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Comparison of intraoperative functional brain map obtained with RGB imaging with preoperative functional brain map obtained with functional magnetic Resonance imaging

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Introduction

Context

Non invasive functional brain mapping is an imaging technique used before brain tumor resection to **localize the functional areas** of the patient brain.

f-MRI and **electrical brain stimulation (EBS)** are two complementary clinical tests performed before neurosurgery.

f-MRI tests are performed before the patient craniotomy (**pre-operative gold standard**). **Electrical brain stimulation** tests are performed once the patient cortex is exposed (**intraoperative gold standard**).

Background

Optical imaging can be used to monitor the **brain activity** [1] with the quantification of **hemoglobin concentration changes** ($\Delta[HbO_2]$ and $\Delta[Hb]$).

A device consisting of a **continuous wave white light illumination** and a **RGB camera** is a suitable approach [2].

Objective - Improve the patient care process

We present the methodology to compare **intraoperative functional brain maps** obtained with a RGB camera to **pre-operative or post-operative fMRI maps**.

Material and methods

Experimental paradigm

The **motor skills** of the patient's left hand was tested with **fMRI** and **optical imaging** using a **task-based procedure** (repetitive hand opening and closing). The neurosurgeon also performed **EBS** during the neurosurgery.

Procedures for identifying functional brain areas

Pre-operative procedures:

- MRI anatomical volume (FLAIR sequence)
- fMRI functional map (EG-EPI sequence) and Statistical Parametric Mapping [3]

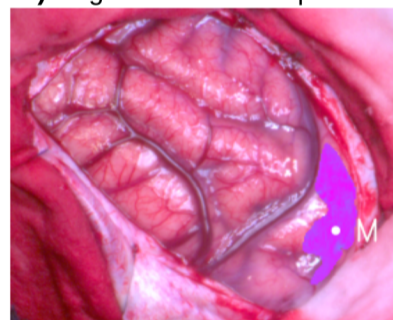
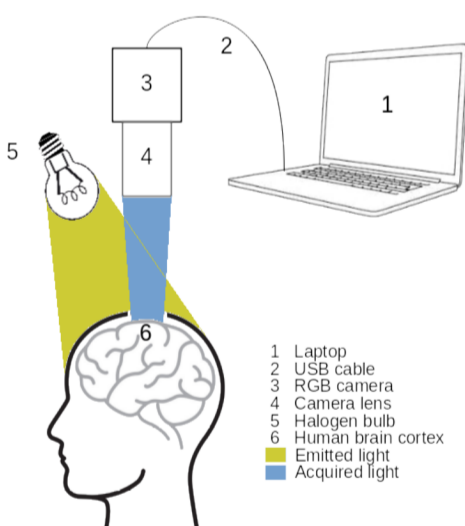
Intraoperative procedures:

- Electrical brain stimulation identifications
- RGB video acquisition, hemodynamics quantification (Modified Beer-Lambert law [2]) and Statistical Parametric Mapping [3,4]

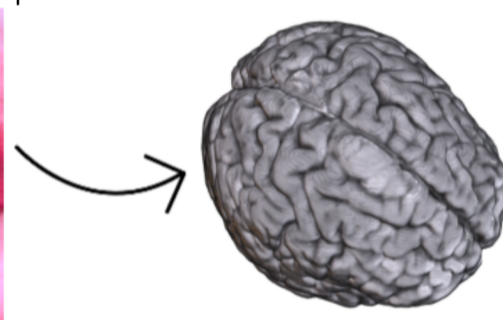
Multi-modality registration procedure

- 1) Segmentation of the cerebral cortex in the pre-operative MRI anatomical volume
- 2) Registration of the fMRI map on the MRI anatomical volume (affine transformation – SPM [3])
- 3) Collection of landmarks in the RGB image and in the MRI anatomical volume
- 4) Computation of the rigid transformation matrix for matching optical and MRI landmarks (least square minimization)
- 5) Registration of the optical map on the MRI volume and of the fMRI map on the RGB image

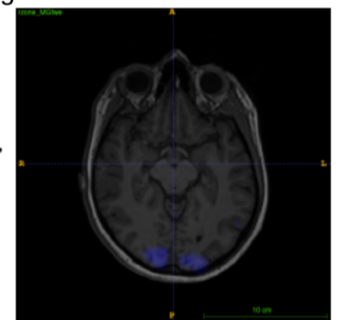
Experimental setup [2]



Intraoperative optical functional map and EBS identification (M)

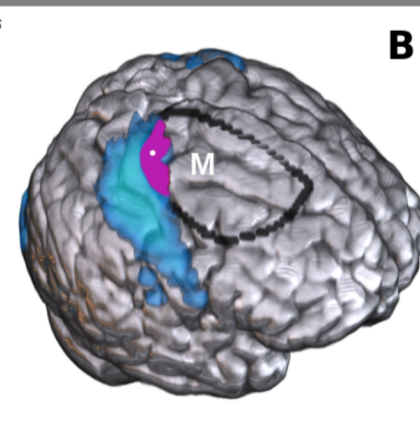
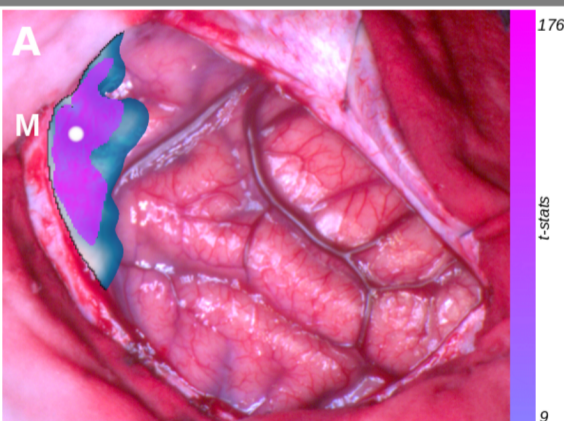


Common referential - Segmented pre-operative MRI anatomical volume



Pre-operative fMRI functional map

Results



(A) Intraoperative functional brain maps (in purple) obtained with RGB imaging [2-4]. (B) Pre-operative fMRI functional brain map (in blue).

The optical brain map is represented in purple. The black contour denotes the extent of the surgical window in image A. The letter M indicates the motor area indentified by EBS.

Good similarity between optical and fMRI functional maps:

$$DICE = \frac{2|fMRI \cap Optics|}{|fMRI| + |Optics|} = 0.69$$

Full overlap of optical map on the fMRI functional map:

$$Overlap = \frac{|fMRI \cap Optics|}{\min(|fMRI|, |Optics|)} = 1$$

Discussion

Automatic registration based on the segmentation of common cerebral structures in MR and optical images

Improving resting-state network detection using RGB imaging [5] by comparing resting-state networks obtained by fMRI

References

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