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Research report

A face identity hallucination (palinopsia) generated by intracerebral stimulation of the face-selective right lateral fusiform cortex

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ABSTRACT

We report the case of a patient (MB, young female human subject) who systematically experienced confusion between perceived facial identities specifically when electrically stimulated inside the lateral section of the right fusiform gyrus. In the presence of a face stimulus (an experimenter or a photograph), intracerebral electrical stimulation in this region generated a perceptual hallucination of an individual facial part integrated within the whole perceived face, i.e., facial palinopsia. In the presence of a distracting stimulus (visual scene or object picture), the patient also experienced an individual face percept superimposed on the non-face stimulus. The stimulation site evoking this category-selective transient palinopsia was localized in a region showing highly selective responses to faces both with functional magnetic resonance imaging ("Fusiform Face Area", "FFA") and intracerebral electrophysiological recordings during fast periodic visual stimulation (FPVS). Importantly, the largest electrophysiological response to fast periodic changes of facial identity was also found at this location. Altogether, these observations suggest that the face-selective right lateral fusiform gyrus plays a role in generating vivid percepts of individual faces, supporting the active role of this region in individual face representation.

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1. Introduction

Individual face recognition plays a critical role in human social interactions. Studies of patients showing individual face recognition impairment after brain damage (i.e., prosopagnosia, following Bodamer, 1947; see Della Sala & Young, 2003 for an early report by Quaglino and Borelli in 1867) have long suggested that this brain function is supported by a large territory of the human ventral occipito-temporal cortex (VOTC), from the occipital pole to the temporal pole, with a right hemispheric advantage (Barton, 2008; Hécaen & Angelergues, 1962; Meadows, 1974; Rossion, 2014; Sergent & Signoret, 1992).

Within this cortical territory, the lateral section of the right posterior/middle fusiform gyrus (latFG) may be particularly important, as this region shows the largest selective response to faces both in neuroimaging ("Fusiform Face Area", "FFA", e.g., fMRI: Puce, Allison, Gore, & McCarthy, 1995; Kanwisher, McDermott, & Chun, 1997; Kanwisher, 2017; PET: Sergent, Ohta, & MacDonald, 1992; Rossion et al., 2000) and intracerebral recordings (Jonas et al., 2016). Recent studies have shown that electrical intracranial stimulation over the right – but not the left – latFG may elicit transient impairment in face perception, with patients reporting a selective distortion of the visual face input (i.e., distortion of people's faces in the room: "prosopometamorphopsia", Parvizi et al., 2012; Rangarajan et al., 2014). However, patients with prosopometamorphopsia, often a transient phenomenon observed shortly after brain damage (e.g., Bodamer, 1947: case 3/patient B), do not present with major difficulties in individual face recognition, in spite of their perceptual distortions (Bodamer, 1947; Hwang et al., 2012; Hécaen & Angelergues, 1962; Nass, Sinha, & Solomon, 1985; Trojano, Conson, Salzano, Manzo, & Grossi, 2009). Although stimulation of the right latFG inducing prosopometamorphopsia offers a causal link between face perception and this area, impairment in individual face recognition, which characterizes patients with prosopagnosia (Hécaen & Angelergues, 1962; Rossion, 2014; Sergent & Signoret, 1992), has so far not been observed following electrical stimulation of this region.

Here, we report a rare case of confusion of facial identity following focal electrical stimulation directly in the grey matter of the right latFG, without any face distortion. When stimulated only in this region, the patient (MB) systematically reported visual hallucinations characterized by the recurrence of individual facial parts (facial palinopsia, Critchley, 1951) integrated within the whole perceived face (a person in the room, or a photograph). Importantly, the electrode contact evoking this category-selective transient palinopsia was localized in a region showing highly selective responses to faces both with functional magnetic resonance imaging and with intracerebral recordings, as well as sensitivity to individual face discrimination with intracerebral recordings. These observations show that a local face-selective region of the right latFG can generate a vivid hallucination of an individual face, highlighting the active role of this region in individual face representation.

2. Materials and methods

2.1. Case description and neuropsychological assessment

The subject is a 30-year-old woman (MB) with refractory focal epilepsy. Intracerebral stereo-electroencephalography (SEEG) delineated her epileptogenic zone in the right lateral occipito-parietal junction (posterior parietal cortex and superior occipital gyrus). The patient was right-handed as attested by the Edinburgh Handedness Inventory (Oldfield, 1971). At the time of the SEEG exploration, her treatment included eslicarbazepine acetate and lacosamide. She was never treated with topiramate, which has been found to be related to generate palinopsia in some cases (Gersztenkorn & Lee, 2015). The fMRI Q1 experiment and the FPVS recordings were approved by the local ethical committee, for which she gave a written consent. She also gave a specific and written consent for using the video material.

MB showed a general intelligence level in the normal range (full-scale IQ of 97). Neuropsychological evaluations revealed normal performance on memory (Taylor Complex Figure, Selective Reminding Test), language (DO80 naming test) and basic visual perception (Visual Object and Space Perception battery, VOSP) functions. The patient never complained of individual face recognition difficulties in everyday life, nor during or after epileptic seizures. Before intracerebral implantation, we conducted an extensive series of behavioral tests to assess MB's face/object perception and memory. Ten control participants (age-, sex- and education level-matched controls) performed the same tests. To compare the results of MB to the control participants, we used the modified *t*-test of Crawford–Howell for single-case studies (Crawford & Howell, 1998) with a p value of $<.05$ considered as statistically significant. These tests included: (1) face/no face categorization test (Mooney faces, experiment 16 in Busigny, Joubert, Felician, Ceccaldi, & Rossion, 2010); (2) tests of face individuation including the Benton Face Recognition Test (BFRT, Benton, Sivan, Hamsher, Varney, & Spreen, 1983), the Cambridge Face Memory Test (CFMT, Duchaine & Nakayama, 2006), an individual face- and car-matching at upright and inverted orientations (experiment 4 in Busigny & Rossion, 2010), as well as an individual matching task of faces presented in different viewpoints (experiment 22 in Busigny et al., 2010); (3) tests of visual memory including an old/new face task (encoding phase followed by an old/new forced choice decision with faces, experiment 3 in Busigny et al., 2010) and an old/new bird task (same task with bird pictures, using the same parameters as for faces); (4) a famous face recognition test (CELEB test, Busigny et al., 2014).

The results of these tests are shown in Table 1. MB performed in the normal range compared to matched normal controls for nearly all tests, either in accuracy or in response times, except that she was significantly slower at a visual memory test with faces and birds (old/new face and old/new bird tests, see Table 1), a slowing down that is often found in epileptic patients under medication. Her decrease of performance for inverted compared to upright faces was also in the

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