the influence of adjuvant treatments and that of  
33 psychosocial factors. We therefore assessed the psychological impact of breast cancer  
34 diagnosis on EAM and self-representation profiles prior to any adjuvant treatment. Patients  
35 newly diagnosed with breast cancer ( $n=31$ ) and women without any history of cancer ( $n=49$ )  
36 were compared on state anxiety, EAM and its emotional characteristics, and self-  
37 representations. The most anxious patients retrieved fewer emotional details for memories  
38 than the controls, and had lower self-representation scores than the least anxious patients, who  
39 had no deficits in emotional detail retrieval. Our results revealed distinct EAM profiles for  
40 patients, reflecting two contrasting modes of coping with breast cancer.

41

42 **Keywords:** breast cancer, period of diagnosis, state anxiety, autobiographical memory, self-  
43 representations

44

## 45 1. INTRODUCTION

46 A growing body of research focuses on cognitive functioning in non-central nervous system  
47 (non-CNS) cancers, mainly in breast cancer. Complaints concern memory, attention or  
48 concentration problems which are mostly quite subtle, although they strongly affect patients'  
49 quality of life. Studies report cognitive deficits during and after completing adjuvant  
50 chemotherapy, often referred to as *chemobrain* (Wefel & Schagen, 2012), but many of the  
51 recent prospective studies report performances below normal scores even before adjuvant  
52 treatment has begun (Ahles *et al.* 2008; Quesnel *et al.* 2009; Cimprich *et al.* 2010; Wefel *et al.*  
53 2010). These results suggest that, in addition to the aggressive effects of chemotherapy,  
54 combinations of biological and medical factors, such as side-effects of surgery and anesthesia,  
55 could also play a role in patients' cognitive impairment (Joly *et al.* 2011). Furthermore, due to  
56 the diagnosis of a life-threatening illness, cancer involves many stressful events that may lead  
57 to psychosocial changes (state anxiety and self-representations), and in some cases, to  
58 psychiatric symptoms, such as those reported in post-traumatic stress disorder (PTSD) or in  
59 major depression.

60 Such psychological distress may have adverse effects on cognition, and one aspect of  
61 cognition that is particularly vulnerable to stress-related symptoms is autobiographical  
62 memory (e.g. St Jacques *et al.* 2013). Autobiographical memory refers to personally relevant  
63 events extended over time and is important for grounding and modifying personal identity as  
64 it enables one to construct a sense of identity and continuity over time (Conway & Pleydell-  
65 Pearce, 2000). A bidirectional relationship exists between autobiographical memory and self-  
66 representations: while autobiographical memory plays a fundamental role in the formation of  
67 self-representations, inversely, retrieval of the past is influenced by the current self, known as  
68 the working self (i.e., one's current beliefs, goals and self-images; Conway, 2005; Klein &  
69 Lax, 2010). The Self-Memory System (SMS, Conway & Pleydell-Pearce, 2000) emphasizes

70 this interrelationship between self and memory. Autobiographical representations are  
71 organized hierarchically along three levels: from lifetime periods (extended over long periods  
72 of time), to generic events (repeated or extended in time), and lastly event-specific knowledge  
73 (contains specific episodic memories). This last level refers to episodic autobiographical  
74 memory (EAM) which supports our capacity to re-experience personal past events (i.e., to  
75 mentally travel in time) with their specific details, such as the spatiotemporal context, factual  
76 and emotional descriptions (Tulving, 2002; Piolino *et al.* 2009) (e.g., “I remember the  
77 moment when Mr O. asked me to sit at his desk to look at my tests. I felt anxious when he  
78 said he had the results. It was in December.”). The SMS proposes an explanation concerning  
79 the voluntary retrieval of EAM when assessed using a semi-structured interview such as the  
80 Autobiographical Memory Task (AMT, Williams & Broadbent, 1986) or the TEMPau task  
81 (for *Test Episodique de la Mémoire du Passé autobiographique*; Piolino *et al.* 2003).  
82 Generative retrieval provides controlled access to event-specific knowledge via the personal  
83 semantic knowledge base (lifetime periods and generic events). This generative retrieval  
84 process relies on both executive functions and the working self, which acts as a moderator  
85 between the demands of correspondence (memory should correspond to experience and  
86 reality) and coherence (memory should be consistent with one’s current goals, self-images  
87 and beliefs) in the formation of memories (Conway *et al.* 2004).  
88 Numerous studies have focused on autobiographical memory functioning in stress-related  
89 disorders. When asked to retrieve a specific episodic life event, depressed or traumatized  
90 patients with PTSD or acute stress disorder (ASD) instead tend to recall broader, repeated and  
91 generic events with no specific details, i.e. overgeneral memories (see Moore & Zoellner,  
92 2007; Sumner *et al.* 2010; Williams *et al.* 2007 for reviews). Based on the SMS,  
93 overgenerality occurs when the generative retrieval search process is aborted prematurely,  
94 before reaching the level of event specific knowledge (e.g., Haque *et al.* 2014). This

95 phenomenon may rely on the interaction between executive dysfunction (deficits in executive  
96 resources limit the ability to conduct a successful retrieval search) and the current self.  
97 According to the CaR-FA-X model (capture and rumination, functional avoidance, and  
98 impaired executive control) proposed by Williams *et al.* (2007), overgeneral memories and  
99 avoidance of intrusive memories contribute to protect the self against specific stressful  
100 memories by decreasing the likelihood of any episodic recollection, as a means of affect  
101 regulation. The model also postulates that overgeneral memories occur when the generative  
102 retrieval search process is aborted as a result of two other mechanisms: capture and  
103 rumination (capture at a general autobiographical level which occurs particularly in  
104 individuals prone to rumination) and impaired executive control (e.g. inhibition and working  
105 memory capacity) which play a role in the strategic retrieval of a specific memory (see  
106 Sumner, 2012).

107 Deeber *et al.* (2012) suggest that the functional avoidance hypothesis might not only be  
108 proposed to explain overgeneral memories in depressed and traumatized patients, but also for  
109 healthy individuals, i.e. without psychiatric disorders. The authors observed that confronting  
110 healthy subjects with an acute stressor increases memory overgenerality, although this  
111 observation depends on the individual's general tendency to engage in (cognitive) avoidant  
112 coping. Thus, overgenerality could be a form of cognitive avoidance strategy used in a  
113 flexible way by nonclinical individuals only under certain conditions (Hermans *et al.* 2008).  
114 These studies suggest that reduced memory specificity for certain unpleasant events may be a  
115 natural and healthy coping strategy in individuals without psychiatric diagnoses. Indeed,  
116 autobiographical memory dysfunction—specifically overgenerality—has also been reported  
117 in specific medical populations (e.g., tinnitus patients, Andersson *et al.* 2013), patients with  
118 chronic pain (Liu *et al.* 2014), or in life-threatening illnesses such as patients with HIV (e.g.,  
119 Abdollahi *et al.* 2012), but some of these patient groups were associated with psychiatric

120 disorders like depression or PTSD.

121 In non-CNS cancer, a life-threatening illness in which psychological turmoil may occur,  
122 autobiographical memory impairment has also been observed (see Giffard *et al.* 2013, for a  
123 detailed review). In early studies, autobiographical memory overgenerality observed in  
124 groups of patients with different types of cancer (breast, gastro-intestinal, lung, etc.) was also  
125 found to be related to major depression or PTSD (Brewin *et al.* 1998; Kangas *et al.* 2005).  
126 However, in comparison studies with healthy controls without any history of cancer,  
127 autobiographical memory overgenerality has also been observed in breast cancer patients who  
128 are in remission and have no stress-related psychiatric disorders (Nilsson-Ihrfelt *et al.* 2004;  
129 Bergouignan *et al.* 2011). In these two studies, patients were assessed several months after the  
130 end of adjuvant treatment (i.e., these patients had undergone surgery, chemotherapy and  
131 radiotherapy, and sometimes hormonal therapy, too). Thus, no clear distinction can be drawn  
132 between the influence of aggressive adjuvant treatments and the impact of breast cancer  
133 diagnosis and its attendant psychosocial (state anxiety and self-representations) factors. The  
134 diagnosis of this life-threatening illness exposes women to the cumulative effects of short-  
135 and long-term stressful life events such as subsequent surgery associated with pain and  
136 modified body image, accepting the possibility of death, uncertainty about the future, and  
137 awaiting consecutive adjuvant treatment such as chemotherapy (Pucheu, 2004; Carver *et al.*  
138 2005; Caron *et al.* 2007; Baize *et al.* 2008; McGregor & Antoni, 2009). A poor body image  
139 resulting from cancer treatments has been shown to be associated with psychological distress  
140 (Przedziecki *et al.* 2013), and may lead to dissatisfaction with oneself (Stokes & Frederick-  
141 Recascino, 2003). The many different stages in this life-threatening illness may trigger or  
142 heighten state anxiety and modify self-representations.

143 No study to date has investigated the relationship between state anxiety, EAM and modified  
144 self-representations after a diagnosis of breast cancer and subsequent surgery, but before

145 adjuvant treatments. Yet, it is crucial to understand the impact of the cancer diagnosis period  
146 on these factors, and the adaptive processes these patients adopt to cope with this life-  
147 threatening illness.

148 The objective of the present study was to assess the psychological impact of cancer diagnosis  
149 on EAM retrieval, measured with a semi-structured interview, and on self-representations. To  
150 this end, we compared patients with breast cancer who were yet to undergo adjuvant treatment  
151 and healthy controls, assessing the main psychological variables that might interfere with  
152 EAM, specifically state anxiety.

153

## 154 **2. METHODS**

### 155 **2.1 Participants and Procedure**

156 Thirty-one women who had been newly diagnosed with breast cancer took part in this study.  
157 Patient inclusion criteria were: (i) at least 45 years old; (ii) no metastatic breast cancer; (iii)  
158 after surgery (tumorectomy or mastectomy) but before chemotherapy (5 Fluorouracil,  
159 Epirubicin, Cyclophosphamide and Docetaxel) and, if necessary, radiotherapy and/or  
160 hormonal therapy; (iv) no major psychiatric disorder before or during breast cancer diagnosis,  
161 according to the criteria of the DSM-IV (Mini-International Neuropsychiatric Interview), and  
162 absence of depressive state, as measured with the abridged version of the Beck Depression  
163 Inventory (BDI; Beck *et al.* 1961); (v) no neurological disease; (vi) no drug use or alcohol  
164 abuse; and (vii) no global cognitive impairment according to the criteria of the Mini Mental  
165 Status Examination (Kalafat *et al.* 2003). Seventy-one patients were preselected on these  
166 criteria at the medical oncology department of the François Baclesse Centre in Caen (France).  
167 Subsequently, participants were contacted to schedule an appointment for our longitudinal  
168 study with cognitive, EAM and psychosocial assessments, as well as MRI scanning sessions  
169 (data not provided in this study) before and after chemotherapy treatment. Of the 71 patients



170 eligible for the study, 22 patients declined their participation for several reasons: fear of the  
171 MRI scanning sessions, length of the longitudinal study, or lack of interest. Ten patients could  
172 not participate because time was too short prior to chemotherapy to conduct all assessments  
173 (professional commitments or MRI scanner availability). The reason was not known for eight  
174 patients. Finally, 31 patients participated in this study (44% agreement rate). All of them  
175 provided written informed consent to the study, which was conducted in accordance with the  
176 Declaration of Helsinki and approved by the local ethics committee.

177 The control group consisted of 49 healthy women. Inclusion criteria were the same for  
178 controls as they were for patients, with the additional criterion of no cancer history past or  
179 present.

180 All participants were fluent in French. Anxiety, cognitive, EAM, and self-representation  
181 assessments (detailed below) were administered in a quiet room, in the same conditions for  
182 both patients and controls. The assessments were proposed over two sessions lasting 1h30  
183 each.

## 184 **2.2 Anxiety assessment**

185 Two questionnaires assessed the presence of anxiety on the basis of the State-Trait Anxiety  
186 Inventory (STAI; Spielberger *et al.* 1970). State anxiety is a measure of situational anxiety,  
187 with participants being asked to respond based on “how you feel right now” (corresponding to  
188 the period of breast cancer announcement for our patients). Trait anxiety is a measure of a  
189 general tendency to be anxious, with participants being asked to respond based on “how you  
190 generally feel”. Each subscale consists of 20 items scored on a four-point Likert-like scale.  
191 Subscale scores range from 20 to 80, with higher scores indicating greater anxiety.

## 192 **2.3 Cognitive assessment**

193 Neuropsychological tests were administered to all participants to assess their cognitive  
194 abilities: two tests of verbal and visual episodic memory processes that had previously been

195 developed in our laboratory, based on the Encoding, Storage, Retrieval (ESR) paradigm  
196 (Eustache *et al.* 1998; Chételat *et al.* 2003; Fouquet *et al.* 2012), the Digit Span Backward,  
197 Letter-Number Sequencing and Arithmetic subtests of the Wechsler Adult Intelligence Scale  
198 (WAIS; Wechsler 2008), the Trail Making Test (TMT) Parts A and B (Reitan, 1992), formal  
199 and semantic verbal fluency (Cardebat *et al.* 1990), and the d2 Test of Attention  
200 (Brickenkamp & Zillmer, 1998).

201 To obtain more robust proxies of cognitive abilities and minimize the issue of multiple  
202 statistical testing, six composite cognitive scores were computed, based on a procedure  
203 described elsewhere (La Joie *et al.* 2014). Performances were Z-transformed and combined  
204 (before averaging,  $z$  scores derived from reaction times and errors were reversed so that  
205 increasing values always indicated better performances). The episodic memory encoding and  
206 retrieval scores were derived from two tests assessing verbal and visual processes, the first  
207 one featuring a list of 16 words (verbal episodic memory), the second a list of eight  
208 nonfigurative graphic signs (visual episodic memory). We used recognition performances for  
209 verbal and visual items that had been superficially and incidentally encoded as a proxy for  
210 encoding abilities (Encoding episodic memory task), and free recall performances for verbal  
211 and visual items that had been deeply and intentionally encoded as a proxy for retrieval  
212 abilities (Retrieval episodic memory task). The total scores on the Digit Span Backward, total  
213 score in Letter-Number Sequencing and Arithmetic subtests were summed to form a working  
214 memory score. Similarly, we combined performances on the TMT (time difference between  
215 Parts B and A, and Part B perseverative errors) and formal and semantic verbal fluency  
216 (number of words beginning with “p” and number of words in the “animals” category  
217 produced in 2 min) to form an executive function score. We summed the time taken to  
218 perform the TMT Part A and the total number of items crossed out within the time limit in the  
219 d2 Test of Attention to obtain a processing speed score. Finally, attentional errors in Parts A

220 and B of the TMT and errors (where participants crossed out a d without two dashes or failed  
221 to cross out a d with two dashes) in the d2 Test of Attention were combined to form an  
222 attentional error score.

#### 223 **2.4 EAM assessment**

224 The EAM assessment took the form of a semi-structured interview developed and validated  
225 by Piolino *et al.* (2002, 2007, 2009): the *Test Episodique de Mémoire du Passé*  
226 *autobiographique* (TEMPau) test. The TEMPau consists in asking participants to retrieve one  
227 specific, detailed event situated in time and space for each of a number of different lifetime  
228 periods. Unlike the Autobiographical Memory Test (AMT, Williams & Broadbent (1986)),  
229 the TEMPau is not time limited. Patients had to retrieve one event from each of following  
230 three lifetime periods: 18-30 years old (*reminiscence bump* period), the last 2 years except for  
231 the last 6 months (*before cancer* period) and the last 6 months (*cancer* period). To compare  
232 them with the control group, patients were instructed to retrieve an event that was not related  
233 to cancer from the *cancer* period. We gave participants a very precise definition of a specific  
234 EAM, that is, a unique event lasting less than a day, located precisely in time and space,  
235 which can be recalled with factual (people, dialogues and anecdotes) and emotional (feelings,  
236 sensations, perceptions) details. In order to collect spontaneous memories only, no cue-word  
237 was given to retrieve memories from the different lifetime periods.

238 Each lifetime period recollection was audiotaped and transcribed verbatim. For each memory  
239 with at least characteristics of uniqueness and short duration (<24h), we then scored the  
240 factual, spatial, temporal and emotional specific details, attributing one point to each detail  
241 that was retrieved. Two independent raters assessed the specific details of each event provided  
242 by participants. There was an interrater agreement rate of 72% ( $\kappa = 0.61$ ,  $p < 0.001$ ). Every  
243 conflicting result was re-examined until a consensus was reached.

244 We calculated the following EAM scores:

- 245 - Three overall scores, one for each lifetime period (/4): we summed the scores for  
246 specific details (factual, spatial, temporal and emotional) for each lifetime period  
247 (remembrance bump, *before cancer* and *cancer*);
- 248 - Four specific detail scores (/3): we summed the scores for each type of specific detail  
249 (factual, spatial, temporal and emotional) across the three lifetime periods  
250 (remembrance bump, *before cancer* and *cancer*).

251 Immediately after an event had been retrieved, we asked participants to rate the emotional  
252 characteristics of their recollection on two Likert-like scales:

- 253 - Emotional valence scale ranging from 0 (*Unpleasant event*) to 5 (*Pleasant event*);
- 254 - Emotional intensity scale ranging from 0 (*Low intensity*) to 5 (*High intensity*).

255 For both assessments, patients rated the emotions they had experienced when the event  
256 originally took place (i.e., at encoding) and the emotions they experienced when they related  
257 that event to the experimenter (i.e., at retrieval).

## 258 **2.5 Self-representation assessment**

259 Self-representations were assessed with the Questionnaire of Self-Representations (QSR)  
260 (Duval *et al.* 2012). This questionnaire incorporates some of the main and recurrent items of  
261 several commonly used self-concept scales, such as the Tennessee Self-Concept Scale 2  
262 (TSCS2; Fitts & Warren, 1996), the Revised Self-Consciousness Scale (RSCS; Scheier &  
263 Carver, 1985) and the Self-Concept Clarity Scale (SCCS; Campbell *et al.* 1996). Participants  
264 have to rate 50 positive or negative descriptive statements (e.g., “I am an honest person”, “I  
265 do not feel at ease with other people”) for self-descriptiveness on a 4-point Likert-like scale  
266 ranging from 1 to 4 (1: *Does not describe me at all*; 2: *Describes me a little*; 3: *Describes me*  
267 *well*; 4: *Describes me absolutely*). Each statement belongs to a particular category of self-  
268 representation (e.g., physical, moral-ethical, personal, family, social, cognitive and  
269 emotional).

270 First, QSR internal validity was controlled for each participant. Validity scores allowed us to  
271 take into account response biases, such as response conflict (difference between responses to  
272 affirmative or negative statements), response incoherence (wide discrepancy between  
273 responses to pairs of items with similar content) and social desirability (giving a favourable  
274 impression). The first two biases were calculated on the basis of the 50 QSR items, and the  
275 latter using the validated lie subscale of Coopersmith's Self-Esteem Inventory (Coopersmith,  
276 1984). Next, we focused on two main scores: certainty and valence. We postulated that these  
277 scores might change following the breast cancer announcement, owing to negative stressful  
278 events and disruption of the daily routine. The certainty of self-concept score is an index of  
279 the stability of self-knowledge trait, as reflected in the number of definite responses. Ratings  
280 of 1 (*Does not describe me at all*) and 4 (*Describes me absolutely*) correspond to clear-cut and  
281 consistent self-representations. Ratings of 2 (*Describes me a little*) and 3 (*Describes me well*)  
282 are regarded as vague responses. The higher the certainty score, the more certain the self-  
283 representation is. Finally, we calculated a valence score that measures self-esteem. The higher  
284 the valence score, the more positive the self-representation is. The certainty and valence  
285 scores are both calculated on the basis of the 50 statements and converted into percentages  
286 (taking all categories of self-representation together).

## 287 **2.6 Statistical Analyses**

288 All the statistical analyses were performed with STATISTICA software (StatSoft, 2011). The  
289 weakest significance threshold was set at  $p = 0.05$ . Pearson's chi-squared tests (goodness of  
290 fit) were conducted to assess the repartition of patients for clinical characteristics. We ran  
291 Student's  $t$  tests to compare the two groups of participants on their demographic,  
292 psychological and composite cognitive scores.

293 To specify the effects of disease and state anxiety on autobiographical memory and self-  
294 representations, participants were divided in two subgroups, based on the median state anxiety

295 scores for each group (patients' median = 32: the least anxious patients,  $n = 16$ , the most  
296 anxious patients,  $n = 15$ ; controls' median = 26: the least anxious controls,  $n = 25$ , the most  
297 anxious controls,  $n = 24$ ). A dispersion graph with the participants' state anxiety scores is  
298 presented in Figure 1. We conducted factorial analyses of variance (ANOVA) with the factors  
299 Group (patients, controls) and Anxiety (least anxious, most anxious) on the TEMPau scores  
300 (overall scores per period, specific detail scores, and emotional intensity and valence scores)  
301 and on the QSR scores (certainty and valence). These ANOVAs were followed by post-hoc  
302 comparisons using Fisher's Least Significant Difference (LSD) tests to compare group means.  
303 Relationships between variables were assessed using Spearman rank correlations.

304

### 305 **3. RESULTS**

#### 306 **3.1 Clinical characteristics, demographic and psychological data, and general cognitive** 307 **assessments**

308 Concerning clinical characteristics of the patient group, 22 women had undergone a  
309 tumorectomy and nine women a mastectomy (none of them had had a reconstruction  
310 procedure before receiving the adjuvant treatment). Seven patients had been diagnosed with  
311 Stage I breast cancer, while 12 patients had been diagnosed with Stage II and 12 with Stage  
312 III. Patients included in this study were younger than those who were excluded ( $53 \pm 5$  vs.  $58$   
313  $\pm 9$  years old,  $p = 0.02$ ), but there was no difference in either education level ( $12 \pm 3$  vs.  $11.9$   
314  $\pm 3.2$  years of education,  $p = 0.8$ ) or disease severity (7 vs. 10 patients with Stage I breast  
315 cancer, 13 vs. 16 patients with Stage II, and 11 vs. 14 with Stage III;  $p = 0.9$  ( $\chi^2$  test)).

316 The clinical characteristics of the patients enrolled in the study, and demographic,  
317 psychological and general cognitive scores of the patients and controls are summarized in  
318 Table 1. No significant differences were observed between the patients and controls for age ( $p$   
319  $= 0.71$ ) or education level ( $p = 0.34$ ). Concerning state anxiety, analyses revealed a significant

320 difference between patients and controls ( $p = 0.01$ ), with patients newly diagnosed for breast  
321 cancer scoring higher than controls. No significant difference was found between the groups  
322 on either trait-anxiety or BDI scores. Analyses of the cognitive assessment revealed  
323 significantly poorer performances in patients compared with controls on episodic memory  
324 retrieval ( $p = 0.048$ ) and attentional scores ( $p = 0.009$ ).

### 325 **3.2 Episodic autobiographical memory (EAM) and self-representations (QSR) results**

326 Considering the significant difference between both groups on state anxiety scores ( $p = 0.01$ )  
327 and the possible effect of state anxiety on EAM and self-representations scores, the two  
328 groups were divided in two subgroups on the basis of their state anxiety median (see 2.6  
329 Statistical analyses). Factorial ANOVAs with the factors Group (patients, controls) and  
330 Anxiety (the least anxious, the most anxious) on EAM and QSR scores show the effects of  
331 illness and anxiety, and interactions between these two factors. Results of these analyses are  
332 presented in Table 2.

333 Concerning the EAM scores per life time period, the factorial ANOVA revealed a significant  
334 effect of group for the reminiscence bump only [ $F(1, 76) = 4.49$ ;  $p = 0.04$ ], LSD post-hoc  
335 showing that the most anxious patients retrieved significantly fewer details for the  
336 reminiscence bump period than the least anxious controls ( $p = 0.04$ ).

337 Concerning the EAM scores for specific details, a main effect of group was observed for the  
338 emotional details only [ $F(1, 76) = 6.33$ ;  $p = 0.01$ ], and no other main effect or interaction was  
339 revealed. The most anxious patients retrieved significantly fewer emotional details than the  
340 most anxious controls ( $p = 0.03$ ) and the least anxious controls ( $p = .03$ ) (see Figure 2).

341 Emotional ratings of memories were also analysed. Concerning Valence at encoding, a main  
342 effect of group was observed [ $F(1, 76) = 5.11$ ;  $p = 0.03$ ] and the interaction group x anxiety  
343 tends to be significant [ $F(1, 76) = 3.36$ ;  $p = 0.07$ ]: the most anxious patients judged their  
344 memories at encoding significantly more positively and more pleasant than the most anxious

345 and the least anxious controls ( $p = 0.006$  and  $p = 0.049$ , respectively). No significant effects  
346 were observed for Valence at retrieval. Concerning Intensity at encoding and Intensity at  
347 retrieval, effects of group were or tended to be significant [at encoding:  $F(1, 76) = 3.71$ ;  $p =$   
348  $0.06$ ; at retrieval:  $F(1, 76) = 4.56$ ;  $p = 0.04$ ], as well as interactions group x anxiety [at  
349 encoding:  $F(1, 76) = 3.40$ ,  $p = 0.07$ ; at retrieval:  $F(1, 76) = 6.76$ ,  $p = 0.01$ ]: the least anxious  
350 patients rated their memories at encoding and at retrieval as less emotionally intense than the  
351 most anxious patients ( $p = 0.07$  and  $p = 0.02$ ), the most anxious controls ( $p = 0.04$  and  $p =$   
352  $0.02$ ), and the least anxious controls ( $p = 0.008$  and  $p = 0.001$ ) (see Figure 3). Furthermore, in  
353 each subgroup, significant Spearman correlations were observed between ratings of emotions  
354 (valence or intensity) experienced at encoding and retrieval, except for intensity in the most  
355 anxious patients (the most anxious patients:  $p = 0.08$  for intensity and  $p = 0.02$  for valence;  
356 the least anxious patients:  $p = 0.004$  for intensity and  $p = 0.02$  for valence; the most anxious  
357 controls:  $p < 0.0001$  for intensity and  $p = 0.001$  for valence; the least anxious controls:  $ps <$   
358  $0.0001$  for intensity and valence).

359 Concerning self-representation scores (QSR scores), no significant effect was reported for  
360 validity scores. On the contrary, for certainty scores, we observed only a significant effect of  
361 anxiety [ $F(1, 76) = 12.28$ ,  $p = 0.0008$ ]: the least anxious patients had higher certainty scores  
362 than the most anxious patients ( $p = 0.009$ ) and the most anxious control ( $p = 0.0004$ ); and the  
363 least anxious controls had higher certainty scores than the most anxious controls ( $p = 0.03$ ).  
364 For valence scores, we reported a main effect of group [ $F(1, 76) = 5.42$ ,  $p = 0.02$ ] and a main  
365 effect of anxiety [ $F(1, 76) = 16.94$ ,  $p < 0.0001$ ]: the least anxious patients obtained higher  
366 valence scores (i.e. more positive) than the most anxious patients ( $p = 0.01$ ) and the most  
367 anxious controls ( $p < 0.0001$ ); and the least anxious controls had higher valence scores than  
368 the most anxious controls ( $p = 0.001$ ). These main effects of anxiety are in line with the



369 significant negative correlations between QRS scores (certainty or valence) and state anxiety  
370 scores in the whole patient group ( $p < 0.006$ ) and in the whole control group ( $p < 0.008$ ).

371

#### 372 **4. DISCUSSION**

373 This study is the first to focus on autobiographical memory functioning in patients newly  
374 diagnosed for breast cancer, before receiving any adjuvant treatment. Previously, only a  
375 handful of studies reported impaired retrieval of specific autobiographical memories in  
376 patients with breast cancer in remission (i.e., these patients had received neurotoxic treatments  
377 like chemotherapy and/or hormone therapy; Nilsson-Ihrfelt *et al.* 2004; Bergouignan *et al.*  
378 2011). Here, we aimed at determining what triggers and causes the impairment of EAM  
379 independently of the impact of adjuvant treatments. State anxiety related to breast cancer  
380 diagnosis typically peaks in the period between breast cancer diagnosis and adjuvant  
381 treatment (e.g., Schnur *et al.* 2008; Montgomery & McCrone, 2010; Galloway *et al.* 2012;  
382 Berman *et al.* 2013; Groarke *et al.* 2013). Consistently, we found a significantly higher level  
383 of state anxiety, but no difference in trait anxiety or in depressive symptoms, in the patients  
384 with breast cancer compared with healthy women with no history of cancer.

385 The impact of state anxiety was specifically explored here, dividing the patient group and the  
386 control group on the basis of state anxiety (STAI) median into “the least anxious” and “the  
387 most anxious” subjects. The main result reveals that the most anxious patients seem to be  
388 impaired in their EAM retrieval, as they reported significantly less emotional details than  
389 controls, whereas the least anxious patients showed a profile of EAM retrieval similar to those  
390 of controls.

391 This result reveals two profiles of emotional processing during autobiographical memory  
392 retrieval among patients who have experienced cumulative stressful events. Although the least  
393 and the most anxious patients have lived the same stressful events related to cancer diagnosis

394 and surgery, they showed different EAM patterns. The hypotheses on the impact of  
395 cumulative stressful events after breast cancer diagnosis and surgery on cognition (Berman *et*  
396 *al.* 2013), and more specifically on EAM (Bergouignan *et al.* 2011), might therefore be  
397 modulated by the psychological reaction (state anxiety level) of patients.

398 Furthermore, although the most anxious patients retrieved fewer emotional details than  
399 controls, we cannot characterise this abnormality as overgeneral memories because, for each  
400 memory retrieved, the event-specific knowledge level was reached. This pattern of results for  
401 the most anxious patients may therefore not be attributable to executive dysfunctions (that are  
402 inexistent in patients). On the contrary, since on one hand, the generative retrieval process  
403 depends on the working self (Conway *et al.* 2004), and on the other hand, our results  
404 demonstrated that state anxiety scores and QSR scores correlated, we suggest that this  
405 particular pattern of EAM is influenced by self-representations. Indeed, immediately after  
406 retrieval, participants rated emotions they had experienced when the event originally took  
407 place (i.e., at encoding) and those they experienced when they related that event to the  
408 experimenter (i.e., at retrieval) on two emotional scales evaluating valence and intensity.  
409 Remarkably, in each subgroup, significant correlations were observed between ratings of  
410 emotions (valence or intensity) experienced at the time of encoding and retrieval, except for  
411 intensity in the most anxious patients. This may suggest modified self-representations for  
412 these patients: their current concern may fade the intensity of the past events. Moreover,  
413 compared with controls (least and most anxious subgroups), the most anxious patients rated  
414 their memories as more pleasant (higher positive emotional valence ratings) at encoding, but  
415 no differences were observed for retrieval. These patients were therefore able to retrieve  
416 positive personal past events, but reduced the emotional verbalization of their memories. It is  
417 worth noting that, in the TEMPau task, memories and their specific details (factual, spatial,  
418 temporal and emotional) were given spontaneously, with no prompting provided by the

419 experimenter, and no restrictions placed on the emotional valence of these memories. These  
420 findings may suggest that the most anxious patients appear to engage in an avoidance strategy  
421 to diminish the emotional impact of recalling strongly negative events from the past, thus  
422 enabling them to cope more effectively with the disease. This strategy could be close to the  
423 hypothesis that reduced memory specificity may be a coping strategy of cognitive avoidance  
424 used under certain conditions by individuals without psychiatric diagnosis (Hermans *et al.*  
425 2008; Deeber *et al.* 2012). We can suggest that a coping strategy that allows a higher  
426 appreciation of past events although entertaining anxiety during the present moment  
427 encourages the impulse to recover past health conditions. Significant differences between  
428 groups were observed for state anxiety scores, but not for trait anxiety scores, suggesting that  
429 anxious preoccupation may indeed be a psychological consequence of the breast cancer  
430 diagnosis experience, and may play an important role in coping with the disease and adhering  
431 to chemotherapy (Greer *et al.* 2008; Watson *et al.* 2012; Groarke *et al.* 2013).

432 By contrast, our results revealed that, after breast cancer diagnosis and despite the context of a  
433 life-threatening disease, some patients exhibited a combination of low state anxiety scores and  
434 high self-representation scores. Unlike the most anxious patients, these patients did not  
435 exhibit any deficit in the specificity of emotional detail in EAM retrieval compared with  
436 healthy controls. Results of the emotional ratings showed that the least anxious patients  
437 judged their memories to be less intense (less emotionally charged), both at encoding and at  
438 retrieval, compared with the most anxious patients and the controls (the least or the most  
439 anxious controls). The least anxious patients had also higher self-representation scores  
440 (certainty and valence) than the most anxious patients and the most anxious controls. To  
441 categorize events as less intense, although possibly being a judgment bias, may reinforce  
442 confidence in the ability to cope with stressful events and then reinforce self-esteem. So, this  
443 subgroup of less anxious patients exhibited stable EAM including emotional details, but rated

444 their memories as being less emotionally intense than the three other subgroups, notably the  
445 least anxious controls. These results may lend support to the theory that autobiographical  
446 memory is closely and reciprocally linked to self-representation (Conway, 2005; Klein &  
447 Gangi, 2010; Haslam *et al.* 2011). This profile may reflect the adoption of another adaptive  
448 process in order to cope with the stressful events related to breast cancer diagnosis (i.e.,  
449 coping strategies). The least anxious patients are able to deal with, regulate and express their  
450 emotions.

451 We can hypothesize that patients implement *emotion-focused coping strategies*, to control the  
452 emotions triggered during the stressful period of breast cancer diagnosis, thereby achieving an  
453 affective and emotional balance (Khalili *et al.* 2013), or *assertive coping strategies*, related to  
454 higher self-representation scores (certainty and valence) (Astin *et al.* 1999). The patients took  
455 part in a lengthy research study over three sessions with cognitive, EAM and psychosocial  
456 assessments, as well as neuroimaging exams, on three occasions (before adjuvant treatment,  
457 after treatment, and one year later). This suggests that the patients included in this study had  
458 to be highly self-willed. In this context, our results could be interpreted as indicative of a  
459 positive temperament and/or the ability to engage in an adaptive process to cope with the  
460 disease. To test this hypothesis, other studies will be needed to prospectively assess patients  
461 who have a positive mammogram finding before and after any breast cancer diagnosis.  
462 Interviews with immediate family members (children or partners) to obtain descriptions of the  
463 patients before and after the breast cancer diagnosis experience might also be interesting.

464

## 465 **5. Conclusions and Perspectives**

466 We were able to identify two patient profiles for emotional processing in autobiographical  
467 memory retrieval. Compared with healthy women with no history of cancer, the most anxious  
468 patients exhibited impaired EAM retrieval, particularly regarding the specificity of emotional

469 details. Another, less expected profile involved the least anxious patients with higher self-  
470 representation scores, who did not exhibit any deficit in emotional detail retrieval in EAM.  
471 More research is needed to confirm these profiles and provide advice regarding the  
472 psychological impact on cognition among patients and oncologists. Other avenues for  
473 research might include investigating EAM, state anxiety, and self-representation profiles after  
474 chemotherapy, in order to find out whether or not the changes observed during the breast  
475 cancer diagnosis experience are temporary. One might suggest that therapeutic methods for  
476 decreasing state anxiety could minimize memory dysfunctions and more largely cognitive  
477 deficits.  
478

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