Clinical Neurology and Neurosurgery 111 (2009) 601–605

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Case report

Evidence for an occipito-temporal tract underlying visual recognition in picture naming

Emmanuel Mandonnet[a], Peggy Gatignol[b], Hugues Duffau[a,b,c,*]

[a] INSERM U678, Hôpital de la Salpêtrière, 47-83 Bd de l'hôpital, 75651 Paris, Cedex 13, France
[b] Laboratoire de Psychologie et de Neurosciences Cognitives, CNRS FRE 2987, Université René Descartes, Paris V, France
[c] Department of Neurosurgery, Hôpital Gui de Chauliac, CHU Montpellier, 80 Av Augustin Fliche, 34295 Montpellier, France

ARTICLE INFO

Article history:
Received 27 August 2008
Received in revised form 21 February 2009
Accepted 29 March 2009
Available online 2 May 2009

Keywords:
Brain mapping
Connectivity
Direct electrical stimulation
Visual recognition
Inferior longitudinal fasciculus
Visual word form area

ABSTRACT

A 24-year-old male underwent awake surgery for a lesion in the left dominant basal temporo-occipital junction.

During the intraoperative functional mapping using picture naming, cortical stimulation near the visual word form area led to visual paraphasia. These visual paraphasias were also elicited axonally by subcortical stimulation at the anterior wall of the cavity.

We propose to discuss the existence of this "visual object form area", devoted to the visual recognition of object, and its links with the closely related "visual word form area". We suggest that its afference, whose stimulation also induced visual paraphasias, may be one part of the U-shaped fibers distributed along the posterior part of the occipito-temporal connection system (inferior longitudinal fasciculus). Preservation of this white matter tract is essential for visual recognition. Thus, it should be mapped intraoperatively more systematically.

1. Introduction

Since the seminal work of Ungerleider and Mishkin in non-human primates [1], the processing of visual information is divided in two principal streams: the ventral one, specialized in object identification (the "what" pathway) and the dorsal one, dedicated to the analysis of spatial position (the "where" pathway). More recently, based on fMRI studies, the dorsal pathway has been subdivided into the classic "where" pathway (from occipital to superior parietal cortex) and an "how" pathway (from occipital to middle frontal regions), processing information about "how" to interact with a visually presented object [2]. Regarding the ventral route, it is currently thought that the posterior basal temporal areas are involved in visual recognition [3–7], with specific areas for faces (faces fusiform area (FFA), on the right hemisphere [8]), tools (bilateral temporal regions [9]), houses (bilateral parahippocampal gyrus [10]) and words (visual word form area (VWFA), left hemisphere, dominant in language processing [11,12]). Although these cortical regions were extensively studied in the recent literature, using both lesion and neuroimaging works, the underlying subcortical connectivity has received less attention, with the exception of a very recent study [13] based on DTI imaging in the case reported in 2006 by Gaillard et al. [14]. Nevertheless, the anatomical validity of fibers tracks obtained by DTI is still limited by methodological concerns on tracking algorithms.

Here, we present the case of a patient operated on awake for a left basal temporo-occipital dysplasia. Brain mapping during picture naming test revealed, just in front of the lesion, a cortical site whose stimulation induced disturbances of visual recognition. Such a dysfunction was also generated by axonal stimulation of an occipito-temporal white matter tract.

Analyzing the anatomical correlates of these results, we hypothesize that U-shaped fibers of the left inferior longitudinal fasciculus (ILF) may subserve visual recognition in humans. We also attempt to integrate the cortical sites whose stimulation generated errors during picture naming testing in this patient within the wider networks sustaining picture naming and reading tasks (with special attention to the controversial visual word form area [15]).

2. Case report

2.1. Clinical presentation

The patient was a 24-year-old right-handed male with no previous medical history, who presented a first generalized tonic seizure, preceeded by an aura with right hemianopsia and vertigo. Despite

* Corresponding author at: Department of Neurosurgery, Hôpital Gui de Chauliac, CHU Montpellier, 80 Av Augustin Fliche, 34295 Montpellier, France.
Tel.: +33 4 67 33 74 88; fax: +33 4 67 33 75 57.
E-mail address: h-duffau@chu-montpellier.fr (H. Duffau).

0303-8467/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.clineuro.2009.03.007

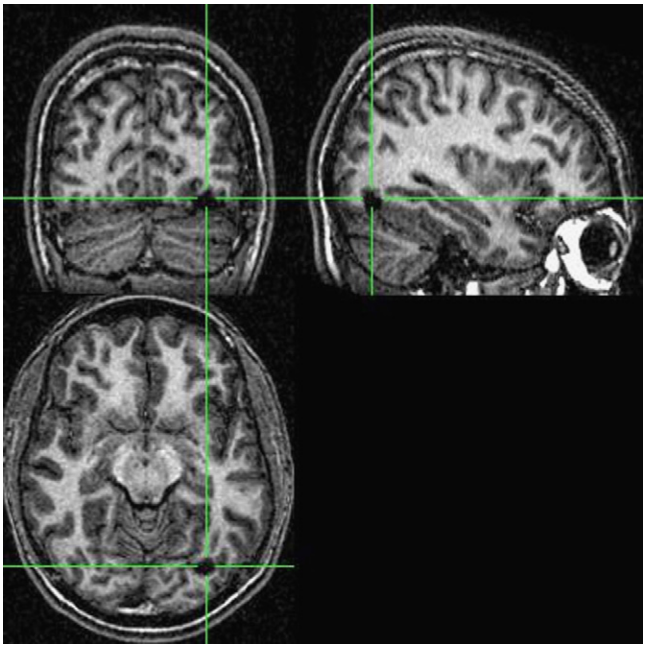

Fig. 1. Preoperative T1-weighted MRI showing the lesion after normalization in the MNI atlas (using the Lesionmask procedure, freely available at http://www.sph.sc.edu/comd/rorden/mritut.html). In Talairach coordinates, the lesion is centered around $X = 36$ mm, $Y = -76$ mm, and $Z = -4$ mm. The Y coordinate ranged from −72 to −84.

medication by Valproate, the patient exhibited a partial simplex seizure 6 months later, with visual disturbances in the right hemifield (phosphenes) and vertigo. In the post-ictal period, the patient reported language disorders, lasting a few minutes. He also complained of transient difficulties to recognize the voice and the face of his father.

The neurological examination as well as language testing (Boston Diagnostic Aphasia Examination (BDAE) [16] and "DO 80" picture naming test [17]) before surgery were normal (he rated 80/80 on the DO 80). Handedness, as assessed by Edinburgh Handedness Inventory [18] confirmed the patient was right-handed.

The preoperative anatomical MRI showed a small hypo-T1 lesion, with contrast-enhancement after gadolinium injection, located on the left basal temporo-occipital junction (Fig. 1).

2.2. *Intraoperative electrostimulation technique*

Due to the location of the lesion in the dominant hemisphere, an awake intraoperative functional mapping was performed during the surgical resection [19], in order to minimize the risk of permanent postsurgical neurological deficit.

The cortical and axonal mapping was obtained using the method of electrostimulation previously described by the authors [20]: a 5-mm spaced-tips bipolar probe delivering a biphasic current was applied during 4 s on the brain (pulse frequency of 60 Hz, single pulse phase duration of 1 ms) (Nimbus, Hemodia*, Labège, France). Under local anesthesia, the patient was asked to perform a picture naming task (preceeded by reading the short phrase "this is a . . ." in French)—in order to identify the essential cortical language sites known to be *inhibited* by stimulations [19,20]. The naming task is referred to as "DO 80" and consists of 80 black and white pictures selected according to variables such as frequency, familiarity, age of acquisition, and level of education. These stimuli are homogeneous along the different categories, with normative data [17].

During the functional mapping language disturbances were assessed on-line by a speech therapist, present in the operating room. At least one picture presentation without stimulation separated each stimulation, and no site was stimulated twice in succession, to avoid seizures. Each cortical site (size 5 mm × 5 mm) of the entire cortex exposed by the boneflap was tested three times to determine the functional relevance of the stimulated area for picture naming.

Each eloquent area was marked using a sterile number tag on the brain surface, and its location correlated to the anatomical landmarks (sulci/gyri/lesion boundaries) previously identified by ultrasonography. A photograph of the cortical map was made before resection.

After cortical mapping, the lesion was removed, by alternating resection and subcortical stimulations. The functional pathways were followed progressively from the cortical eloquent sites already mapped, to the depth of the resection. The patient had to continue to name when the resection became close to the subcortical eloquent structures, which were also identified by functional inhibition during stimulation as at the cortical level [21]. Again, the type of disturbances was detailed by the speech therapist throughout the resection. In order to perform the best possible tumor removal with preservation of the functional areas, the resection was pursued until eloquent pathways were encountered around the surgical cavity. Thus, there was no margin left around the cortico-subcortical eloquent areas. As for the cortical sites, each subcortical pathway is causally identified by repeated stimulations along the fasciculus.

2.3. *Postoperative course*

Immediately and at 6 months following the surgery, the patient underwent the same neurological and language examination as preoperatively.

A control MRI was performed immediately and 3 months after surgery. This imaging allowed first to evaluate the quality of lesion removal, and secondly to analyze the anatomical location of the functional pathways—i.e. at the periphery of the cavity, where the resection was stopped, a methodology that we previously used [20–23].

3. Results

3.1. *Intraoperative findings*

Using an intensity of 3.2 mA, anomia was elicited at the posterior part of middle temporal gyrus (tag 19) (Fig. 2a). Posteriorly to the Labbe vein (tag 20), at the junction between inferior temporal and fusiform gyrus, stimulation systematically (three errors for three trials) generated paraphasias (see Fig. 2b): miroir for fauteuil (i.e. mirror for arm-chair), rasoir for accordéon (i.e. razor for accordion), glace for louche (i.e. ice cream for serving spoon). The patient also reported a feeling of "three dimensional vision". However, there was neither visual field defect nor phosphenes. As a consequence, the resection was undertaken posteriorly to this site.

At the end of the resection, subcortical white matter stimulation generated similar visual paraphasias (two errors for two trials) at the level of the anterior and deep wall of the cavity (tag 21): chat for masque (i.e. cat for masque) and filet for grillage (i.e. fishnet for wire netting) (see Fig. 2b). Moreover, when stimulation was performed more superiorly in the depth of the cavity, hemianopsia and phosphene were elicited. Thus, the resection was stopped according to cortical and axonal functional boundaries.

3.2. *Postoperative course*

3.2.1. *Immediate postoperative results*

During the first few days after surgery, the patient noted "troubles of shape recognition at the center of an object, a word or a