



Research report

Remembering verbally-presented items as pictures: Brain activity underlying visual mental images in schizophrenia patients with visual hallucinations



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ABSTRACT

Background: Previous research suggests that visual hallucinations in schizophrenia consist of mental images mistaken for percepts due to failure of the reality-monitoring processes. However, the neural substrates that underpin such dysfunction are currently unknown. We conducted a brain imaging study to investigate the role of visual mental imagery in visual hallucinations.

Method: Twenty-three patients with schizophrenia and 26 healthy participants were administered a reality-monitoring task whilst undergoing an fMRI protocol. At the encoding phase, a mixture of pictures of common items and labels designating common items were presented. On the memory test, participants were requested to remember whether a picture of the item had been presented or merely its label.

Results: Visual hallucination scores were associated with a liberal response bias reflecting propensity to erroneously remember pictures of the items that had in fact been presented as words. At encoding, patients with visual hallucinations differentially activated the right fusiform gyrus when processing the words they later remembered as pictures, which suggests the formation of visual mental images. On the memory test, the whole patient group activated the anterior cingulate and medial superior frontal gyrus when falsely remembering pictures. However, no differential activation was observed in patients with visual hallucinations, whereas in the healthy sample, the production of visual mental images at encoding led to greater activation of a fronto-parietal decisional network on the memory test.

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Conclusions: Visual hallucinations are associated with enhanced visual imagery and possibly with a failure of the reality-monitoring processes that enable discrimination between imagined and perceived events.

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1. Introduction

Visual hallucinations occur in schizophrenia with a lower prevalence than do auditory hallucinations, and hence they have been the object of much scantier investigation (Waters et al., 2014; van Ommen et al., 2016). Visual hallucinations appear to be associated with activity in the visual cortex (Zmigrod, Garrison, Carr, & Simons, 2016). The brain imaging study of a schizophrenia patient with visual hallucinations evinced brain activity in higher visual areas corresponding to the content of the hallucinations, as well as in the hippocampus, involved in memory retrieval (Oertel et al., 2007). Visual hallucinations might consist of reactivation of mental images retrieved from visual memory and misinterpreted as perceptions (Barnes, 2015; Bentall, 1990). To explore this theory at a cognitive level, Brébion, Ohlsen, Pilowsky, and David (2008) presented a mixture of pictures and labels of common items to a sample of patients with schizophrenia, and required the participants to remember afterwards whether a picture of the item had been presented. The patients with visual hallucinations were found to demonstrate greater propensity than the other patients to erroneously remember pictures when only the label of the items had been presented. This suggests that the visual mental images they had formed on the basis of the word-stimuli were later mistaken for real pictures. Such confusion may stem from excessive visual imagery production, or alternatively, from defective reality monitoring processes by which mental images would be readily accepted as perception independent of their abundance or vividness.

Several studies have attempted to determine the neural bases of confusion between imagined and perceived pictures in the general population. Gonsalves et al. (2004) reported that their participants activated the precuneus, the inferior parietal cortex, and the anterior cingulate during the encoding of words they later remembered as pictures. These authors argued that false memories of pictures were induced by the activation of brain areas that are involved in visual imagery. Kensinger and Schacter (2005) obtained different but compatible results. In their study, the encoding of neutral items later remembered as pictures was associated with activation of the parahippocampal and fusiform gyri, and these brain regions were also assumed to be involved in visual imagery. Other studies have focused on the brain areas activated during the memory test, when participants have to use reality-monitoring processes to judge whether pictures have been seen or only imagined—a decision partly made on evaluation of the contextual features of these pictures (Johnson, Hashtroudi, & Lindsay, 1993). Okado and Stark (2003) reported that false memories of pictures were associated with activation of the right anterior cingulate gyrus. They

concluded that this activation was driven by the high level of conflict and effort required in judging the status of the imagined pictures. Indeed, the anterior cingulate has been identified as involved in conflictual decision making (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Brown, 2013; Chudasama et al., 2013; Walton, Crosson, Behrens, Kennerley, & Rushworth, 2007; Whitman, Metzack, Lavigne, & Woodward, 2013). In Kensinger and Schacter's (2006) study, the pictorial misattribution of word stimuli during the memory test was associated with activation of the left middle frontal gyrus.

No brain imaging study, as far as we know, has related false memories of pictures to ratings of visual hallucinations or visual imagery. We conducted an fMRI study of schizophrenia patients and healthy individuals, using the same paradigm as in Brébion et al. (2008), to investigate the brain areas associated with the mistaking of imagined pictures for real ones in patients with visual hallucinations and in non-clinical individuals with high visual imagery abilities. The results obtained in the healthy sample have been reported in another manuscript (Stephan-Otto et al., 2017). A subgroup of healthy individuals with high abilities in generating visual imagery mentally was found to activate the left inferior occipital gyrus—an area involved in visual perception—when processing the words they later remembered as pictures. In the memory test, these individuals did not make more picture misattributions overall than did their counterparts with lower visual imagery abilities. However, they took longer to respond that they remembered seeing pictures when there was none, and they differentially activated the left middle frontal gyrus as well as the inferior and superior parietal lobes while making these false judgments. We assumed that these brain areas were involved in the reality-monitoring process that enables the participants to evaluate whether the imagined pictures that came to mind had actually been perceived. The activation of the left middle frontal gyrus corroborates Kensinger and Schacter's (2006) observation. With regard to the parietal lobe, it has been proposed as being involved in the retrieval of contextual information (Kensinger & Schacter, 2006; King & Miller, 2014; Kurkela & Dennis, 2016; Leiker & Johnson, 2015; Mitchell & Johnson, 2009).

In the current report we present the results derived from the schizophrenia sample. In agreement with previous behavioral findings (Brébion et al., 2008), we expected the visual hallucination scores to be associated with increased rates of false memories of pictures. At the brain level, we hypothesized that the patients with visual hallucinations, similarly to the visual imagery-prone healthy individuals, activated visual areas when processing the words they later remembered as pictures. Following the above-mentioned studies of healthy individuals, we expected the anterior cingulate (Okado &

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