HIGH-DENSITY SCALP SOMATOSENSORY EVOKED POTENTIALS IN MACAQUE MONKEYS IN THE CONTEXT OF A FUTURE MOTOR CORTEX LESION

Anne-Dominique Gindrat[1], Charles Quairiaux[2,3], Juliane Britz[3], Florian Lanz[1], Denis Brunet[3], Christoph M. Michel[3] and Eric M. Rouiller[1]

[1] Unit of Physiology, Department of Medicine, Faculty of Sciences and Fribourg Centre for Cognition, University of Fribourg, Fribourg, Switzerland
[2] Faculty of Medicine, Department of Fundamental Neurosciences, University of Geneva, Geneva, Switzerland
[3] Functional Brain Mapping Laboratory, Departments of Clinical and Fundamental Neuroscience, Geneva University Hospital, Geneva, Switzerland

INTRODUCTION

- Somatosensory evoked potential (SSEP) recordings from the scalp are widely used in human clinics. They are among others a good predictor of outcome after a brain injury such as stroke. Recordings from the scalp with a high-density electrode array are also relevant for research purposes to reveal the time course of evoked topographies based on the high temporal resolution of EEG.
- In this pilot study, we made a transposition of SSEP recordings to macaque monkeys using a multichannel electrode array.
- The goal of the present study was to develop a simple and minimally invasive method to record SSEPs from the whole scalp surface in anaesthetised adult macaque monkeys, with the anticipated application of establishing a reliable procedure for repeated assessment of the activity in neural circuits in the context of a central nervous system lesion. It is expected that SSEPs will allow assessing non-invasively the post-lesional reorganisation of neuronal networks and relate it to functional recovery, for instance following a permanent motor cortex lesion.

MATERIALS AND METHODS

I. SSEP recordings in macaque monkeys

- Four adult macaque monkeys (*Macaca fascicularis*)
- Recordings with a customised EEG cap containing 33 electrodes regularly distributed over the scalp (EASYCAP GmbH, EEG Recording Caps and Related Products, Herrsching, Germany)
- 2.5% - 3.5% sevoflurane anaesthesia
- Electrical stimulations to the median nerve and to the tibial nerve, successively on each side (400-µsec duration, 0.5 Hz repetition rate, intensity slightly above the visible motor threshold, total of about 80 sweeps)

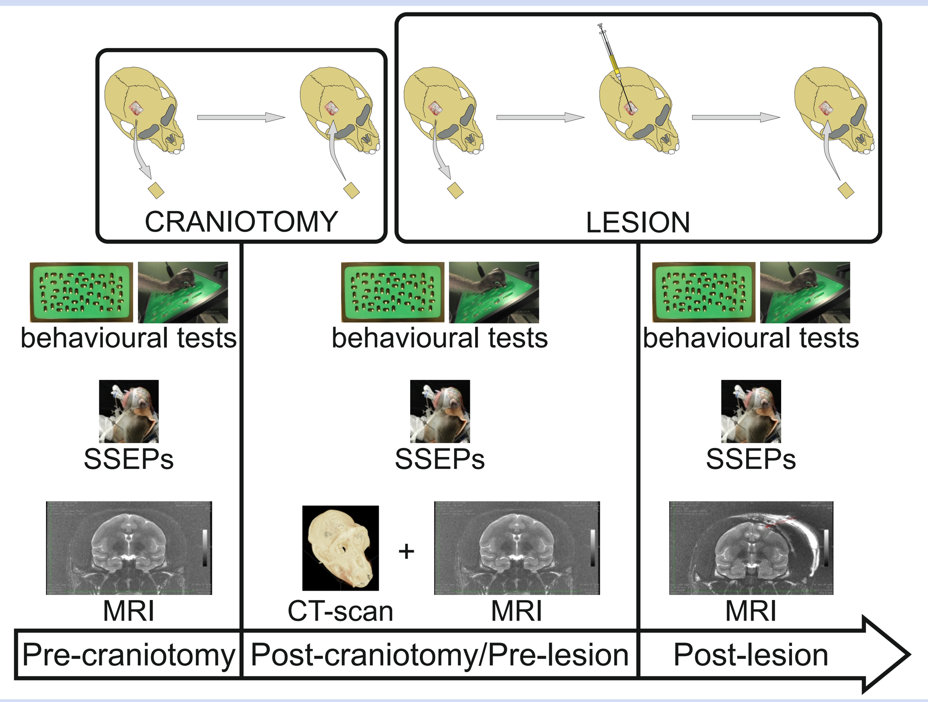
II. SSEP data analysis and source estimation

- SSEP data were analysed with the Cartool software (http://sites.google.com/site/fbmlab/cartool) and computed against the average reference.
- K-Means cluster analysis of the SSEP voltage maps (data-driven approach revealing a series of scalp topographies reflecting the steps in information processing)
- LAURA (**L**ocal **Au**to**r**egressive **A**verage) inverse solution algorithm with LSMAC (**L**ocally **S**pherical **M**odel with **A**natomical **C**onstraints) head model

III. Lesion

- Future permanent unilateral lesion performed in the hand area of the right primary motor cortex, requiring a craniotomy
- "Sham lesion" consisting in the craniotomy (300 mm²) alone over the hand area of the right sensorimotor cortex, with bone flap resuture and fixation with bone substitute HydroSet (Stryker®) → crucial to distinguish the effect on SSEPs of the craniotomy from that of the post-lesional plasticity of the neural circuits

IV. Experimental design



CONCLUSION

- SSEPs can be successfully and reproducibly recorded from a high-density EEG cap in macaque monkeys.
- The inverse solution algorithm allowing source estimation seems to be a very promising tool to better understand the different mechanisms involved in post-lesional cortical reorganisation.
- Based on rodent studies, SSEPs are expected to help to investigate the post-lesional cortical reorganisation of neuronal networks, especially to highlight which areas of the brain may take over the function of the primary motor cortex affected by the lesion. From a clinical point of view, we also hope that post-lesional modifications in SSEP signals will help us to predict the level of recovery after the lesion.

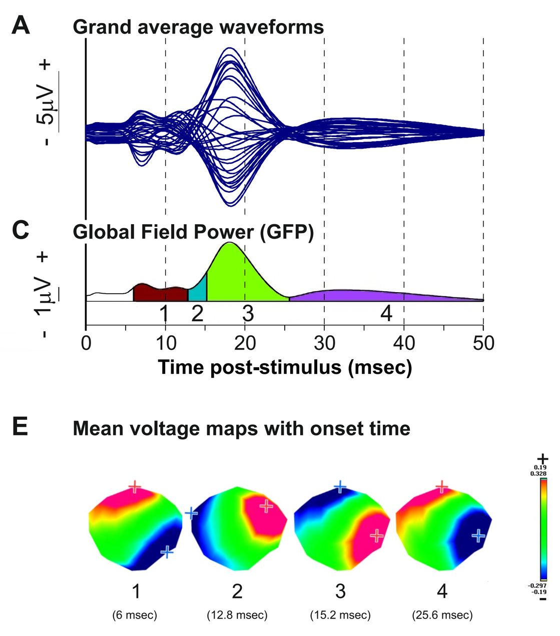
anne-dominique.gindrat@unifr.ch

Supported by Swiss National Science Foundation grant 310000-110005 (EMR) and NCCR Neuro

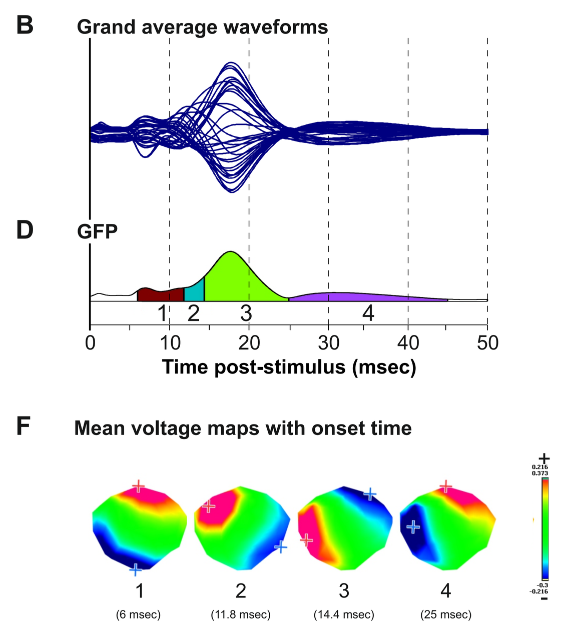
RESULTS

1) Pre-craniotomy SSEPs

Left median nerve SSEPs

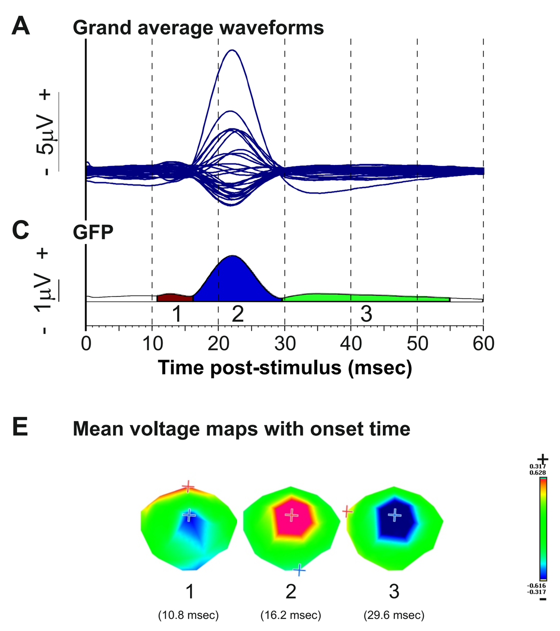


Right median nerve SSEPs

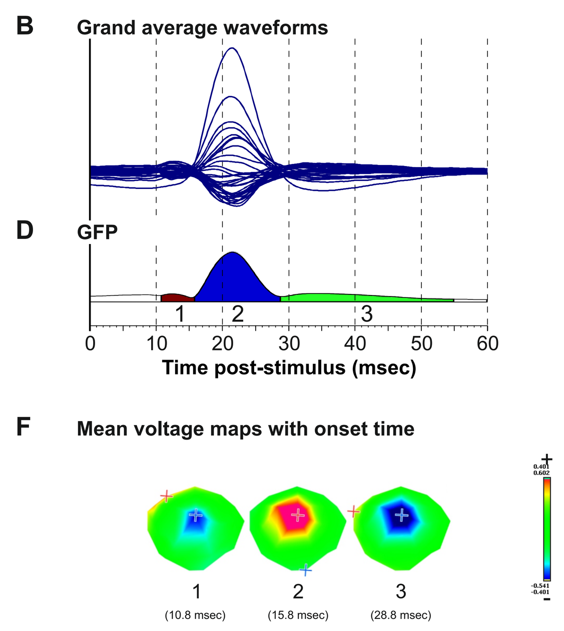


The colour scaling is the same for both map series.

Left tibial nerve SSEPs



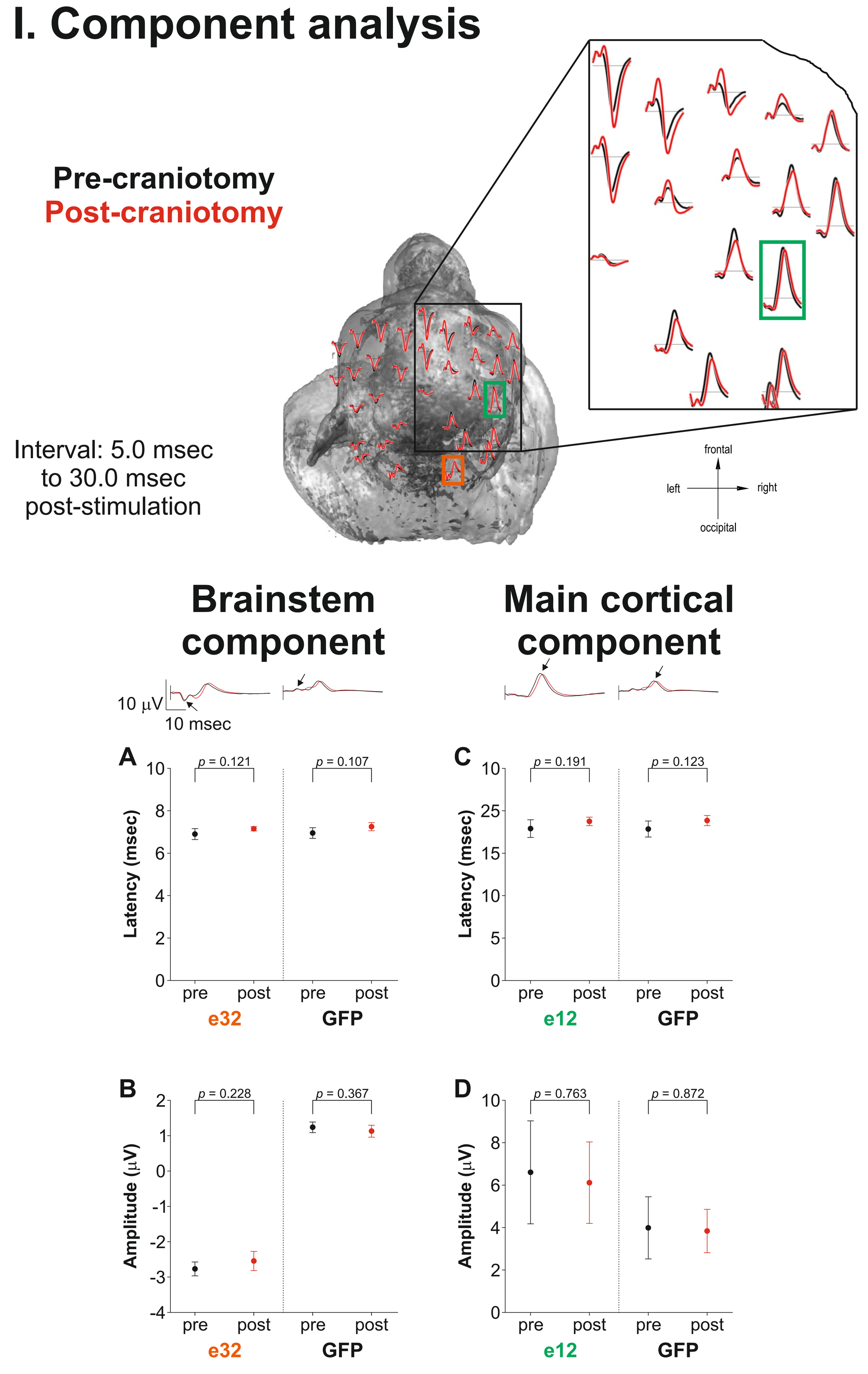
Right tibial nerve SSEPs



The colour scaling is the same for both map series.

2) Effect of the craniotomy on left median nerve SSEPs

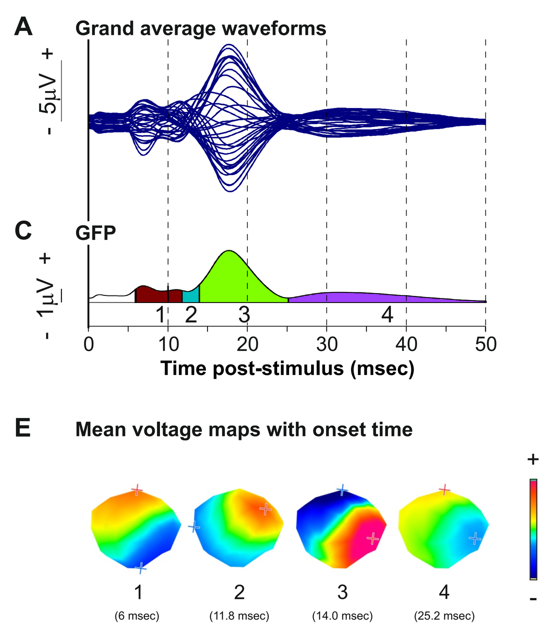
I. Component analysis



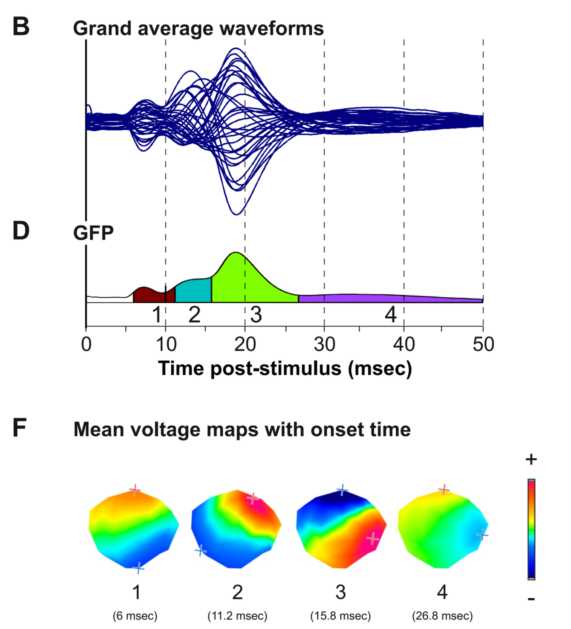
All the data presented here were acquired in the same monkey.

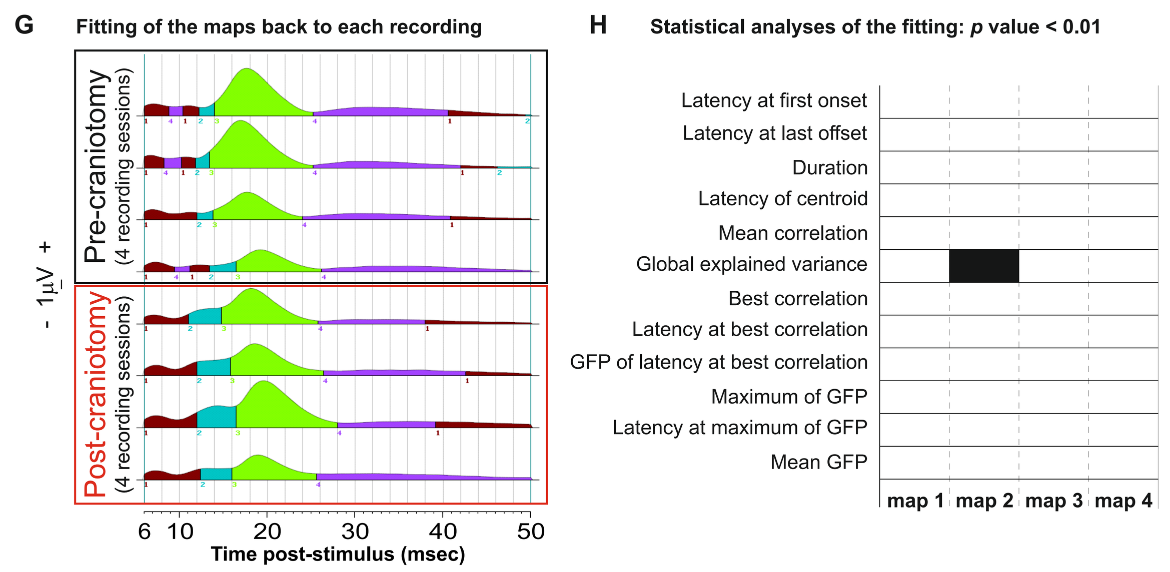
II. Topographical analysis

Pre-craniotomy SSEPs



Post-craniotomy SSEPs

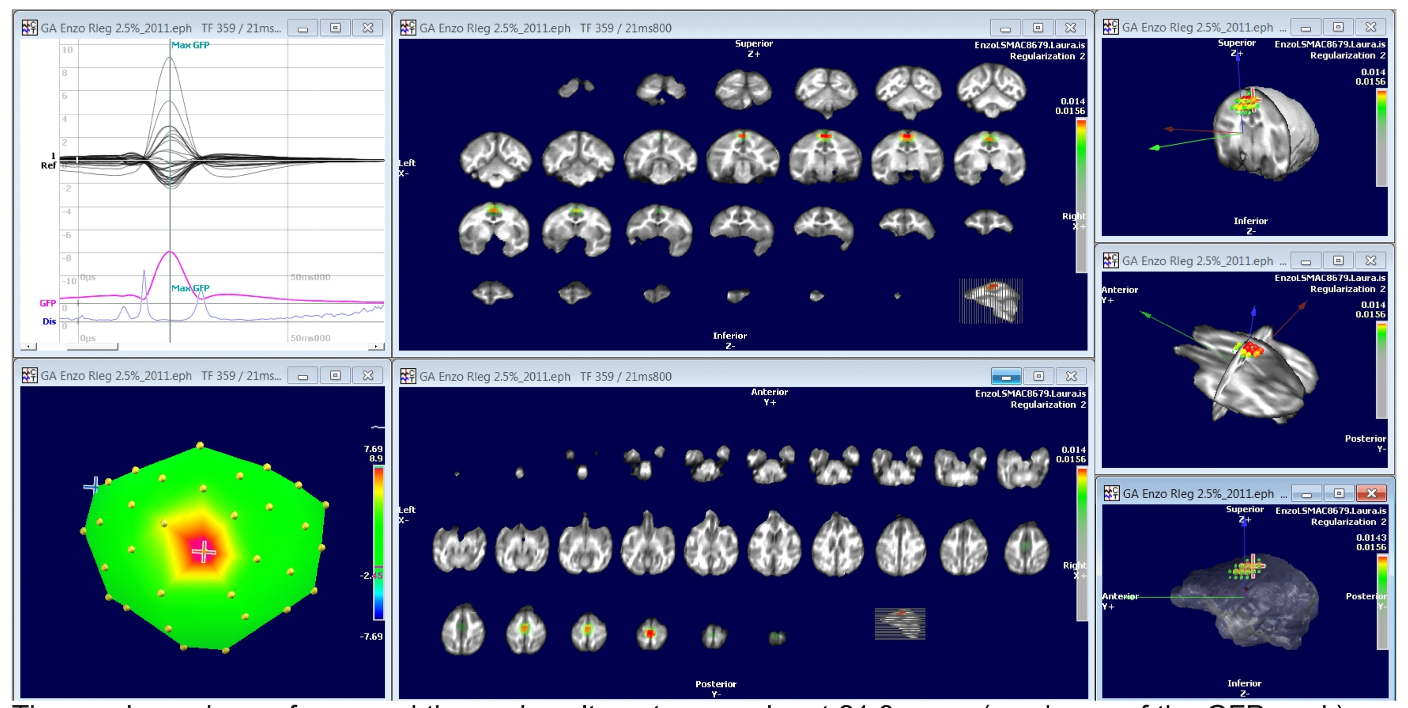




- SSEPs in macaque monkeys are characterised by a progression of quasi-stable brain component maps.
- Voltage topographies after stimulation on one side are essentially mirror images of those of the other side in relation to the antero-posterior axis.
- The voltage topography of SSEPs obtained after either median or tibial nerve stimulations is in line with the somatotopical organisation of the sensorimotor cortex.
- Intraindividual stability and interindividual reproducibility of SSEPs (Similar pre-craniotomy data were obtained in 3 other animals.)
- Post-craniotomy voltage topographies do not show any major changes or artefacts compared to pre-craniotomy maps, indicating that the craniotomy itself does not have any strong adverse effect on the recorded SSEPs.
- The inverse solution model shows an appropriate localisation of the main cortical activation after tibial nerve stimulation (leg representation of the sensorimotor cortex).

3) First data of inverse solution

Pre-craniotomy right tibial nerve SSEPs



The overlapped waveforms and the scalp voltage topography at 21.8 msec (maximum of the GFP peak) are represented on the left part. The right windows show different views of the source estimation on MRI at this same time point.