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Abstract

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

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

1. INTRODUCTION

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

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

this interrelationship between self and memory. Autobiographical representations are organized hierarchically along three levels: from lifetime periods (extended over long periods of time), to generic events (repeated or extended in time), and lastly event-specific knowledge (contains specific episodic memories). This last level refers to episodic autobiographical memory (EAM) which supports our capacity to re-experience personal past events (i.e., to mentally travel in time) with their specific details, such as the spatiotemporal context, factual and emotional descriptions (Tulving, 2002; Piolino *et al*. 2009) (e.g., "I remember the moment when Mr O. asked me to sit at his desk to look at my tests. I felt anxious when he said he had the results. It was in December."). The SMS proposes an explanation concerning the voluntary retrieval of EAM when assessed using a semi-structured interview such as the Autobiographical Memory Task (AMT, Williams & Broadbent, 1986) or the TEMPau task (for *Test Episodique de la Mémoire du Passé autobiographique*; Piolino *et al*. 2003). Generative retrieval provides controlled access to event-specific knowledge via the personal semantic knowledge base (lifetime periods and generic events). This generative retrieval process relies on both executive functions and the working self, which acts as a moderator between the demands of correspondence (memory should correspond to experience and reality) and coherence (memory should be consistent with one's current goals, self-images and beliefs) in the formation of memories (Conway *et al*. 2004).

Numerous studies have focused on autobiographical memory functioning in stress-related disorders. When asked to retrieve a specific episodic life event, depressed or traumatized patients with PTSD or acute stress disorder (ASD) instead tend to recall broader, repeated and generic events with no specific details, i.e. overgeneral memories (see Moore & Zoellner, 2007; Sumner *et al*. 2010; Williams *et al*. 2007 for reviews). Based on the SMS, overgenerality occurs when the generative retrieval search process is aborted prematurely, before reaching the level of event specific knowledge (e.g., Haque *et al*. 2014). This

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

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

disorders like depression or PTSD.

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

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

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

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

2. METHODS

2.1 Participants and Procedure

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

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

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

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

2.2 Anxiety assessment

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

2.3 Cognitive assessment

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

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

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

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

2.4 EAM assessment

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

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

We calculated the following EAM scores:

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

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

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

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

2.5 Self-representation assessment

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

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

2.6 Statistical Analyses

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

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

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

3. RESULTS

3.1 Clinical characteristics, demographic and psychological data, and general cognitive assessments

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

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

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

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

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

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

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

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

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

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

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

4. DISCUSSION

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

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

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

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

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

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

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

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

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

5. Conclusions and Perspectives

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

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

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