EEG- and fMRI-based communication tools in disorders of consciousness: which is the most reliable method?

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INTRODUCTION

- The assessment of cognition in **disorders of consciousness** is often challenging.
- Novel **fMRI** paradigms based on mental imagery tasks have provided unambiguous evidence of volition and awareness in some patients, and have been used as **communication tools** (Monti et al., 2010).
- Unfortunately, fMRI cannot be used on a routine basis to assess awareness (high cost, low availability, stress induced, etc.).
- **EEG**, which is a portable and less expensive device, **has recently provided evidence of volition** in some patients (Cruse et al., 2011).

OBJECTIVE

(1) To **compare** whether fMRI and EEG show similar accuracy in detecting volitional brain activity.

(2) To investigate whether EEG can also be used as a **reliable communication tool**.

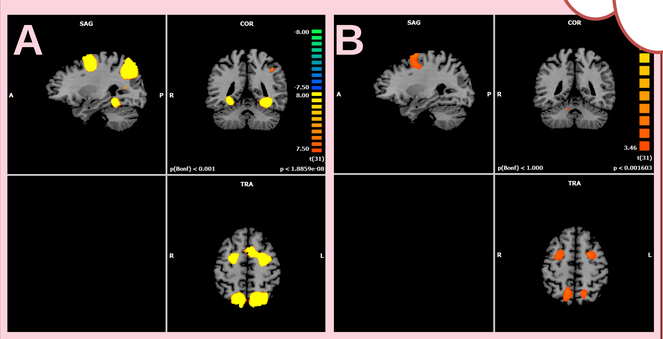
METHODS

- **Sixteen** healthy participants performed two distinct neuroimaging sessions, one with **fMRI**, and the other with a **64-electrode EEG** system
- In a first part of each session ("explicit task"), participants were instructed to perform two **mental imagery** tasks (replicated from Monti et al, 2010; and Cruse et al, 2011) :
  - Imagine **playing tennis** / **moving in their house** for fMRI
  - Imagine **squeezing their hand into a fist** / **wiggling the toes** of their feet with EEG
- In a second part ("communication task"), participants had to answer **three autobiographical** yes-or-no **questions** (e.g. Do you have any brothers?) by using one of the previously performed imagery tasks. One of them had randomly been defined as a yes answer and the other one as a no answer.

RESULTS

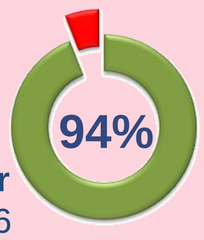
fMRI

Explicit task



All participants showed a similar pattern of activation :
- a **parahippocampal activation** in response to the instruction to "imagine moving around in their house" (A)
- only a **supplementary motor area activation** occurred when the participants were instructed to "imagine playing tennis" (B)

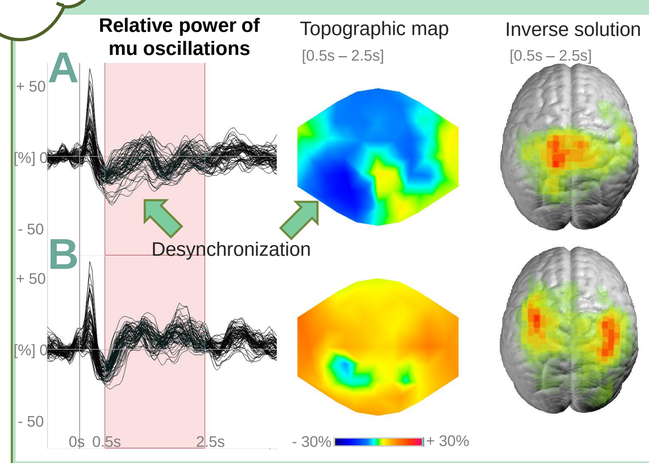
Communication task



The fMRI-based communication tool detected **the right answer in 94% of the trials**. 14/16 subjects had 100% correct answers.

EEG

Explicit task



All subjects could generate appropriate and distinct brain responses:
- a major left **decrease** of mu oscillations during the imagined hand movement (A)
- a **bilateral increase** of mu oscillations during the imagined toes movement (B)

Communication task

The EEG-based communication tool detected **the right answer in 63% of the trials**. 4/16 subjects had 100% correct answers

DISCUSSION & CONCLUSION

- Both EEG and fMRI showed an **excellent accuracy in detecting changes** of volitional brain activity.
- However, **only fMRI showed consistent results** in the communication task.
- As a conclusion, if EEG can be efficiently used to detect awareness in patients with disorders of consciousness, a neuroimagery switch towards fMRI is still mandatory when one expects to communicate with unresponsive but aware patients. To improve EEG-based communication, new and personalized paradigms need to be developed in the future

References :

Monti, M.M., Vanhaudenhuyse, A., Coleman, M.R., Boly, M., Pickard, J.D., Tshibanda, L., Owen, A.M,, Laureys, S. Willful modulation of brain activity in disorders of consciousness. In N Engl J Med 2010, 362(7):579-89.

Cruse D, Chennu S, Chatelle C, Bekinschtein TA, Fernández-Espejo D, Pickard JD, Laureys S, Owen AM. Bedside detection of awareness in the vegetative state: a cohort study. Lancet. 2011 Dec 17;378(9809):2088-94.