Self-face hallucination evoked by electrical stimulation of the human brain

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ABSTRACT

Objectives: Self-face hallucination (autoscopic hallucination or AH) has been reported in patients with widespread brain damage or retrospectively after epileptic seizures. The neural basis and the self-processing operations underlying AH remain unknown.

Methods: We report the results of intracerebral electrical stimulations of the right medial occipitoparietal cortex (right precuneus and occipitoparietal sulcus) in 2 patients with epilepsy who underwent a stereo-EEG.

Results: Immediately after the onset of the stimulation, the 2 patients reported seeing their current own face, facing themselves, in their left visual field.

Conclusions: Our study shows that the medial occipitoparietal junction has a key role in generating AH. This region has been shown to have a central role in various self-processing operations and especially in self-face recognition. Our observations further reveal that this region is involved in a visual representation of our own face, which is generated during the pathologic phenomenon of AH. This visual representation of our own face may be useful for self-face recognition and social cognition processes involving judgment of self-facial resemblance to others. *Neurology*® 2014;83:1–3

GLOSSARY

AH = autoscopic hallucination; **OBE** = out-of-body experience.

The conscious experience of the self is one of the most astonishing features of the human brain and comprises different facets (the sense that I exist separately from others, my autobiographical memories, the awareness of my own body, what I look like, etc.). One of the most important elements of our sense of identity is the appearance of our own face. Notably, although we are rarely confronted with our own face compared with others in everyday life, we are quicker at identifying our own face than other people's faces. This has been interpreted as reflecting the existence of a robust neural self-face representation.

One of the most fascinating phenomena related to the disturbance of the neural processes underlying the representation of the self is autoscopic hallucination (AH). AH is characterized by the visual hallucination of one's own face, sometimes including the upper parts of one's body. AH is part of a heterogeneous class (autoscopic phenomena) of pathologic visual illusory reduplication of one's own body in the extrapersonal space, which also contains out-of-body experiences (OBEs) and heautoscopy.[1–3] While the neural basis and the self-processing operations underlying OBEs and heautoscopy have been well documented (i.e., temporoparietal junction, disturbance of the awareness of our own body), these aspects remain debated for AH.[1] Here we report the first description of AH evoked by focal electrical stimulation of the human brain.

METHODS **Case descriptions.** We report the cases of 2 right-handed patients with epilepsy who never experienced AH during their seizures. Patient 1 is a 46-year-old man and patient 2 is a 24-year-old woman. Both patients underwent a stereo-EEG, which delineated the epileptogenic zone in the right medial temporal lobe for patient 1 and in the right posterior insula for patient 2.

Supplemental data at Neurology.org

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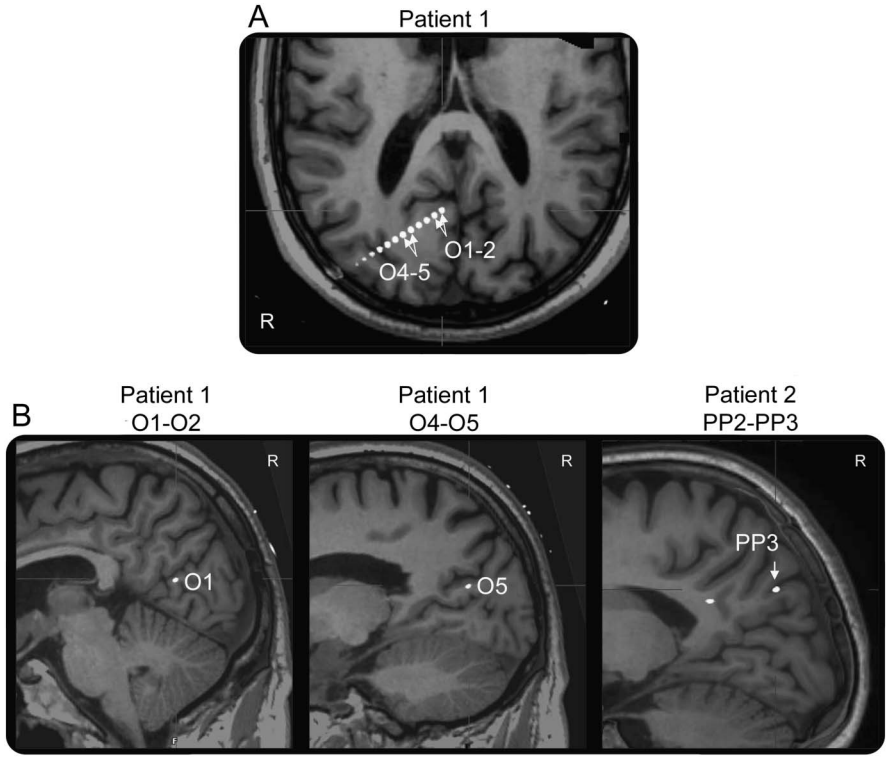
Cortical stimulations. Stereotactic placement of the intracerebral electrodes consisted of 5 to 18 contiguous 2-mm-long contacts separated by 1.5 mm. Intracerebral stimulations were performed to localize the epileptogenic zone and to map functionally relevant areas. Bipolar electrical intracerebral stimulations were applied between 2 contiguous contacts and performed at 50 Hz over 5 seconds, at intensities ranging from 0.5 to 2 mA. Patients were not aware of the stimulation onset and termination, the stimulation site, or the potential evoked perceptual changes.

RESULTS **Patient 1.** Patient 1 reported transient visual hallucinations of his own face during stimulations of 2 different sites in the posterior bank of the right occipitoparietal sulcus (figure). One site was located in the medial part of the right occipitoparietal sulcus (contacts O1-O2, 1 mA, 2 of 6 stimulations) and the other site was located in the lateral part of the sulcus (contacts O4-O5, 1.2 mA, 2 of 4 stimulations). Immediately after stimulation onset, the patient reported seeing a face in his left visual field ("I see a face"). When asked whose face it was, the patient spontaneously responded: "it seems to be my face," "I think it's my face." When asked if he saw any other parts of his body, the patient stated that he also saw his bust. Stimulations of the most medial contacts of electrode O in the occipitoparietal sulcus (contacts O1-O2) evoked garish, colored hallucinations of his own face (video 1 on the *Neurology*® Web site at Neurology.org). When asked if the hallucinated face was his current own face, he responded directly: "my face, yes." Four additional stimulations at this site produced hallucination of faces that were not spontaneously recognized as his own face. Stimulations of intermediate contacts of electrode O located in the white matter evoked either hallucinations of unknown faces (O2-O3, 2 stimulations) or elementary visual hallucinations (O3-O4, 1 stimulation). Notably, stimulations of more lateral contacts of electrode O located within the lateral part of the right occipitoparietal sulcus evoked hallucinations of the patient's own face again (contacts O4-O5, 2 stimulations). At this site, the patient saw his own face with the bandage that he was currently wearing during stereo-EEG (video 2). Stimulations of the most lateral contacts outside the occipitoparietal sulcus evoked hallucinations of unknown faces (O5-O6 and O6-O7, 2 stimulations).

Patient 2. Stimulation of one site in the right posterior precuneus at the edge of the occipitoparietal sulcus evoked a transient hallucination of the patient's own face (PP2-PP3, 1.2 mA; figure). During the stimulation train and the local after-discharge limited to the immediate vicinity of the stimulated site, the patient reported vertigo ("I am dizzy") and visual hallucination

Figure **Anatomical locations of relevant contacts that produced autoscopic hallucination at stimulation**



(A) Axial view of electrode O in patient 1 (bipolar stimulations of contacts O1-O2 and contacts O4-O5). Note that only stimulations of contacts located within the right occipitoparietal sulcus induced autoscopic hallucination. (B) Sagittal view of relevant contacts in patient 1 (bipolar stimulations of contacts O1-O2 and contacts O4-O5) and in patient 2 (bipolar stimulations of contacts PP2-PP3). For each pair of contacts, only one contact is represented.

in the left visual field ("there is something in front of my left eye"). She spontaneously reported: "I saw myself like in a mirror," "I saw my face," "I recognized myself like in a mirror," "there was something metallic like a mirror, I looked and I saw myself," "it was on my left," "I was colored like in a mirror" (video 3). Three subsequent stimulations at this site performed at lower intensities (0.8 and 1 mA) only evoked vertigo and elementary colored hallucinations in the left visual field.

Standard protocol approvals, registrations, and patient consents. Ethics committee approval was not requested because we only report results that were obtained in a clinical context. Also note that patients are not recognizable in the text or the videos.

DISCUSSION To our knowledge, we report the first 2 cases of self-face visual hallucination evoked by electrical stimulation of the human brain. In contrast to previous brain stimulation studies evoking autoscopic phenomena (OBEs) with subdural electrodes applied over the cortical surface,[4,5] our investigations used intracerebral depth electrodes. In this approach, the stimulations are not only performed in the lateral cortex but also in the sulci and in deep and medial cortical structures that are essential to self-processing (e.g., precuneus, cingulate cortex, medial prefrontal cortex).[6]

Phenomenologically, these hallucinations are similar to the pathologic AH described in various cerebral diseases causing damage to the right occipital and/or the parietal region. However, the heterogeneous and widespread localization of brain lesions has prevented establishing firm conclusions concerning the critical region(s) generating AH.[2,3] A recent study showed an overlap of these lesions in the right occipital lobe (cuneus, and the right superior occipital gyrus).[1] Focal electrical stimulation findings reported here provide a more accurate anatomo-functional correlation pointing toward the right precuneus and right parieto-occipital sulcus. Moreover, electrical stimulations further provide a causal link between the stimulated brain areas (right medial occipitoparietal junction) and the occurrence of AH.

Our current observations are consistent with functional neuroimaging studies in healthy subjects that showed a central role of the occipitoparietal sulcus and the precuneus in various self-processing operations.[7] More specifically, the right precuneus has been shown to have a role in self-face processing within a widespread cortical network involving the left fusiform gyrus, and bilateral middle and inferior frontal gyri.[8] Our results emphasize the crucial role of the right precuneus and occipitoparietal sulcus within this large cortical network.

The present observations show the key role of the right precuneus and occipitoparietal sulcus in representing self-face visual information within a distributed neural network dedicated to self-face processing. We suggest that AH may represent an abnormal activation of a visual internal template of our own face. Such a visual internal template of our own face may be useful for self-face recognition and judgment of self-facial resemblance of others, a function that is very important for social cognition, including trusting behavior, prosocial perceptions, and sexual preferences.[9] However, because our face changes with age and experience, such a template has to be a malleable construct and updated by recent visual experience of our own face.[10] This may explain why both patients reported seeing their current face (with his bandage for patient 1 and "like in a mirror" for patient 2).

AUTHOR CONTRIBUTIONS

J.J. wrote the article, L.M. performed the stimulations and wrote the article, S.F. wrote the article, S.C.-C. implanted the intracerebral electrodes and provided the figures, H.V. wrote the article, B.R. wrote the article, and J.-P.V. performed the stimulations and wrote the article.

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DISCLOSURE

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