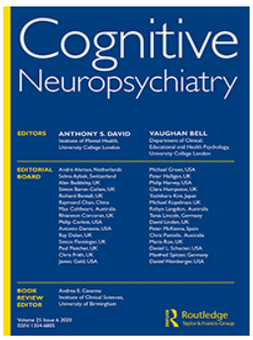

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Hallucinations and source monitoring in Alzheimer's disease

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ABSTRACT

Introduction: the source monitoring account has been widely investigated for hallucinations in schizophrenia. According to this account, hallucinations are inner events that are misattributed to another source. Our paper investigated this account for Alzheimer's disease.

Method: we investigated hallucination experiences in participants with Alzheimer's disease and age-matched healthy controls, as well as their source monitoring ability. The assessment of source monitoring included three conditions. In the first condition, participants had to remember whether objects were previously manipulated by themselves or by the experimenter (i.e. reality monitoring). In the second condition, they had to remember whether objects were previously manipulated by a black or white experimenter-gloved hand (i.e. external monitoring). In the third condition, participants had to remember whether they had previously manipulated objects or had imagined having done so (i.e. internal monitoring).

Results: relative to healthy control participants, participants with Alzheimer's disease experienced hallucinations more often and lower hits on source monitoring. Interestingly, significant correlations were only observed between hallucinations and the internal monitoring condition in participants with Alzheimer's disease.

Discussion: hallucinations in Alzheimer's disease seem to be related to the processes of making judgments about the (internal) context in which an event has occurred.

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Alzheimer's disease; hallucinations; source monitoring

Introduction

Hallucinations are considered as the most frequent perceptual symptom in Alzheimer's disease (AD) (Ropacki & Jeste, 2005; Scarmeas et al., 2005; Wilson et al., 2000). Hallucinations in AD are mainly visual and auditory (Jeste & Finkel, 2000; Rubin et al., 1988; Tariot et al., 1995) but somatic, olfactory, and tactile hallucinations can sometimes be

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observed (Burns et al., 1990; Deutsch et al., 1991). Regardless of their modality, hallucinations are associated with greater cognitive impairment and a more rapidly deteriorating course in AD (Scarmeas et al., 2005; Stern et al., 1987; Sweet et al., 2003; Weamer et al., 2009; Wilkosz et al., 2006). As for the occurrence of hallucinations in AD, these perceptual symptoms have been reported to occur mainly in patients with a later onset of the disease (Bassiony & Lyketsos, 2003; Devanand et al., 1992; Jost & Grossberg, 1996). Hallucinations in AD are associated with verbal outbursts, aggressive behaviour, functional decline, falls, as well as with stress, depression, and high burden of care in caregivers (El Haj et al., 2017).

Hallucinations in AD can be understood in light of the ALZHA (ALZheimer and HAllucinations) model (El Haj et al., 2017), according to which hallucinations can be attributed to neurological, genetic, iatrogenic, and cognitive factors. Among the cognitive factors, the ALZHA model proposes memory decline as a key factor that contributes to hallucinations in AD. More specifically, the ALZHA model proposes that hallucinations in AD can be attributed to difficulties in suppressing irrelevant thoughts and memories. This theoretical assumption is supported by experimental research demonstrating a relationship between hallucinations and inhibition in AD and, more specifically, with the ability to suppress irrelevant information in memory (El Haj, 2016a; El Haj et al., 2015). This research mirrors the model of Hemsley (2005), according to which inhibitory dysfunction leads to the emergence of redundant or irrelevant information from memory into awareness, subsequently resulting in the generation of hallucinations. This assumption has been supported by research showing that difficulties in intentionally inhibiting irrelevant thoughts or representations may, at least in part, underlie hallucinations in schizophrenia (Badcock et al., 2005) as well as in individuals predisposed to hallucinations (Paulik et al., 2007; Soriano et al., 2009). In addition to the suppression account, hallucinations in AD have also been found to be related with psychological distress such as depression (El Haj et al., 2015) and loneliness (El Haj et al., 2016b).

In this paper, we investigated the relationship between hallucinations in AD and difficulties in source monitoring. Source monitoring refers to the ability to make judgments about the context in which information was acquired (e.g. remembering where and when information was presented) (Johnson et al., 1993). The relationship between hallucinations and source monitoring has been extensively highlighted in schizophrenia because a distinguishing feature of hallucinations in schizophrenia is that these perceptual experiences are perceived as originating from another agency (Frith & Dolan, 1997). The source monitoring account is also relevant to the theory of Frith (Frith, 1996; Frith & Dolan, 1997), which proposes that hallucinations consist of inner events that are misattributed to another source due to difficulties in distinguishing sensations caused by one's own speech or actions. This theory fits with an influential cognitive model by Bentall (1990) proposing that hallucinations in schizophrenia can be explained by a difficulty in source monitoring and that hallucinating subjects have a specific bias toward attributing their thoughts to an external source (i.e. an externalising bias). Considering the link between hallucinations and source monitoring in schizophrenia, the present paper aimed to investigate this relationship, for the first time, in AD.

AD has not only been associated with hallucinatory experiences but also with compromise in source monitoring abilities. Research has shown that AD patients have difficulties

remembering whether memories were previously acquired via the experimenter or via someone else (Goldman et al., 1994), whether words were previously generated by the experimenter or by themselves (Multhaup & Balota, 1997), or whether actions were previously imagined or performed by themselves (Fairfield & Mammarella, 2009). Source monitoring compromise in AD can be assessed with reference to its three categories, as defined by Johnson et al. (Johnson et al., 1993): that is, reality monitoring, external monitoring and internal monitoring. Reality monitoring refers to the ability to discriminate between memories of self- versus other-generated sources (e.g. "Did I turn off the light or did the caregiver turn it off?"). External monitoring refers to the ability to discriminate between memories derived from at least two external sources (e.g. "Did caregiver X turn off the light or did caregiver Y turn it off?"). Internal monitoring refers to the ability to discriminate between at least two types of self-generated sources ("Did I turn off the light or am I imagining that I turned off the light?"). A previous study assessed these three categories of source monitoring by asking AD patients to remember whether objects were: (1) previously placed in a bag by themselves or by the experimenter (i.e. reality monitoring) (2) placed in a bag by a black or white experimenter-gloved hand (i.e. external monitoring) and (3) placed or imagined being placed in a bag (i.e. internal monitoring) (El Haj et al., 2012). Relative to healthy controls, AD patients showed a significantly poorer performance for the three source monitoring categories; however, the link between hallucinatory experiences and source monitoring ability was not assessed.

Taken together, the empirical research and cognitive models have suggested that hallucinations arise from the misattribution of internally generated cognitive events to external sources. Our study aimed to investigate this assumption for AD, by examining the relationship between hallucinations and compromise of source monitoring ability in patients with AD. More specifically, the specific source monitoring category (i.e. reality, external, or internal monitoring) that may be related with hallucinations was also examined.

Methods

Participants

The present study included twenty-five participants with a clinical diagnosis of probable AD at the mild stage (18 women and 7 men; *M* age=70.96 years, *SD*=5.37; *M* years of formal education=8.36, *SD*=2.66) and 27 matched healthy controls (17 women and 10 men; *M* age=68.07 years, *SD*=7.08; *M* years of formal education=9.36, *SD*=2.94). The AD patients were diagnosed with probable AD by an experienced neurologist or geriatrician, based on the National Institute on Aging-Alzheimer's Association clinical criteria (McKhann et al., 2011). Healthy controls were all autonomous and living in their own homes. Both groups were matched for age [$t(50) = 1.61$, p=.11], sex [X^2 (1, N=52) = .48, p=.49], and educational level [$t(50) = 1.30$, p=.20]. For all participants, exclusion criteria were as follows: psychiatric or neurological disorders (other than AD for the patients group), history of alcohol or drug use. All participants freely consented to participate and could withdraw from the study whenever they wished.

Material

Cognitive and clinical assessment

Participants were administered tests of general cognitive functioning, episodic memory, working memory, verbal fluency, and completed a measure of depression.

General cognitive functioning was assessed using the Mini Mental State Examination, with a maximum score of 30 points. Episodic memory was evaluated with the French version of the Grober and Buschke task. Participants had to retain 16 words, and after immediate cued recall, they proceeded to a 20-second distraction phase during which they had to count numbers aloud. This phase was followed by two minutes of free recall; the score from this phase (out of a maximum of 16) was retained as the episodic score. Working memory was assessed by asking participants to repeat a string of single digits in the same order (i.e. forward span) or in the reverse order (i.e. backward span). For the verbal fluency task, participants had two minutes to generate as many words beginning with the letter P (proper names and variants of the same words were not considered). Depression was assessed with the self-report Hospital Anxiety and Depression Scale, which consists of seven items that are scored on a four-point response scale ranging from zero (not present) to three (considerable). The maximum score was 21 points.

Assessment of hallucinations

A revised version of the Launay–Slade Hallucination Scale (LSHS-R), validated in a large sample (n=193) of healthy older adults (Larøi et al., 2005) was used to assess hallucinations.

The version of the LSHS-R used in the present study (see also (El Haj et al., 2016b; 2015)) included six items related to hallucinations. These items were as follows: "On certain occasions I have felt the presence of someone close who had passed away", "I often hear a voice speaking my thoughts aloud", "In the past I have had the experience of hearing a person's voice and then found that there was no-one there", "I have been troubled by hearing voices in my head", "Sometimes, I have seen objects or animals even though there was nothing there", and "On certain occasions I have seen a person's face in front of me when no-one was in fact there". The six items were scored on a five-point Likert scale ranging from zero ("certainly does not apply to me") to four ("certainly applies to me"). High scores (maximum = 24 points) indicate an increased tendency to hallucinate. The items were completed by the healthy controls and by the participants' informants for the AD group. Healthy controls completed the LSHS-R scale because some hallucinatory experiences may also be observed in normally aging non-clinical populations (Badcock et al., 2017; Johns et al., 2014; Larøi et al., 2005). Informants (e.g. spouses, siblings, caregivers) were solicited to control for any potential effect of anosognosia, limiting awareness of hallucinations in AD patients. Informants were provided with the following instructions: "Hallucinations refer to any perceptual experience in the absence of external stimuli (e.g. the patient may hear, see, or sense the presence of persons who are not there). Please indicate the degree to which the patient has had this experience based on her/his past or current behaviour".

Source memory

We replicated procedures of a previous study on the three categories of source monitoring in AD (El Haj et al., 2012). Thirty-six everyday objects corresponding to medium- to high-frequency words were carefully selected to be normal-sized and without distinctive features (e.g. clothespin, one euro coin, shoelace, spoon, paintbrush). One-third of the objects were randomly assigned to one of the three source monitoring conditions (i.e. reality, external, and internal monitoring).

The reality monitoring condition consisted of exposing participants to a set of 12 objects. These objects were successively presented on a table, in which the experimenter was seated in front of the participant, and participants were asked to name each object. After naming, participants had either to place the object in a black bag that was placed on the table or to watch the experimenter doing this action. Half of the 12 objects were pre-randomised to be placed in the bag by the participants, whereas the other half was pre-randomised to be put in the bag by the experimenter. This order was indicated on a predetermined grid so that the experimenter could easily carry out the procedure. Participants were clearly instructed that they had to remember whether the objects were manipulated by themselves or by the experimenter for a later recall task. After the objects were put in the bag, the participants were engaged in an interpolated activity that consisted of reading strings of numbers aloud for one minute. Afterwards, the 12 formerly shown objects were successively presented to the participants who were asked to decide whether the objects had been originally placed in the bag by themselves or by the experimenter. In the external monitoring assessment, the experimenter wore a black and a white standard medical latex glove and placed half of 12 objects in the bag with his black-gloved hand and the other half with his white-gloved hand; after the interpolated activity, participants had to remember whether objects were originally placed in the bag with the black or with the white gloved-hand. The internal monitoring condition consisted of asking participants to either place half of the 12 objects in a bag or to imagine themselves placing the other half in the bag, then to remember, after the interpolated activity, whether they had previously placed the objects themselves or whether they had imagined doing so. Performance (accuracy) on this task corresponded to the proportion of hits (i.e. correct responses).

Statistical analysis

Analysis was performed with SPSS 20 software. Prior to compare scores on the hallucinations scale as well as on the source monitoring task(s), we compared performances of AD participants and controls on the cognitive and clinical assessment. Comparisons of the Mini-Mental State Examination, digit span, and the Hospital Anxiety and Depression Scale scores were performed with Mann-Whitney's U test (due to a non-normal distribution), whereas comparisons for the remaining tasks were performed using Student's *t*-test (normal distribution). We then compared scores on the hallucinations scale as well as on the source monitoring task(s) between AD participants and controls. We then investigated, for each group, correlations between hallucinations and the three source monitoring conditions. Prior to performing analyses, all variables were plotted and checked for normal distribution with the Shapiro-Wilk test that showed a non-normal distribution for the variables. Between-group comparisons were performed using the Mann–Whitney U test; within-group comparisons were performed using the

Friedman test followed by Wilcoxon signed-rank tests. For all comparisons, the level of significance was set at $p \leq 0.05$, p values between 0.051 and 0.10 were considered as trends. As for correlational analyses, non-parametric correlations (Spearman's rank correlation coefficient) were used. To control for multiple comparisons, we used a Bonferroni correction, where only correlations reaching a threshold of $p < .012$ were considered as significant. This level was obtained by dividing the alpha level by the number of comparisons (0.05/4).

Results

Low cognitive function in AD

As illustrated in Table 1, and compared with control participants, patients with AD demonstrated lower general cognitive functioning ($U = 59.00$, $p < .001$, Cohen's $d = 3.43$), episodic memory [$t(50) = 5.56$, $p < .001$, Cohen's $d = 2.43$] forward span ($U = 69.00$, $p < .001$, Cohen's $d = 1.92$) backward span ($U = 179.00$, $p = .008$, Cohen's $d = .79$) verbal fluency [$t(50) = 3.92$, $p < .001$, Cohen's $d = 1.30$] but more depression ($U = 144.00$, $p = .001$, Cohen's $d = 1.05$).

High hallucinations and low source monitoring in AD

As depicted in Table 2, AD patients had a significantly higher score on the LSHS_E compared to the healthy controls ($U = 88.00$, $p < .001$, Cohen's $d = 1.64$). AD patients also had significantly poorer performance on the reality monitoring ($U = 205.00$, $p = .013$, Cohen's $d = .73$), external monitoring ($U = 196.00$, $p = .009$, Cohen's $d = .78$), and internal monitoring ($U = 209.50$, $p = .018$, Cohen's $d = .69$) conditions compared to the healthy controls. Within the AD group, significant differences were observed across the three source monitoring conditions [X^2 (2, $N = 25$) = 16.43, $p < .001$, Cohen's $d = 2.67$]. Post-hoc comparisons showed that AD participants had significantly poorer performance levels for the external compared to the internal condition ($Z = -1.97$, $p = .048$, Cohen's $d = .85$) or compared to the reality monitoring condition ($Z = -3.75$, $p < .001$, Cohen's $d = 2.27$), and had significantly poorer performance levels for the internal condition compared to the reality monitoring condition ($Z = -2.26$, $p = .024$, Cohen's $d = 1.01$). In the healthy control group, significant differences were observed across the three source

Table 1. Cognitive and clinical characteristics of Alzheimer's disease (AD) and healthy control participants.

		AD $n = 25$	Healthy controls $n = 27$	
General cognitive functioning	Mini-Mental State Examination	21.72 (1.74)	28.07 (1.41)	$p < .001$
Episodic memory	Grober and Buschke	6.32 (2.48)	11.00 (3.45)	$p < .001$
Working memory	Forward span	4.00 (1.15)	6.30 (1.38)	$p < .001$
	Backward span	3.36 (1.18)	4.48 (1.50)	$p = .008$
Verbal fluency	Fluency task (letter *P*)	17.84 (5.59)	23.56 (4.92)	$p < .001$
Depression	Hospital Anxiety and Depression Scale	11.68 (2.44)	7.89 (2.45)	$p = .001$

Note: Standard deviations are presented in brackets; performance on the Mini-Mental State Examination refers to correct responses/30; performance on the Grober and Buschke task refers to correct responses/16; performance on the forward and backward spans refers to the number of correctly repeated digits; performance on the verbal fluency task refers to the number of correctly generated words; the maximum score on the depression scale was 21 points.

Table 2. Hallucinations and source monitoring scores in Alzheimer's disease (AD) and controls.

	AD *n* = 25	Healthy controls *n* = 27
Hallucinations	13.72 (4.31)***	7.19 (3.09)
Reality monitoring	.58 (.25)*	.76 (.24)
External monitoring	.28 (.24)**	.47 (.29)
Internal monitoring	.41 (.26)*	.59 (.23)

Note: Standard deviations are presented in brackets; the maximum score on the hallucination scale was 24 points; source monitoring scores refer to the proportion of hits; group differences were significant at *$p < .05$, **$p < .01$, ***$p < .001$.

monitoring conditions [X^2 (2, $N = 27$) = 20.28, $p < .001$, Cohen's $d = 3.38$]. Post-hoc comparisons showed that control participants had significantly lower performance for the external condition compared to the internal condition ($Z = -2.02$, $p = .043$, Cohen's $d = .83$) or compared to the reality monitoring condition ($Z = -3.70$, $p < .001$, Cohen's $d = 2.03$), and showed a significantly poorer performance for the internal compared to the reality monitoring condition ($Z = -2.93$, $p = .003$, Cohen's $d = 1.36$).

Relations between hallucinations and internal monitoring in AD

As depicted in Table 3, significant correlations were detected in AD participants between scores on the hallucinations scale and performance on the internal monitoring condition. As for the healthy control participants, performance on the internal and reality monitoring conditions were correlated at .48, $p = .030$, internal and external monitoring were correlated at .37, $p = .058$, and external and reality monitoring were correlated at .31, $p = .086$. All remaining correlations were at the $p > .10$ level.

For convenience, we carried out correlations analysis between hallucinations and the three categories of source monitoring in each population, controlling for depression. Analysis demonstrated significant correlations between scores on the hallucinations scale and performance on the internal monitoring condition in AD participants ($r = -.50$, $p = .011$). No significant correlations between observed between scores on the hallucinations scale and performance on the external ($r = -.20$, $p = .30$) or reality monitoring ($r = -.46$, $p = .020$) condition in AD participants. Thus, the relationship between hallucinations and source monitoring in AD participants is not influenced by depression. The same thing can be said for healthy control participants as performance on the internal and reality monitoring conditions were correlated at .46, $p = .033$, internal and external monitoring were correlated at .38, $p = .059$, and external and reality monitoring were correlated at .33, $p = .089$.

Table 3. Correlational matrix for scores on the hallucinations scale and performance on the three source monitoring conditions in Alzheimer's disease (AD) participants.

		Hallucinations		Reality monitoring		External monitoring		Internal monitoring
AD	Hallucinations	–						
	Reality monitoring	-.47	$p = .018$	-				
	External monitoring	-.22	$p = .28$	.26	$p = .21$	-		
	Internal monitoring	**-.51**	$p = .010$	.34	$p = .092$	.17	$p = .40$	–

Note: Correlation coefficients in bold are significant after applying a Bonferroni correction (threshold of $p < .012$).

Discussion

In light of research showing a relationship between hallucinations and compromise of source monitoring in schizophrenia, our study examined this same relationship in probable AD. Using a task assessing three distinct types of source monitoring, significant correlations between the presence of hallucinations and internal monitoring (but not reality or external monitoring) in AD were observed.

The relationship between hallucinations and source monitoring has been extensively shown in schizophrenia based on the idea that hallucinations are perceived by schizophrenia patients to originate from another agency (Bentall et al., 1991; Frith & Dolan, 1997). This externalising bias has been supported by theoretical accounts proposing that hallucinations consist of inner events that are misattributed to another source due to difficulties in distinguishing sensations caused by one's own speech or actions (Frith, 1996; Frith & Dolan, 1997). Our paper extends the relationship between hallucinations and source monitoring to AD. More specifically, our study demonstrates an important relationship between these perceptual symptoms and internal monitoring in AD. This is not surprising because, unlike external or reality monitoring, internal monitoring is, in essence, concerned with distinguishing enacted from imagined scripts and actions. In addition to being significantly correlated with internal monitoring, hallucinations in AD participants also showed important correlations (albeit did not reach the Bonferroni correction level), with reality monitoring abilities. This is an interesting finding because reality monitoring allows distinguishing internal from external source, hence, hallucinations in AD may be related to a bias toward attributing inner events such as thoughts and images to an external source (i.e. an externalising bias). As for external monitoring, this ability showed no significant correlations with hallucinations, probably because these perceptual symptoms mainly involve dealing with inner events rather than with distinguishing external sources per se.

The link between hallucinations and source monitoring can be understood with a model by Larøi and Woodward (Laroi & Woodward, 2007), according to which source monitoring does not directly explain hallucinations, but it provides a rich framework for understanding some of the cognitive processes that contribute to hallucinations. More specifically, this model focuses on two steps that may underlie the onset of hallucinations, namely, alienation and misattribution. Alienation refers to a loss of the cognitive representations of an inner event, in other words, an inner event is (subjectively speaking) not clearly experienced as inner or self-generated. Misattribution deals with the localisation of the cognitive event in space; in other words, hallucinations occur when a subject attributes inner event to an outer space (i.e. a location outside of the subject). According to Laroi and Woodward (2007), hallucinations originate as inner events but are somehow altered such that they are experienced as outer events, either because of changes in the person's description of the event's subjective origin (i.e. alienation) or due to changes in the event's subjective spatial location (i.e. misattribution), or a combination of both. Future research may consider the alienation and misattribution concepts for AD as these concepts may provide valuable insights into the cognitive mechanisms of hallucinations in AD. A prominent venue for future research is assessing how information associated with the cognitive processing of imagination can be altered in AD. Indeed, Johnson et al. (Johnson et al., 1993) suggest that imagined events typically

involve information about the cognitive operations (e.g. records of organising, elaborating, retrieving, and identifying) that were established when the imagination was formed, and thus future research may investigate whether loss of information about cognitive operations in AD may result in alienation of inner events (i.e. hallucinations). As for misattribution, future research may investigate how ownership of an inner event can be attributed to another person (i.e. outer location) in AD.

The link between hallucinations and source monitoring in AD can be further understood by highlighting a model by Badcock and Waters et al. (Badcock et al., 2005; Waters et al., 2006), which suggests that at least two cognitive deficits must be present to explain auditory hallucinations. The first deficit is in intentional inhibition which leads to auditory mental representations intruding into consciousness in a manner that is beyond the control of the subject. The second deficit is in binding contextual cues, resulting in a difficulty to form a complete representation of the origins of mental events. The model by Waters et al. (Waters et al., 2006) suggests that, as a result of the inhibitory and binding deficits, inner events are experienced as involuntary and intrusive and are misattributed to an outer source. This model can be supported by research demonstrating compromised abilities in binding verbal (Parra et al., 2009) and visual information in memory (Parra et al., 2010), and this binding deficit is thought to decrease the ability of AD patients to discriminate one event from another during retrieval (El Haj & Kessels, 2013). The latter findings might support the assumption that hallucinations in AD result from a difficulty to form a complete representation of the origins of mental events.

Given the small sample size in our study, future studies should confirm our findings in a larger population. Another suggestion for future research is to explore relationship between hallucinations and source monitoring using a verbally-based source task. Because hallucinations are typically verbal or visual, a verbally-based, rather than an action-based, source monitoring task would be more suitable to assess relationship between hallucinations and source monitoring.

To summarise, fundamental to an understanding of hallucinations in AD is the study of cognitive mechanisms that may underlie these perceptual symptoms. Although the present paper draws heavily on the source memory account, other cognitive accounts such as memory suppression seems also to be involved in hallucinations in AD. In light of the available research, we propose that a combination of cognitive deficits (e.g. compromise in suppression in memory and source monitoring) can, at least partly, account for the occurrence and the phenomenological characteristics of hallucinations in AD.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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