Seeing or hearing one's memories: Manipulating autobiographical memory imagery in schizophrenia

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ABSTRACT

The prevalence of auditory hallucinations in schizophrenia, and theories suggesting a link between autobiographical memory and hallucination, raise the possibility of a dominant role of auditory imagery in autobiographical remembering in patients with schizophrenia, whereas visual imagery is dominant in autobiographical memory of healthy adults. The present study explored this possibility by comparing autobiographical memory characteristics, according to sensory modality, in patients with schizophrenia versus healthy controls. Twenty-eight patients and 28 matched controls were asked to retrieve autobiographical memories that were dominated by auditory, visual, gustatory-olfactory, or tactile imagery. ANOVA analysis showed that patients rated their memories lower on specificity, contextual information, feeling of reliving, overall vividness, coherence and autobiographical me-ness (i.e. whether an autobiographical memory is experienced as belonging to the self), $ps < 0.03$, compared with control participants. The effects of sensory modality imagery were largely similar for patients and controls, as no interaction effects were observed. The findings did not support a dominance of auditory imagery in patients' autobiographical memory. In the patient group, reduced autobiographical me-ness was predicted by lower ratings of contextual information related to the setting of the event. Future research should examine whether these effects extend to involuntary autobiographical memory in schizophrenia.

1. Introduction

It is well-documented that autobiographical memory—that is, the ability to remember events in the personal past—is impaired in schizophrenia (e.g, Berna et al., 2016). However, it is not clear how this memory impairment is related to the imagery associated with re-collecting personal memories. Visual imagery is considered to play a key role in remembering past events, especially in mentally reliving those events and traveling back in time (Brewer, 1996; D'Argembeau and Van der Linden, 2006; Vannucci et al., 2016). This is consistent with neuropsychological data showing that damage to areas known to support visual imagery result in an impairment of autobiographical memory (Conway and Fthenaki, 2000; Greenberg and Rubin, 2003; Rubin, 2006; Rubin et al., 2003; Rubin and Greenberg, 1998). In addition, autobiographical memory impairments (observed in relapsing-remitting multiple sclerosis patients) were alleviated using a cognitive facilitation program based on mental visual imagery (Ernst et al., 2015, 2012). Regarding the specific relationship between imagery constructs and autobiographical recollection, object

imagery has been associated with phenomenological judgments about the autobiographical events while spatial imagery has been shown to predict the level of episodicity of the memories (Aydin, 2018).

In recent years, several studies have linked autobiographical memory to hallucination in psychosis (Allé, Berna, & Berntsen, 2018; Hardy et al., 2016; McCarthy-Jones, Thomas, et al., 2014; McCarthy-Jones, Trauer, et al., 2014; Steel, 2015; Waters, Badcock, Michie, & Maybery, 2006), but the mechanisms underlying this relationship are far from understood. The difference in predominant sensory modality between hallucination in psychosis (mostly auditory) and autobiographical memory in general (mainly visual) led us to examine whether auditory imagery might be more dominant in patients' autobiographical memory than in healthy control. Previous studies in schizophrenia showed that patients' memories overall are less vivid than those of controls, suggesting a mental imagery deficit related to autobiographical remembering (Berna et al., 2016; Raffard et al., 2010). Yet, no study has investigated a potential mental imagery imbalance in autobiographical memory for patients with schizophrenia. Speculatively, one could assume that a reduced visual imagery, to the

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benefit of auditory imagery in schizophrenia, might explain autobiographical memory impairments, such as reduced level of episodicity or feeling of reliving in those patients (see Berna et al., 2016).

Mental imagery consists in the simulation or re-creation of perceptual experiences across sensory modalities, (Kosslyn et al., 2001; Pearson et al., 2013, 2008) and the vividness of the mental representation, referring to both its luminosity and clarity, reflects its subjective experience. In psychosis, vivid mental imagery has been found to be associated with poorer ability to distinguish real perception from imagery (i.e., reality monitoring impairment) (Mintz and Alpert, 1972). Several studies have reported that patients with schizophrenia, patients' first degree relatives and high schizotypy individuals display greater vividness of mental imagery than the general populations (Böcker et al., 2000; Oertel et al., 2009), while others have observed no differences between patients with hallucinations and healthy controls on auditory imagery (Brett and Starker, 1977; Chandiramani and Varma, 1987). Starker and Jolin (Starker and Jolin, 1982) even showed mental imagery impairment in schizophrenia. It is worth noting that when self-assessed using a mental imagery questionnaire (Sheehan, 1967), impairment of mental imagery vividness was not found to vary as a function of sensory modality in schizophrenia (Oertel et al., 2009). In contrast, Böcker et al., (2000) showed, using an experimental setup, that for hallucinating patients, vividness of mental images tends to be higher in the auditory modality than in the visual modality. Taken together, these studies preclude any firm conclusion on the role of mental imagery in hallucination processes.

The main aim of the present study was to determine whether autobiographical memory impairments previously observed in schizophrenia vary as a function of sensory modalities composing the memory imagery. Research on sensory modality and autobiographical memory in healthy population have shown that memories evoked by verbal, visual, or olfactory cues differ with respect to experiential rating. Overall, odor-evoked memories are consistently older than memory evoked by other sensory cues, and they are also thought of less frequently (for review see Hackländer et al., 2019). However, when considering other qualitative properties of memories such as the pleasantness, feeling of reliving, or emotion intensity, findings are mixed and vary according to the method (Chu and Downes, 2002; Herz and Schooler, 2002; Miles and Berntsen, 2011; Willander et al., 2015; Willander and Larsson, 2006).

In the present study, we introduced a new paradigm, which examines the effects of sensory imagery manipulation on the characteristics of autobiographical memories in patients diagnosed with schizophrenia versus controls participants. Participants were asked to retrieve and record autobiographical memories in response to four verbally presented sensory imagery instructions: auditory, visual, gustatory-olfactory and tactile. For each condition, they were asked to retrieve a memory of a past experience in which the sensory modality was prominent in the mental imagery associated with the memory. The properties of each cued memory were then self-assessed by the participants. A wide range of variables reflecting features typically associated with recollecting autobiographical memories (i.e. feeling of reliving, coherence, specificity, context, vividness, visual perspective, emotion, belief in accuracy) was explored to carefully examine the influence of sensory imagery predominance on autobiographical memory construction and mental representation in schizophrenia, while controlling for the temporal distance of the memories.

We hypothesized that patients' autobiographical memories would be impaired in several aspects, in comparison to those of healthy controls, as previously reported in the literature. We thus expect patients' memory to be: less specific, less vivid and less associated with a feeling of reliving or contextual information (Berna et al., 2016; Danion et al., 2005; Potheegadoo et al., 2014; Ricarte et al., 2017). Moreover, we hypothesized that the sensory modality predominance in memory imagery (e.g., auditory versus visual) would impact the degree of

autobiographical memory impairments, as reflected by interaction effects between group and sensory modality on the subjective characteristics. More specifically, we expected memory dominated by auditory imagery to be rated higher on several autobiographical memory measures than memories dominated by other types of sensory imagery.

As a secondary objective, we investigated the degree of autobiographical memory awareness (or self-connection) through several variables, to better understand whether autobiographical memories might be experienced as less connected to the self in schizophrenia, as suggested by memory-based theoretical model of hallucination (Waters et al., 2006).

In order to more carefully measure the reduced sense of self associated with autobiographical memory in schizophrenia, we introduced a new measure, *autobiographical me-ness.* This variable examined the extent to which an autobiographical memory is experienced as belonging to the self or is experienced as something external to the self (or distant from the self). The notion of me-ness was initially introduced by James (1880) and defined as "that "warmth and intimacy" […], as characterizing all memories "appropriated " by the thinker as his own." (James, 1890). Autobiographical me-ness is different from, albeit related to, the concept of autobiographical belief. Autobiographical belief is understood as the truth value attributed to the occurrence and the accuracy of the event, whether it has happened or not, and whether the content of memory correspond to the objective reality of the event (Brewer, 1996; Mazzoni et al., 2010; Rubin et al., 2003; Scoboria et al., 2014). Autobiographical me-ness, on the other hand, probes a sense of subjective belongingness, and a feeling that the remembered event took place in one's own personal life and not in the life of someone else. Theoretically, it is possible to experience a high sense of me-ness for a memory, while still doubting its objective veracity, for example, whether the details are accurately represented. In short, autobiographical me-ness corresponds to a subjective self-related feeling of having *personally* experienced the event whereas belief is a metacognitive judgment of the objective accuracy of the memory and how well it corresponds to a past reality.

2. Methods

2.1. Participants

An a priori power analysis, using G*power 3.1 (Faul et al., 2007), was performed based on previous literature on autobiographical memory research in schizophrenia. With a power set at 0.95, $\alpha = 0.5$, and $\eta_p^2 = 0.12$ (effect size of significant interaction effect observed in Allé et al., 2016), the estimated sample size was 46 (i.e. 23 participants in each group).

Table 1 shows the demographic, clinical and cognitive measures of the participants. Twenty-eight outpatients with schizophrenia spectrum disorder (schizophrenia, n = 24; schizoaffective disorder, n = 4) from the Psychiatry Department of Strasbourg University Hospitals (France) took part in the study. They met the DSM-5 (American Psychiatric Association, 2013) criteria for schizophrenia or schizoaffective disorder as determined by a psychiatrist during a one-hour in-depth interview. Patients experienced no change in their symptomatology or medication and had not been hospitalized for the last 3 months. Positive, negative and general symptoms of schizophrenia were assessed by a psychiatrist using the Positive And Negative Syndrome Scale (Kay et al., 1987). All patients were receiving long-term second generation antipsychotic treatment. Twenty-eight healthy control participants were included so that the patients and controls groups did not differ in terms of age, gender and level of education. During a pre-screening phase, it was made sure that none of the control participants had a psychiatric illness or was under psychotropic medication. No participants from either group had a history of neurological disorders or substance abuse. Control participants who scored > 8 on the Beck Depression Inventory (BDI-II; Beck et al., 1996), and patients scoring > 4 on the Calgary

Table 1
Demographic, Clinical and Cognitive Characteristics of Patients With Schizophrenia and Control Participants.

Measures	Patients with Schizophrenia (n = 28)		Control participants (n = 28)		Statistics		
	M	SD/%	M	SD/%	t-test	d	95% IC
Age (years)	37.76	9.64	36.33	9.60	0.55	0.15	[-3.73, 6.59]
Gender (female)	8	28.6%	8	28.6%			
Level of education	12.38	2.26	13.22	1.97	-1.48	0.40	[-1.98, 0.30]
Clinical Measures							
BDI	–	–	1.2	0.84			
CDSS	1.37	1.54	–	–			
PANSS – Total score	52.61	20.12	–	–			
PANSS – Positive symptoms	13.32	5.71	–	–			
PANSS – Negative symptoms	16.37	7.20	–	–			
PANSS – Psychopathology	23.5	9.45	–	–			
Length of illness	12.82	7.16	–	–			
Cognitive Measures							
Premorbid IQ	105.92	7.78	109.60	5.36	-1.86	0.56	[-7.66, 0.30]
Phonemic Verbal Fluency[b]	-0.09	1.00	0.34	0.86	-1.50	0.27	[-1.00, 0.15]
Semantic Verbal Fluency[b]	-0.33	1.32	0.77	1.65	-2.42**	0.74	[-2.02, -0.18]

Note. BDI = Beck Depression Inventory; CDSS = Calgary Depression Scale for Schizophrenia; fNART = National Adult Reading Task (French Version); IQ = Intelligence Quotient; PANSS = Positive and Negative Syndrom Scale
[a]N = 3, [b]z-scores
*p < .05; **p < .01; ***p < .001

Depression Scale for Schizophrenia (CDSS; Addington et al., 1993) were excluded from the study, after the clinical assessment (n = 3, in total) and did not complete the protocol. The study was approved by the Strasbourg Ethics Committee, and all participants gave their informed written consent once procedures had been fully explained to them.

3. Material

Premorbid IQ. The premorbid IQ was assessed for each participant with the National Adult Reading Task, French version (f-NART; Mackinnon & Mulligan, 2005). Participants were asked to read aloud a list of unusual French words, the number of pronunciation errors was counted and converted into an estimated premorbid IQ.

Verbal fluency. The ability to self-initiate strategic and quick search for information was assessed with the phonemic (letters P and R) and semantic (animals and fruits) verbal fluency tests (Cardebat et al., 1990), for 120 seconds for each letter and semantic category.

Autobiographical memory task. This task was developed for the purpose of the present study (full instructions are given below). Participants were asked to recall and write down autobiographical memories in response to four sensory imagery instructions: auditory, visual, gustatory-olfactory, and tactile. For each perceptual modality, participants were asked to focus on this specific modality and try to recall two personal events in which the imagery reflecting this sensory modality was prominent. Memories from all parts of their lives were accepted. Thus, each participant generated a total of eight memories, two for each cue. The participant indicated the qualities of each memory by answering a series of questions. These questions were derived or modified from previous work (Berntsen & Bohn, 2010; Rubin & Berntsen, 2009; see Rubin et al., 2003 for questionnaires development). Table 2 shows the questions and the rating scales for each item.

In addition, memory specificity was the only variable to be both self-assessed and externally assessed by the experimenter (M.C.A.) and an independent rater. Each memory was categorized as either specific (i.e. being a unique event, which took place at a particular time in a particular location and lasted less than 24 hours; Williams & Broadbent, 1986; score = 1) or non-specific (score = 0), with a good inter-reliability (κ = 0.79). Each disagreement (n = 48 out of 424) was discussed and resolved. The proportion of specific memories is used in the following analyses.

Table 2
Variable labels, questions and ratings composing the questionnaire.

(Specificity) Is the memory about a specific situation that happened on a specific day in your past? *Yes/No*

(Context) Can you remember the setting of the event? *From 1 = Not at all to 5 = Perfectly*

(Reliving) While remembering the event, I feel as though I am reliving it. *From 1 = Not at all to 5 = as if it were happening now*

(Overall vividness) How vivid is the memory in your mind? *From 1 = Very vague to 5 = Clear and very detailed*

(Auditory vividness) How vivid are the sounds in your mind? *From 1 = Very vague to 5 = Clear and very detailed*

(Visual vividness) How vivid are the pictures in your mind? *From 1 = Very vague to 5 = Clear and very detailed*

(Gustatory-Olfactory vividness) How vivid are the tastes and/or odors in your mind? *From 1 = Very vague to 5 = Clear and very detailed*

(Tactile/Body vividness) How vivid are the physical feelings in your mind? *From 1 = Very vague to 5 = Clear and very detailed*

(Voluntary recall) Since it happened, I have willfully thought back to the event in my mind and thought about it or talked about it (*voluntary*) *From 1 = Never to 5 = Very often*

(Involuntary recall) This memory has previously come to me "out of the blue", without me trying to think about it. *From 1 = Never to 5 = Very often*

(Coherence) How is your mental representation of this event? *From1 = My memory comes in pieces, fragments with missing bits to 5 = My memories comes to me as a coherent story*

(Visual perspective) What is your location in the memory? *From 1 = Looking out from my own eyes to 5 = I could see myself in the memory, like an external observer*

(Temporal distance) How old is the initial event? *Several Years/Several Months/Several Weeks/Several Days*

(Emotional valence) Was the memory particularly emotional? *From 1 = Very negative to 5 = Very positive*

(Me-ness) To which extend do you consider this memory as yours? *From 1 = I feel that this memory does not belong to me, it is not mine. to 5 = I am convinced that this memory is mine*

(Belief in accuracy) I believe the event in my memory really occurred in the way I remember it and I have not imagined or fabricated anything that did not occur. *From 1 = 100% imaginary to 5 = 100% realistic*

3.1. Procedure

Participants were tested at the psychiatric hospital during individual two-hour session. After clinical and cognitive assessments, they were asked to complete the autobiographical memory questionnaire in writing. The interviewer provided the following written instructions and made sure participants understood them, as well as all questions composing the survey, by reading them aloud with the

participant if necessary.

"Dear participant, we would like you to recall memories of specific events you experienced in your life, meaning events that happened at a specific time and a specific place, i.e. "The day I went raspberry picking with my mum and sister in the forest". The events can be remote as well as recent. We would like you to focus on memories relating to a very salient sensory modality in your mind. The different sensory modalities are hearing, vision, taste and/or smell, and touch. We would like you to choose memories according to these modalities. Each memory should be associated with one sensory modality."

In order to make the instructions clear, participants were given examples of autobiographical memories related to the different sensory modalities (examples are shown in the Appendix).

"Let's start with the auditory modality. Please try to remember a moment when you heard significant sounds, noise, music or voices. Once you have retrieved a memory associated to auditory perception, please write it down and answer the following questions in relation to the memory. […] Now I will ask you to focus on the visual modality and try to remember a personal experience in which you saw something significant. It could have been significant colors, shapes, landscapes, objects or persons. Once you have retrieved a memory associated to visual perception, please write it down and answer the following questions in relation to the memory. […] Let's move now to the gustatory-olfactory modality. You can remember an event in which both modalities were notable or chose to focus on one of them. Once you have retrieved a memory associated to gustatory and/or olfactory perception, please write it down and answer the following questions in relation to the memory. […] To finish, I will ask you to focus on tactile and body sensation, and try to recall a situation where you felt significant internal and/or external physical sensation you ever felt. Once you have retrieved a memory associated with tactile and body sensation, please write it down and answer the following questions in relation to the memory." See the Appendix for the detailed instructions.

4. Results

4.1. Clinical and cognitive measures

Between groups comparisons were performed on all demographic and cognitive measures of participants. Descriptive clinical measures and t-tests results are reported on Table 1. The only significant difference between patients and controls was observed for the semantic verbal fluency, with patients having lower scores than controls.

4.2. Autobiographical memory measures

Manipulation check. We first wanted to examine whether the instructions to focus on specific types of mental imagery actually led to a greater dominance of this particular imagery in the recorded memory. In order to conduct this manipulation check, we conducted a series of 2 (Group: patients versus controls) x 4 (Sensory Imagery Instruction: auditory versus visual versus gustatory-olfactory versus tactile-body sensation) repeated measures ANOVAs, with Sensory Imagery Instruction as repeated measures factor and Group as a between subjects variable. Fig. 1 shows the mean ratings of overall imagery vividness, auditory imagery vividness, visual imagery vividness, gustatory-olfactory imagery vividness and tactile imagery vividness for both groups, as a function of sensory imagery instructions.

Significant main effects of sensory imagery instructions were found, $Fs(1, 162) > 6.44$; $ps < 0.001$; $\eta_p^2 > 0.11$, such that the visual imagery instruction led to more visually vivid memories, the auditory imagery instruction led to more auditorily vivid memories, the gustatory-olfactory imagery instruction led to more gustatorily and/or olfactorily vivid memories, and the tactile imagery instruction led to more tactilely vivid memories. This series of analyses confirmed that the imagery manipulation through instructions on memory imagery had been effective.

Autobiographical memory ratings. The results show a consistent pattern with patients' memories being rated lower than those of control participants for most of the characteristics assessed (Fig. 2). In the following, we provide the inferential statistics for all variables assessed.

Significant main effects of group were observed for both the proportion of specific memories externally rated, $F(1,54) = 12.66$; $p = .001$; $\eta_p^2 = 0.18$, and self-rated, $F(1,54) = 4.52$; $p = .04$; $\eta_p^2 = 0.07$. Patients recalled significantly fewer specific memories than control participants did. Similarly, we observed significant group effects for the mean ratings of context, coherence and reliving $Fs(1,54) > 8.05$; $ps < 0.01$; $\eta_p^2 > 0.11$, reflecting that patients' memories were less contextualized, less coherent and less associated with a feeling of reliving compared with controls' memories. A significant group effect was observed for the overall vividness, $F(1,54) = 6.6$; $p = .02$; $\eta_p^2 = 0.09$, reflecting a reduced vividness for patients' memories. No significant interactions between group and sensory instruction were observed, $Fs(3159) < 0.75$; $ps > 0.52$; $\eta_p^2 > 0.01$ (see Fig. 1).

No group effects were observed for retrieval time, frequency of voluntary or involuntary recall, visual perspective, emotional valence and belief in accuracy ($ps > 0.11$). Chi square analysis showed no group effect regarding memories' temporal distance, $\chi^2 = 6.26$; $p = .10$. This result reflects that patients and controls have a similar temporal distribution of their autobiographical memories recalled during the task.

Overall, the pattern of lower ratings in the patient group was quite consistent across sensory modality instructions. Only one significant interaction between group and sensory modality instruction was observed for ratings of me-ness, $F(3159) = 2,75$; $p = .049$; $\eta_p^2 = 0.05$. Post-hoc analyses showed that autobiographical memory me-ness was significantly reduced in patient group compared to control group for all sensory modalities ($ps < 0.02$), except for gustatory-olfactory modality, for which a trend was observed ($p = .08$).

Finally, main effects of sensory instruction were observed for specificity (both externally rated and self-rated) $Fs(1159) > 4.34$; $ps < 0.006$; $\eta_p^2 > 0.06$, coherence $F(3159) = 4.22$; $p = .01$; $\eta_p^2 = 0.07$, emotional valence $F(3159) = 6.81$; $p < .001$, and belief in accuracy $F(3159) = 3.32$; $p = .02$; $\eta_p^2 = 0.05$, reflecting instructions influence on the phenomenology ratings. In most cases, these effects reflected that visually dominated memories were associated with higher ratings than auditory- olfactory/gustatory- or tactile-dominated memories, except for overall vividness and coherence, where tactile imagery predominance led to higher ratings (see Supplemental Material S1).

4.3. Correlation analyses

We introduced a novel variable, the autobiographical me-ness, to investigate the hypothesized deficit of autobiographical memory self-connection in schizophrenia, and its relationship to reduced contextual information (Waters et al., 2006). We conducted correlation analyses to explore which other factors could be related to autobiographical me-ness. We conducted these analyses in the patient group only, as a ceiling effect was observed for the ratings of me-ness in the control group. Correlation coefficients are summarized in Table 3. We observed significant correlations between the amount of contextual information retrieved and the autobiographical me-ness ($rs > 0.29$; $ps < 0.04$), in almost all conditions (except for auditory memories). For the tactile memories, me-ness was also significantly correlated with reliving and vividness ($rs > 0.41$; $ps < 0.02$). As expected, autobiographical me-ness also showed high correlations with autobiographical belief, across all types of memories ($rs > 0.55$; $ps < 0.01$).

No clear pattern of correlations was observed between clinical symptoms or cognitive measures and autobiographical memory variables, in the patient group (for all cued-memories grouped together, $rs < 0.24$; $ps > 0.22$; for more details, see Supplemental Material S2).
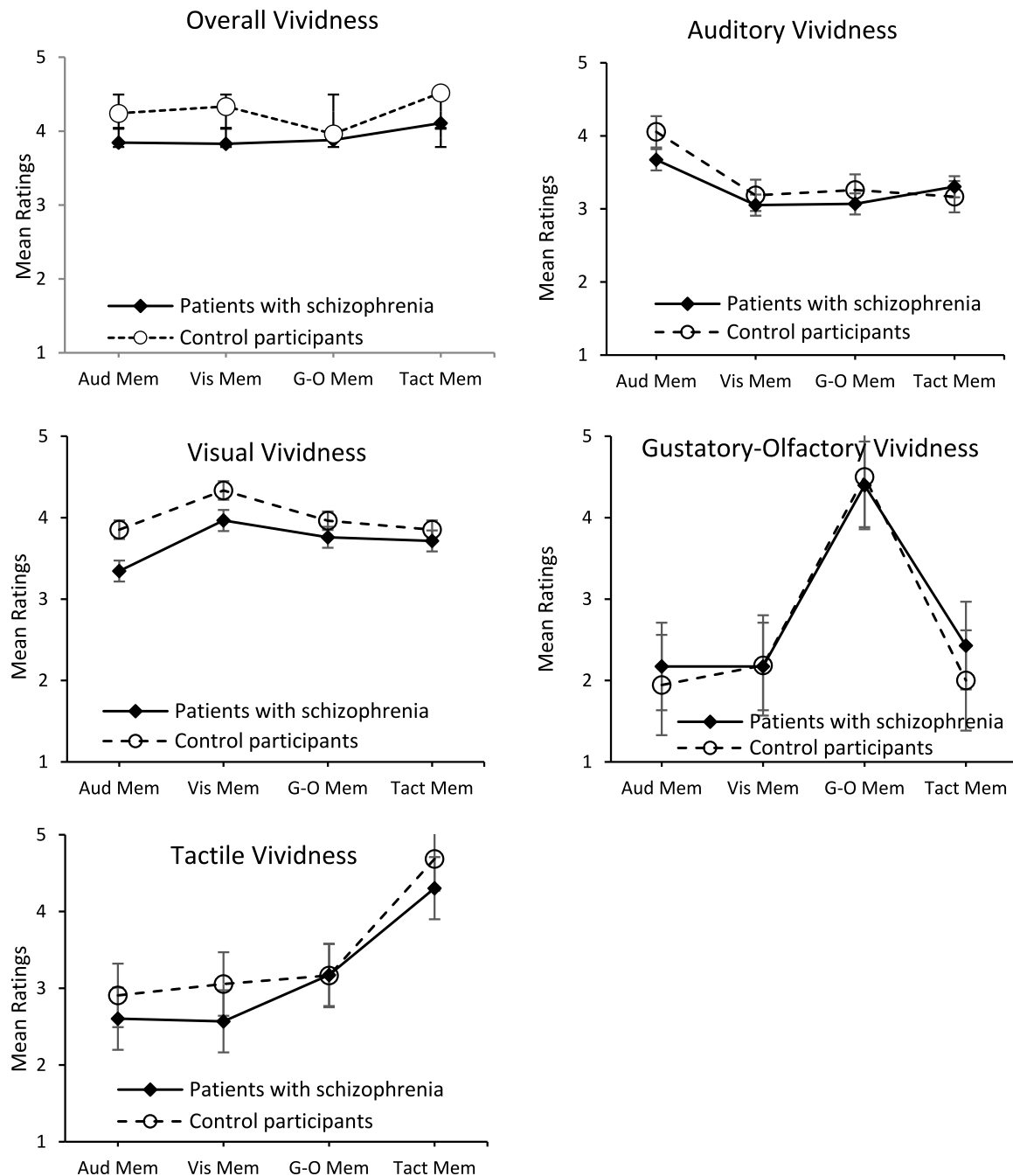
Fig. 1. Mean ratings of autobiographical memory vividness according to the different sensory modalities (auditory, visual, gustatory-olfactory and tactile), as a function of sensory cue and group. Error bars represent the standard errors of the means. Aud Mem = Auditory Autobiographical Memories; Vis Mem = Visual Autobiographical Memories; G-O Mem = Gustatory-Olfactory Autobiographical Memories; Tact Mem = Tactile Autobiographical Memories.

4.4. Regression analysis

We performed a regression analysis to investigate whether ratings of contextual information predicted ratings of autobiographical memory me-ness even when controlling for potentially confounding factors such as specificity, reliving and belief in accuracy.

The regression analysis was performed in the patient group only, on all cued-memories grouped together. Autobiographical me-ness was the dependent variable, and mean ratings of specificity, reliving or belief in accuracy, were added in the regression model as independent predictors. The final model was significant, $F(2, 26) = 6.06$; $R^2 = 0.61$; $p = 0.001$, and contextual information was a significant predictor of autobiographical memory me-ness ($p < .02$). Importantly, even when controlling for the belief of accuracy, which was highly correlated with autobiographical memory me-ness, contextual information remained a significant predictor of me-ness (see Table 4).

5. Discussion

This study aimed to investigate the influence of sensory modality imagery on autobiographical memory recall in schizophrenia. Overall, a consistent pattern was found, with patients' memories being rated lower than those of control participants for specificity, contextual information, feeling of reliving, overall vividness, coherence, and feeling of autobiographical me-ness, regardless of the sensory modality imagery predominance. Importantly, the autobiographical me-ness was
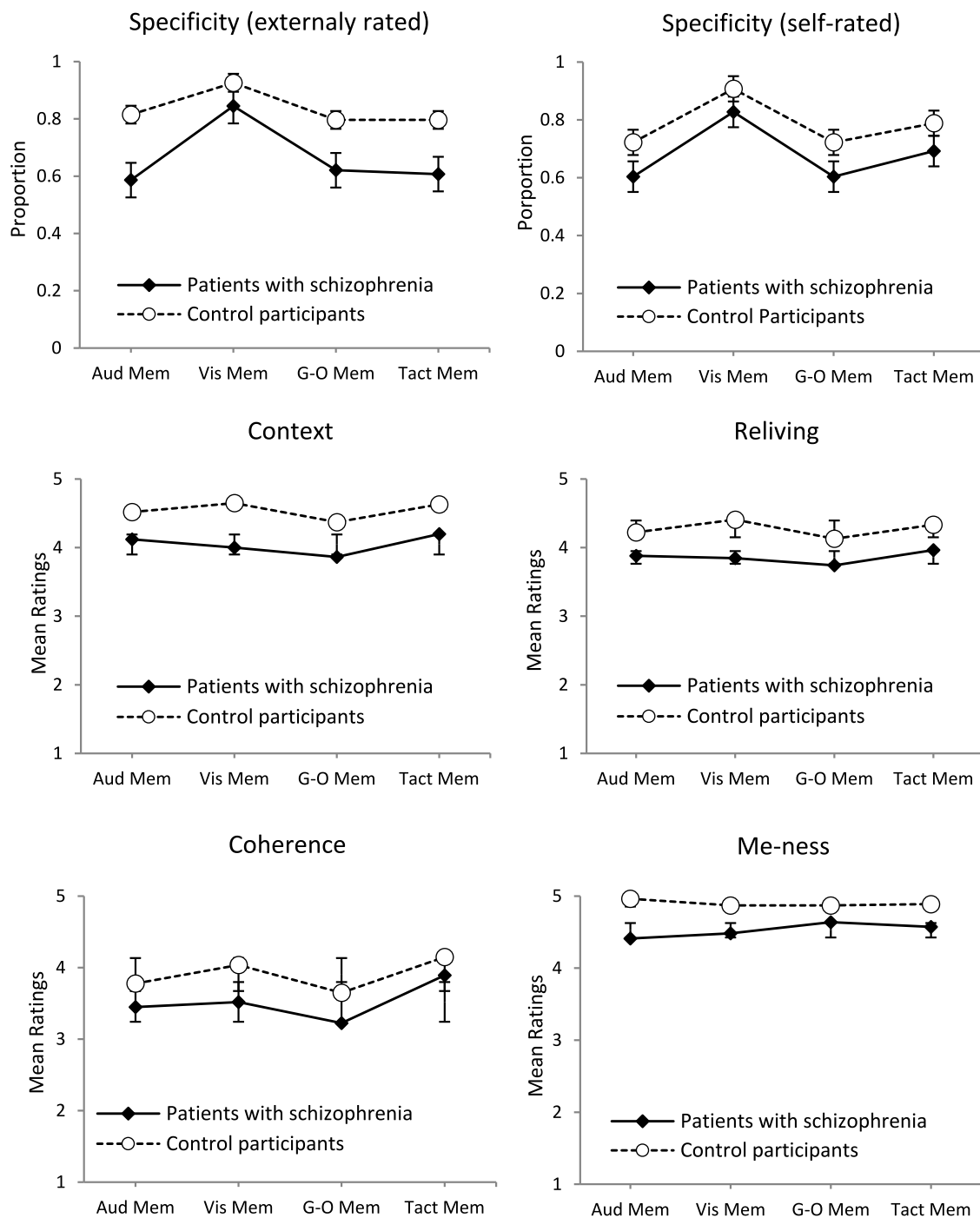
Fig. 2. Mean ratings of autobiographical memory characteristics (specificity, context, reliving, vividness, coherence and me-ness) as a function of sensory cue and group. Error bars represent the standard errors of the means. Aud Mem = Auditory Autobiographical Memories; Vis Mem = Visual Autobiographical Memories; G-O Mem = Gustatory-Olfactory Autobiographical Memories Ced; Tact Mem = Tactile Autobiographical Memories.

weaker in patients for all sensory modalities except for olfactory memories. Analyses conducted within the patient group showed that the feeling of autobiographical me-ness was correlated with the amount of contextual information available at retrieval. In the following, we discuss the possible implications of these findings.

We found that voluntary retrieval of autobiographical memories was broadly impaired in schizophrenia, regardless of the dominant memory imagery modality. Indeed, patients had difficulty remembering specific events, and their memories were less vivid, less associated with a feeling of reliving and less coherent than those of controls. Taken together, these impairments replicated and extended previous findings

regarding voluntary autobiographical memory in schizophrenia (Berna et al., 2016; Danion et al., 2005; Ricarte et al., 2017) and may be associated with poorer ability to travel back in time and remember past lived events in schizophrenia, likely contributing to a reduced sense of self observed in these patients (Allé et al., 2016; Berna et al., 2016).

In addition, we observed a reduction of contextual information associated with the autobiographical memories. Impairment of contextual information processing is well-documented in schizophrenia in a range of tasks. Patients have been found to have severe difficulty in dealing with contextual information and integrating peripheral features to construct a coherent representation of a scene in working memory

Table 3
Correlation analyses between autobiographical memories variables for each sensory cue and for all cued-memories grouped together, in the patient group (n = 28).

Patients	Me-ness	Specificity	Context	Reliving	Vividness	Belief in accuracy
Auditory cue						
Me-ness	–	0.07	0.29	0.20	0.31	0.55**
Specificity		–	0.21	0.04	0.05	0.22
Context			–	0.41*	0.53**	0.56**
Reliving				–	0.83***	0.50**
Vividness					–	0.50**
Belief in accuracy						–
Visual cue						
Me-ness	–	-0.01	0.40*	0.31	0.24	0.60**
Specificity		–	-0.06	0.14	0.02	0.08
Context			–	0.57**	0.60**	0.35¤
Reliving				–	0.81***	0.57**
Vividness					–	0.55**
Belief in accuracy						–
Gustatory-Olfactory cue						
Me-ness	–	0.04	0.58**	0.19	0.27	0.72***
Specificity		–	0.13	0.25	0.04	0.26
Context			–	0.67***	0.72***	0.41*
Reliving				–	0.71***	0.22
Vividness					–	0.25
Belief in accuracy						–
Tactile cue						
Me-ness	–	-0.10	0.50**	0.41*	0.41*	0.57**
Specificity		–	0.09	-0.14	-0.01	0.09
Context			–	0.74***	0.80***	0.53**
Reliving				–	0.64***	0.33¤
Vividness					–	0.54**
Belief in accuracy						–
All cues						
Me-ness	–	0.03	0.57**	0.33¤	0.33¤	0.69***
Specificity		–	0.15	0.15	0.06	0.30
Context			–	0.68***	0.76***	0.58**
Reliving				–	0.87***	0.60**
Vividness					–	0.61***
Belief in accuracy						–

Note. N = 28;
¤ $p < .10$
* $p < .05$
** $p < .01$
*** $p < .001$

Table 4
Hierarchical multiple regression analysis predicting autobiographical memory me-ness from contextual information and controlling for specificity, reliving and belief in accuracy, in the patient group (n = 28), for all cued-memories grouped together.

	Autobiographical memory me-ness		
Predictors	β	t	p-value
Contextual information	0.43	2.37	.03
Specificity	-0.19	-1.42	.17
Reliving	-0.36	-1.95	.06
Belief in accuracy	0.71	4.13	.000
Total R^2	**0.61***		

Note. N = 28
***p < .001

(Bazin et al., 2000; Cohen et al., 1999), hindering the formation of integrated memory representations (Altamura et al., 2013; Danion et al., 1999). A reduction of memory for contextual information has also been reported in both episodic and autobiographical memory

tasks (Potheegadoo et al., 2014; Rizzo et al., 1996). Potheegadoo et al., (2014) showed that, although patients with schizophrenia were able to improve certain qualities of their autobiographical memory, such as emotional or cognitive details, when given executive support at retrieval, contextual information remained to some extent inaccessible for them. Raffard et al., (2010) showed that the reduction of contextual information affected every kind of mental representation: autobiographical memory, scene construction and future projection. The present study also showed that reduced memory for contextual information, specifying the setting of the event, was consistent across different imagery modality instructions, again reflecting a general contextual memory deficit in schizophrenia.

Contextual information provides details that allow the person to differentiate one memory from another or from other mental events (Chalfonte and Johnson, 1996). According to Johnson and colleagues, the reduction of contextual information can lead a person to having only a feeling a familiarity regarding the initial event without being able to relive it (Johnson et al., 1993). Moreover, being able to reconstruct the setting or scene of the event is key to having a sense of reliving of past events, corresponding to autonoetic consciousness, a defining feature of episodic memory (Rubin et al., 2019; Rubin and Umanath, 2015; Tulving, 2002; Wheeler et al., 1997).

Consistent with these considerations, patients' memories were also associated with lower feelings of reliving in the present study. A measure of autobiographical me-ness was introduced in the present study to explore whether patients with schizophrenia experience a certain feeling of dissociation or disconnection in remembering personal events. A feeling of reliving measures the ability to travel back in time and re-experience the event as it occurred initially, whereas me-ness is the subjective feeling of belonging-ness, of having truly experienced the event in one's own personal life (James, 1890). As hypothesized, we showed that patients indeed reported a lower autobiographical me-ness in their memories. It is a direct measure of whether the person subjectively feels ownership for the memory, and feels convinced the memory is about their own personal life and not the life of somebody else. Not surprisingly, a ceiling effect was observed for the control group. This reflects that the reduced autobiographical me-ness probably is pathogenic and supposedly related to dissociative symptoms in schizophrenia, which may result in externalization of thought or mental events (Nijenhuis and van der Hart, 2011).

It is important to emphasize that the results did not indicate that patients considered their memories as exterior or non-personal, as their me-ness scores remained high. However, the lower score of me-ness suggested that, for some patients and some particular memories, there was a certain disconnection from the self, unlike in controls. These results were moderated by imagery modality predominance, as the autobiographical me-ness was significantly lower for all autobiographical memories except for olfactory memories. Although speculatively, this exception might be understood in the light of previous researches as memories triggered by olfactory information have been shown different than memories evoked by verbal and visual information (e.g., Herz & Schooler, 2002; Willander & Larsson, 2006). Evidence have suggested that the phenomenological experience of olfactory memory differs from the processing of other sensory information. More precisely, the feeling of being brought back in time to the occurrence of the event often is experienced as stronger for odor-cued memories than memories evoked by words or pictures (Herz, et al., 2004; Herz & Schooler, 2002; Willander & Larsson, 2006).

Importantly, we also showed in the patient group that contextual information was a key predictor of autobiographical me-ness. Hence, the extent to which contextual information was retrieved with the memory itself predicted patients' sense of autobiographical me-ness. In line with Rubin and Umanath's theory of scene construction (Rubin & Umanath, 2015), this finding emphasizes the importance of context integration in forming event memory, and connecting the lived event to the self. In addition, this observation supports Waters' (2006) theory of

memory-based hallucination suggesting that the disconnection between autobiographical memories and the self may be partly explained by the reduced contextual information associated with the memories.

Belief in accuracy was also strongly associated with autobiographical me-ness, and was its strongest predictor. This relationship might reflect some overlap between the two concepts. Or, as an alternative interpretation, Rubin et al., (2003) showed that a decreased belief in the accuracy of one's memories was associated with a greater dissociative experience. Similarly, in the present study, autobiographical me-ness could reflect some sort of dissociative feelings experienced at memory retrieval, and be in line with previous work (Rubin et al., 2003).

Counter to our initial hypothesis, we did not find that the phenomenological characteristics of patients' autobiographical memory varied according to imagery modality. Patients' auditory-prominent autobiographical memories were not more vivid or more strongly associated with a sense of reliving than their other sensory-prominent autobiographical memories, despite what could have been expected with regard to memory-based hallucination theories (McCarthy-Jones et al., 2014b; Steel, 2015; Waters et al., 2006).

The overall imagery manipulation worked well as reflected in a congruence between the specific imagery instructions and the modality-specific vividness ratings (Fig. 1). This pattern replicated for both patients and controls. Therefore, our findings do not support a sensory modality imbalance in cued autobiographical memories in schizophrenia. However, we have to acknowledge one major limitation of our study. The present paradigm only focused on voluntary memories strategically retrieved in response to sensory modality cues, whereas hallucination is a spontaneous process, which occurs unintentionally and is experienced as intrusive (Morrison & Baker, 2000; Morrison et al., 1995; Nayani & David, 1996). In addition, voluntary recall is goal-directed and supported by executive functions, which play a particularly important role in mental imagery (Pearson et al., 2013), but are known to be impaired in schizophrenia (Heinrichs and Zakzanis, 1998).

Hence, the present results may reflect that voluntary autobiographical memory is probably not involved in hallucination processes in schizophrenia. Future research on the relationship between hallucination and autobiographical memory therefore should focus on patients' autobiographical memories that are involuntarily recalled. Indeed, these memories, similarly to hallucination, are spontaneous, popping up in the mind without preceding intent or without involving cognitive control (Berntsen, 2010). Patients' involuntary autobiographical memories, by-passing cognitive deficits, might be even more vivid than their voluntary counterpart, and perhaps more sensitive to sensory modality imagery modulation.

6. Conclusion

This study showed that autobiographical memories of patients with schizophrenia are impaired in terms of specificity, contextual information, feeling of reliving, overall vividness, coherence, and autobiographical me-ness, across instructions that enhanced different forms of sensory modality imagery. Decreased autobiographical me-ness has not been documented before in schizophrenia, and provides additional evidence of autobiographical memory impairment in this disorder. The reduced autobiographical me-ness was robustly associated with reduced contextual information in patients' memories. Future research should examine whether the present findings replicate in patients' involuntary autobiographical memories and further explore the relation between context memory and a sense me-ness.

Funding

Open practices statement

The data and/or materials are available on request.

CRediT authorship contribution statement

Mélissa C. Allé: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft. **Fabrice Berna:** Resources, Supervision, Writing - review & editing. **Jean-Marie Danion:** Resources, Writing - review & editing. **Dorthe Berntsen:** Conceptualization, Methodology, Resources, Supervision, Writing - review & editing.

Declaration of Competing Interest

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2020.112835.

Appendix

Examples given to participants to illustrate autobiographical memories related to sensory modalities (auditory, visual, gustatory/olfactory, and tactile):

"I will give you an example to illustrate what we would like you to do. For instance, if I consider a particular event of my life such as the first time I saw my baby niece, what comes to my mind first are the baby's sounds. In that case, hearing is the most salient sensory modality of my memory, and I can describe this event as follows:

First, when I arrived at my sister's place, the baby was crying very loudly and it made me feel uncomfortable. I was surprised by the power of her voice coming from such a tiny body. Besides, the cries were continuous without a break, it was so intense. But finally, my sister fed her and my niece felt better. She started to babble and laugh. Hearing her laugh touched me a lot.

Someone else could have remembered this event through another sensory modality, for instance vision. In that case, the memory can be described as follows:

When I arrived at my sister's place to meet my niece, I was immediately surprised by her small size. She was so tiny, she could have been held in one hand. I remember she was very red because she was crying. I noticed she already had some hair on her head. Then, I thought she definitively looked like my sister: they have the same nose.

Or, the same event could be told focusing on other sensory modalities, smell/taste.

When I arrived at my sister's place to meet my niece, she was crying a lot because she was hungry. My sister gave me the baby while she was preparing the bottle to feed her. I was rocking her to calm her down and kissing her forehead. I remember particularly her smell, the baby smell. I don't know where this smell comes from, maybe from all the baby products we use, but it was so specific and unique I can still remember it now.

Finally, it is also possible to remember this same specific event according to another sensory modality, touch, and tell it like this:

When I arrived at my sister's place to meet my niece, she was crying a lot because she was hungry. My sister gave me the baby while she was preparing the bottle to feed her. My niece was so light, I barely felt her in my harms. Because she was crying she was completely tense, and it was even harder to carry her. I remember that, at one point, she took my finger in her hand and held it very tightly. I was surprised by her strength. Then, she put my finger into her mouth like she wanted to eat it and was very hungry. I remember touching her small tongue and her toothless gums; it was a weird feeling. When she was finally fed and calmed down, we had a relaxing time together. I remember then the incredible softness of her skin.

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