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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 ± 5 vs. 58
313 ± 9 years old, $p = 0.02$), but there was no difference in either education level (12 ± 3 vs. 11.9
314 ± 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; $p = 0.9$ (χ^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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483

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