



HAL
open science

Intraoperative functional brain mapping based on RGB imaging

C. Caredda, L. Mahieu-Williame, R. Sablong, M Sdika, J. Guyotat, B. Montcel

► **To cite this version:**

C. Caredda, L. Mahieu-Williame, R. Sablong, M Sdika, J. Guyotat, et al.. Intraoperative functional brain mapping based on RGB imaging. fNIRS UK, Sep 2019, Birmingham, United Kingdom. hal-02894964

HAL Id: hal-02894964

<https://hal.science/hal-02894964>

Submitted on 9 Jul 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Intraoperative functional brain mapping based on RGB imaging

C. Caredda¹, L. Mahieu-Williams¹, R. Sablong¹, M. Sdika¹, J. Guyotat² and B. Montcel¹

¹CREATIS; CNRS (UMR 5220); INSERM (U1206); INSA Lyon; Université de Lyon, France.

²SERVICE DE NEUROCHIRURGIE D ; HOSPICES CIVILS DE LYON ; Bron, France.

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 is the preoperative gold standard and electrical brain stimulation is the intraoperative gold standard.

The objective of these two techniques is to indicate to the neurosurgeon the cortical areas that can be removed without cognitive impairment.

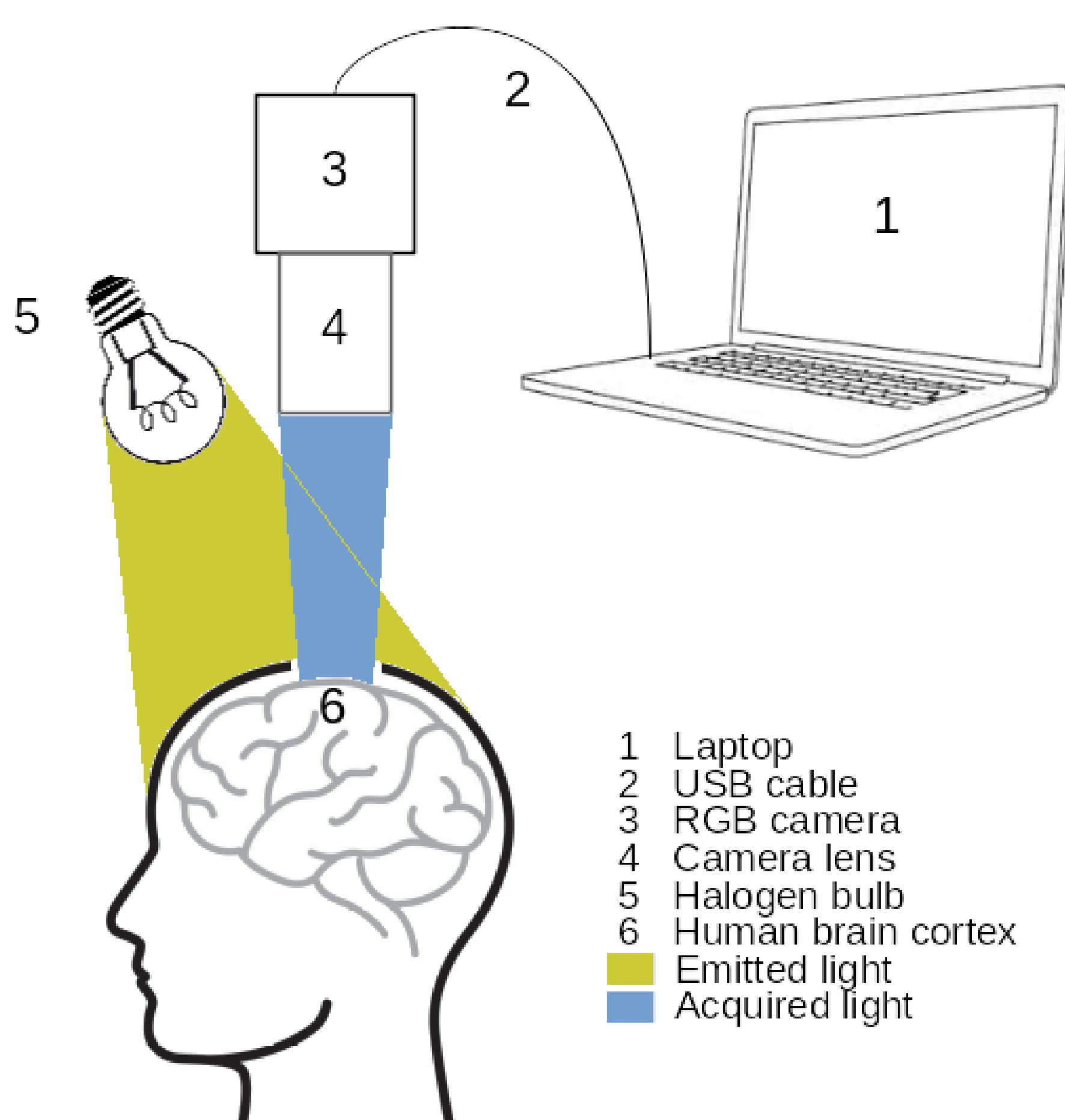
Background: Optical imaging can be used to monitor the brain activity [1] with the measure of hemoglobin concentration changes ($\Delta[HbO_2]$ and $\Delta[Hb]$). A device consisting of a continuous wave white light illumination and a RGB camera is a suitable approach [2].

Objectives: We propose to realize the localization of brain functional areas using a RGB camera with the analysis of the $\Delta[HbO_2]$ and $\Delta[Hb]$ time courses which are closely linked with the Bold contrast in f-MRI studies.

Material & methods

Experimental paradigm: After the patient craniotomy and before the brain tumor resection, the patient was awakened and functional tests have been realized. The stimulation of the patient cortex was achieved through a repetitive and alternative hand opening and closing at ≈ 1 Hz. The paradigm consisted of 3 steps : 30s of rest, 30s of stimulation and 30s of rest. The neurosurgeon realized electrical brain stimulations to localize the patient brain motor and sensory areas.

Experimental setup



Functional model

A - Image acquisition : 8 bits images were acquired at 30 Fps.

B - Image segmentation : The first image of the video was segmented into three classes using a semi automated procedure (K-Means algorithm) : grey matter, surface and buried blood vessel.

C - Camera and brain motion compensation [3]

D - Filtering and data correction : The RGB intensities were filtered using a low-pass Bessel filter (0,05Hz) and the slow drift of the collected intensity (cortical dessication) was corrected through a linear regression subtracted to the original data.

E - Pixel-wise modified Beer Lambert model [4,5]

$$\begin{bmatrix} \Delta A_R(t) \\ \Delta A_G(t) \\ \Delta A_B(t) \end{bmatrix} = \begin{bmatrix} E_{R,Hb} & E_{R,HbO_2} \\ E_{G,Hb} & E_{G,HbO_2} \\ E_{B,Hb} & E_{B,HbO_2} \end{bmatrix} \times \begin{bmatrix} \Delta[Hb](t) \\ \Delta[HbO_2](t) \end{bmatrix} \quad \text{with} \quad E_{i,n} = \int \epsilon_n(\lambda) \times D_i(\lambda) \times S(\lambda) \times L(\lambda) d\lambda.$$

L : Optical mean path length estimated by Monte Carlo simulations [6] in a pixel-wise manner. D_i : Camera detector spectral sensitivity. S : light source spectrum. ϵ_n : Extinction coefficient ($L \cdot Mol^{-1} \cdot cm^{-1}$) of chromophore n (Hb , HbO_2)

F - Active/non active binary biomarker

1 – The ROI was divided into N cortical areas of interest **Cort** (1,8mm wide squares)

3 – Successive T-Tests were computed to compare the mean values of the **Ref** and the **Cort** areas ($\langle \bar{C} \rangle$ and $\langle r \rangle$).

2 – Selection of a non activated cortical area as a reference area: **Ref**

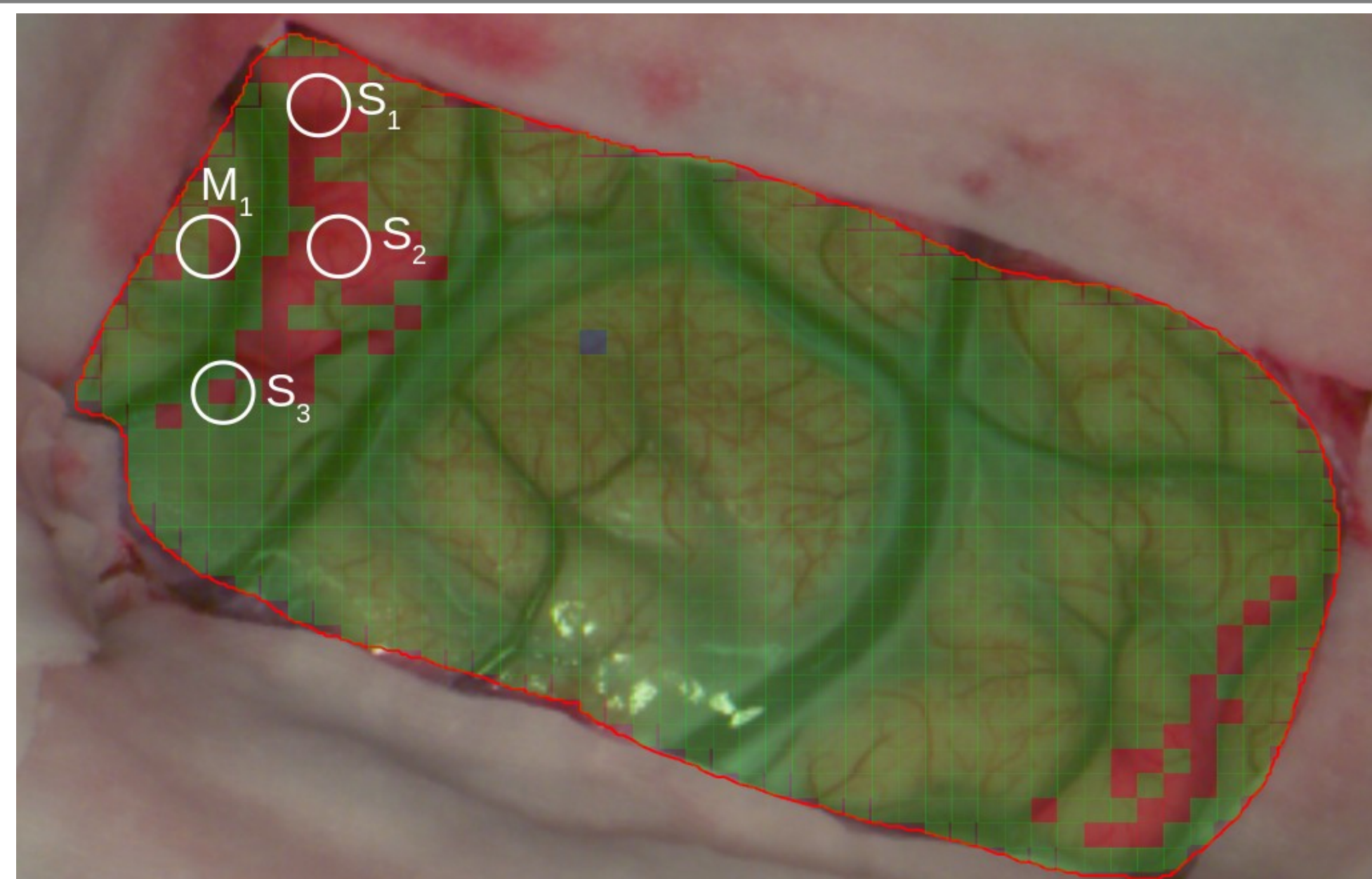
4 – One- and two-tailed T-Tests (hypotheses H_0 , H_1 and H_2) were tested at $1/(N-1)$ % significance level (Bonferroni correction)

$$H_0(X) = \begin{cases} \text{True,} & \text{if } X_{Cort} \neq X_{Ref} \\ \text{False,} & \text{otherwise.} \end{cases} \quad H_1(X) = \begin{cases} \text{True,} & \text{if } X_{Cort} > X_{Ref} \\ \text{False,} & \text{otherwise.} \end{cases} \quad H_2(X) = \begin{cases} \text{True,} & \text{if } X_{Cort} < X_{Ref} \\ \text{False,} & \text{otherwise.} \end{cases}$$

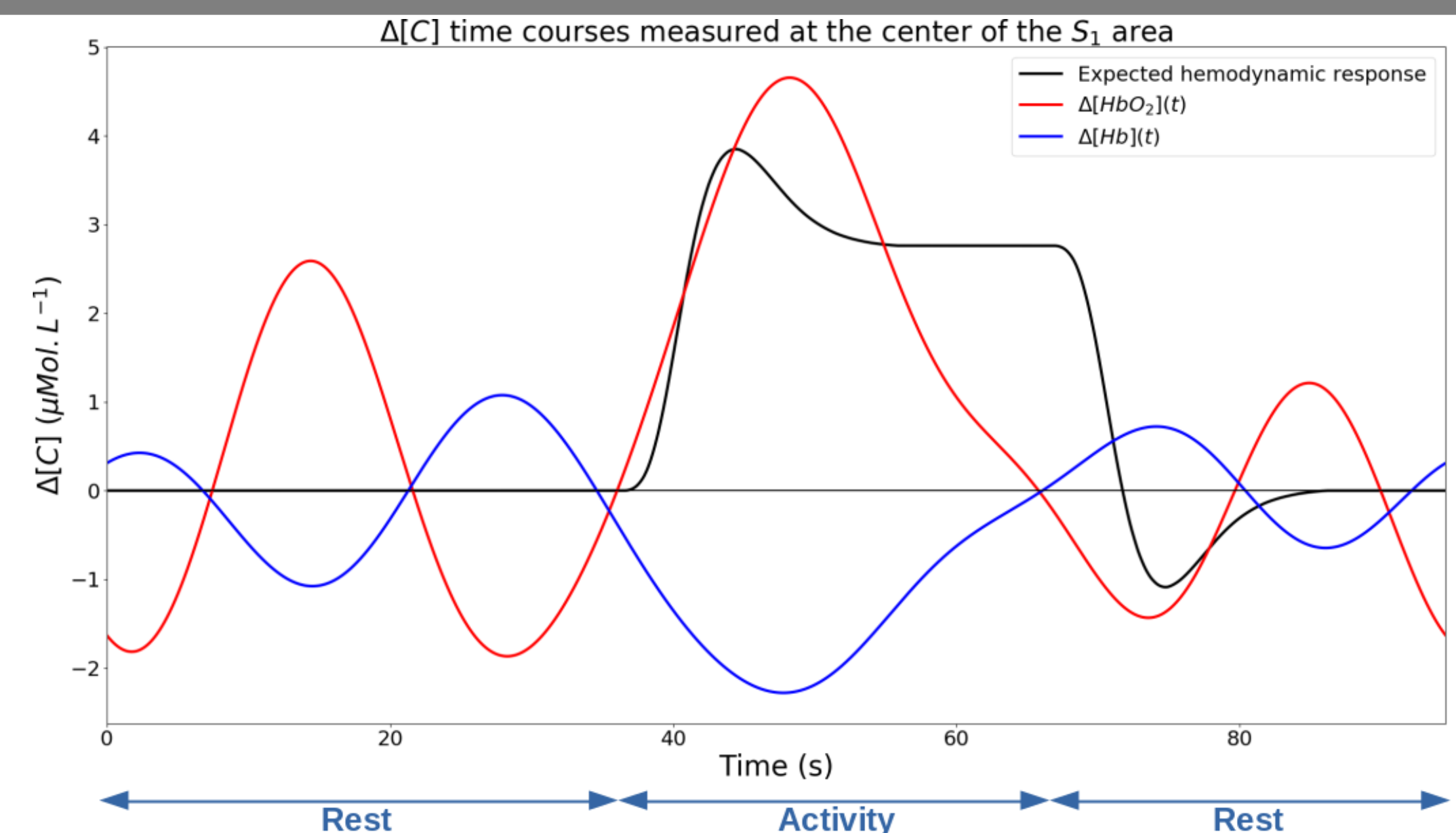
$$Cort = \begin{cases} \text{Activated,} & \text{if } H_0(\langle \overline{HbO_2} \rangle) \& H_0(\langle \overline{Hb} \rangle) \& H_1(\langle r_{HbO_2} \rangle) \& H_2(\langle r_{Hb} \rangle) \\ \text{Not activated,} & \text{otherwise.} \end{cases}$$

\bar{C} : $\Delta[C](t)$ averaged over the patient activity period, r : Pearson correlation coefficient between $\Delta[C](t)$ and the expected hemodynamic response [7], $\&$: logical and

Results



■ Reference area **Ref**
■ Non Activated cortical area
■ Activated cortical area
 Areas validated by electrical brain stimulation
 S_i Sensory area i
 M_i Motor area i



Discussion & conclusion

References

- [1] Chance B. et al. Proceedings of the Nat. Ac. of Sc. 90, 3770–3774 (1993).
- [2] Malonek D. et al. Science 272, 551-4 (1996).
- [3] Sdika M. et al. Medical Image Analysis 53, 1-10 (2019).
- [4] Kohl-Bareis M. et al. Apparatus for measuring blood parameters (2012).
- [5] Caredda C. et al. Proc. SPIE 11073, 1107317 (2019).
- [6] Fang Q. et al. Optics express 17, 20178-20190 (2009).
- [7] Veldsman M. et al. Human Brain Mapping 36, 1620-1636 (2015).

✓ The cortical areas identified as activated correspond to the areas validated by the electrical brain stimulation

➤ Automatic and robust choice of the reference area
 ➤ Implementation of the NIRS-SPM analysis

➤ Comparison with fMRI maps
 ➤ Precise delimitation of the functional areas

