

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

Jacques Jonas MD<sup>1,2,3,4,5</sup>, Louis Maillard MD PhD<sup>1,2,3,4</sup>, Solène Frismand MD<sup>1</sup>, Sophie Colnat-Coulbois MD PhD<sup>4,6</sup>, Hervé Vespignani MD<sup>1,2,3,4</sup>, Bruno Rossion PhD<sup>5</sup>, Jean-Pierre Vignal MD<sup>1,2,3</sup>

<sup>1</sup>Service de Neurologie, Centre Hospitalier Universitaire de Nancy, Nancy, France

<sup>2</sup>Université de Lorraine, CRAN, UMR 7039, Nancy, France

<sup>3</sup>CNRS, CRAN, UMR 7039, Nancy, France

<sup>4</sup>Faculté de Médecine de Nancy, Université de Lorraine, Nancy, France

<sup>5</sup>Université Catholique de Louvain, Louvain-la-Neuve, Belgique

<sup>6</sup>Service de Neurochirurgie, Centre Hospitalier Universitaire de Nancy, Nancy, France

**Corresponding author:** Dr. Jacques Jonas, Service de Neurologie, Hôpital Central, Centre Hospitalier Universitaire de Nancy, 29, Avenue du Maréchal de Lattre de Tassigny, F-54000 Nancy, France. E-mail: [j.jonas@chu-nancy.fr](mailto:j.jonas@chu-nancy.fr) Tel: +33 3 83 85 23 77 Fax: +33 3 83 85 25 49

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## ABSTRACT

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

**Methods.** We reported the results of intracerebral electrical stimulations of the right medial occipital cortex (right precuneus and occipito-parietal sulcus) in two epileptic patients who underwent a stereo-electroencephalography.

**Results.** Immediately after the onset of the stimulation, the two patients reported seeing their own current face, facing themselves, in their left visual fields.

**Conclusions.** Our study shows that the right medial occipito-parietal junction plays a key role in generating AH. The medial occipito-parietal junction has been shown to play a central role in various self-processing operations and especially in self-face recognition. Our observations further show that the medial occipito-parietal junction is involved in representing a visual representation of our own face, which is generated during the pathologic phenomena 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.

## INTRODUCTION

The conscious experience of the self is one of the most astonishing features of the human brain that 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. Interestingly, although we are rarely confronted with our own face compared to faces of others, in everyday life we are quicker at identifying our own face than other people's face. 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 the 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 (OBE) and heautoscopy (1,2,3). While the neural basis and the self-processing operations underlying OBE and heautoscopy have been well documented (i.e., temporo-parietal junction, disturbance of the awareness of our own body), this information remains debated for AH (1). Here we report the first description of AH evoked by focal electrical stimulation of the human brain.

## **PATIENTS AND METHODS**

### *Case descriptions*

We reported 2 right-handed epileptic patients who never experienced AH during their seizures. Patient 1 is a 46-year-old male and patient 2 is a 24-year-old female. Both patients underwent a stereo-electroencephalography (SEEG) that delineated the epileptogenic zone in the right medial temporal lobe for patient 1 and in the right posterior insula for patient 2.

### *Cortical Stimulations*

Stereotactic placement of the intracerebral electrodes consisted of 5-18 contiguous of 2 mm long contacts separated by 1.5 mm. Intracerebral stimulations were performed to localize the epileptogenic zone and to map functionally eloquent areas. Bipolar electrical intracerebral stimulations were applied between two 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, of the stimulation site, or of the potential-evoked perceptual changes.

## **RESULTS**

### *Patient 1*

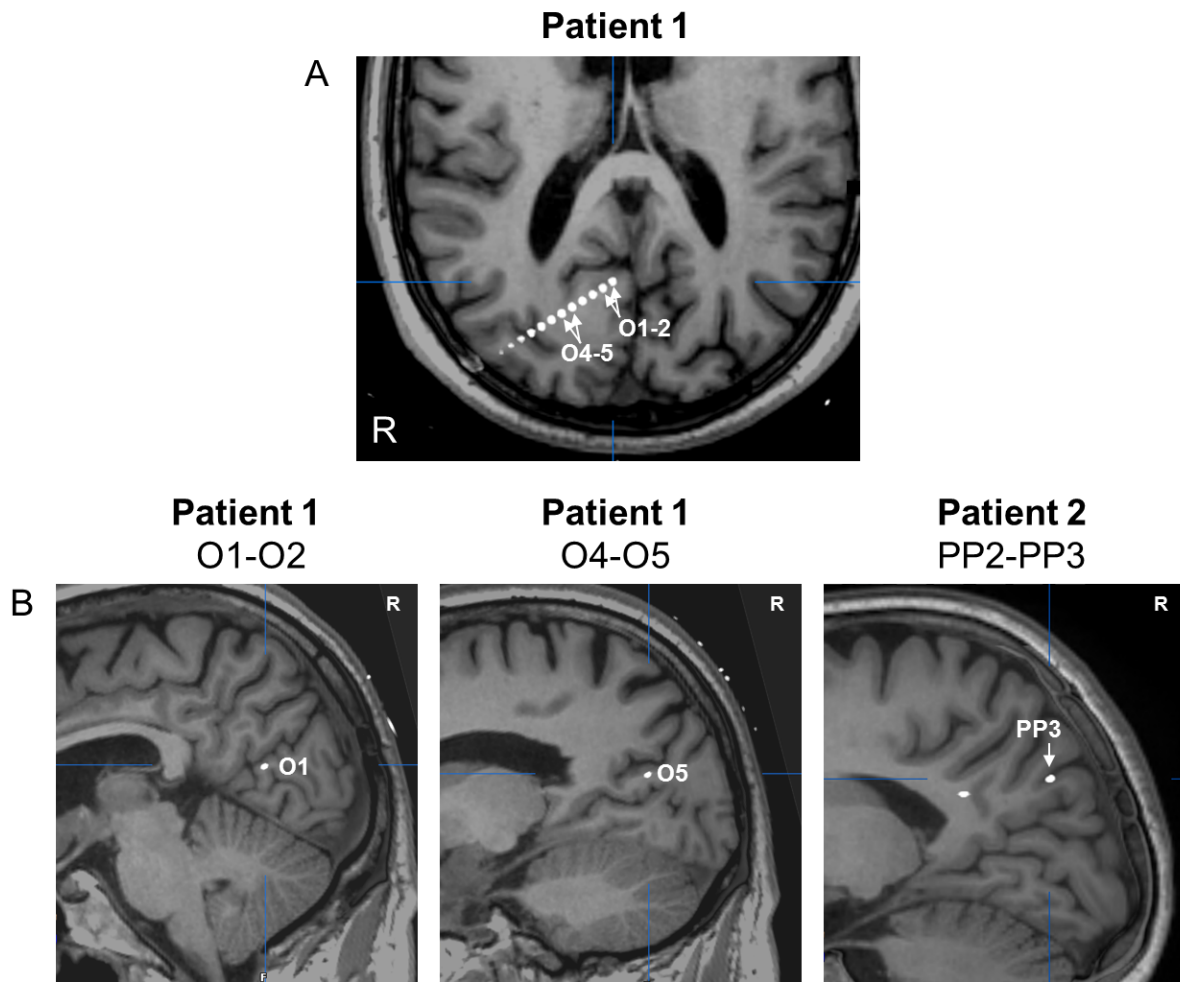
Patient 1 reported transient visual hallucinations of his own face during stimulations of two different sites in the posterior bank of the right occipito-parietal sulcus (Figure 1). One site was located in the medial part of the right occipito-parietal sulcus (contacts O1-O2, 1 mA, 2 out of 6 stimulations) and the other site was located in the lateral part of the sulcus (contacts O4-O5, 1.2 mA, 2 out 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 occipito-parietal sulcus (contacts O1-O2) evoked garish, colored hallucinations of his own face (Supplemental Video 1). When asked if the hallucinated face was his actual 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). Interestingly, stimulations of more lateral contacts of electrode O located within the lateral part of the right occipito-parietal 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 actually wearing during SEEG (Supplemental Video 2). Stimulations of the most lateral contacts outside the occipito-parietal 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 occipito-parietal sulcus evoked a transient hallucination of the patient’s own face (PP2-PP3, 1.2 mA, Figure 1). 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 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” (Supplemental 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.



**Figure 1. Anatomical Locations of Eloquent Contacts Whose Stimulations Produced AH.** **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 occipito-parietal sulcus induced AH. **B.** Sagittal view of eloquent 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.

## DISCUSSION

To the best of our knowledge, we report the first two cases of self-face visual hallucination evoked by electrical stimulation of the human brain. In contrast to previous brain stimulation studies evoking autoscopic phenomena (OBE) 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 cortical surface 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 pathological AH described in various cerebral diseases causing damages of the right occipital and/or the parietal region. However, the heterogeneous and widespread localization of brain lesions has prevented from drawing 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 towards the right precuneus and right parieto-occipital sulcus. Moreover, electrical stimulations further provide a causal link between the stimulated brain areas (right medial occipito-parietal junction) and the occurrence of AH.

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

The present observations show the key role of the right precuneus and occipito-parietal sulcus in representing self-face visual information within a distributed neural network dedicated to self-face processing. We suggest that autoscopic hallucination 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 own current face (with the current bandage for the patient 1 and “like in a mirror” for patient 2).

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