Recordings of scalp somatosensory evoked potentials in macaque monkeys with a high-density electrode array

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Introduction

Somatosensory evoked potential (SSEP) recordings from the scalp are commonly used in human for clinical applications. They are among others 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.

In this pilot study, we made a transposition of this simple and minimally invasive tool to macaque monkeys, allowing repeated monitoring of the brain activity from the whole scalp surface using a multichannel electrode array.

The goal of the present study was to allow repeated assessment of the cortical activity in the context of a central nervous system lesion. It is expected that SSEPs will allow to assess the post-lesional cortical reorganisation of neuronal networks and relate it to functional recovery, following a motor cortex lesion.

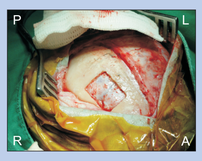
Materials and methods

I. SSEP recordings

- Three adult macaque monkeys (*Macaca fascicularis*)
- Recordings with a customised EEG cap containing 33 electrodes regularly distributed over the scalp
- 2.5% sevoflurane anaesthesia
- Electrical stimulations to the median nerve at the wrist or to the tibial nerve at the ankle, successively on each side (0.5 Hz repetition rate, intensity slightly above the visible motor threshold, total of 75 sweeps)

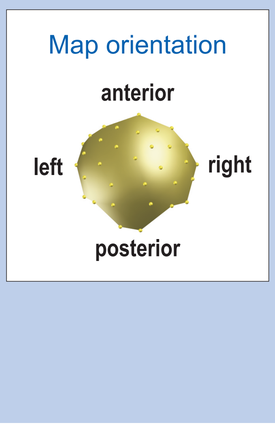
II. Lesion

- Future permanent unilateral lesion performed in the hand representation of M1, requiring a craniotomy
- "Sham lesion" consisting in the craniotomy alone, with bone flap resuture and fixation with bone substitute HydroSet (Stryker®)



III. SSEP data analysis and source estimation

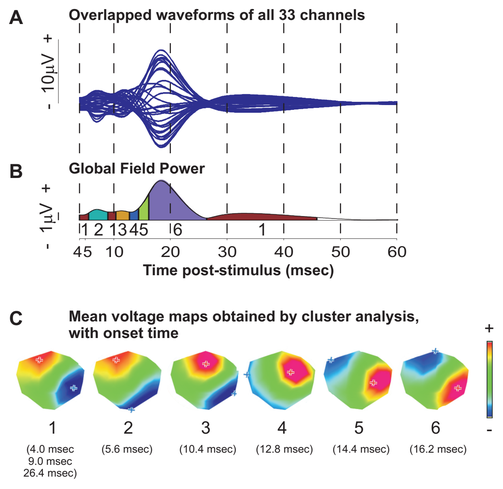
- SSEPs data were analysed with the Cartool software (http://sites.google.com/site/fbmlab/cartool) and computed against the average reference.
- k-means cluster analysis of the SSEP voltage maps (data-driven approach revealing a series of scalp topographies reflecting the steps in information processing)
- 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



Results

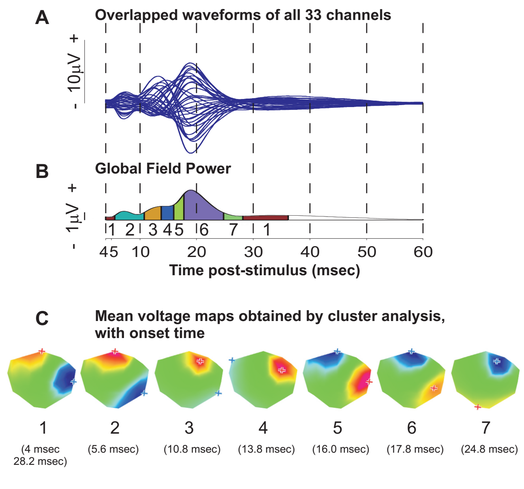
Pre-lesional SSEPs

Left median nerve stimulation
(Grand average of 29 recordings)

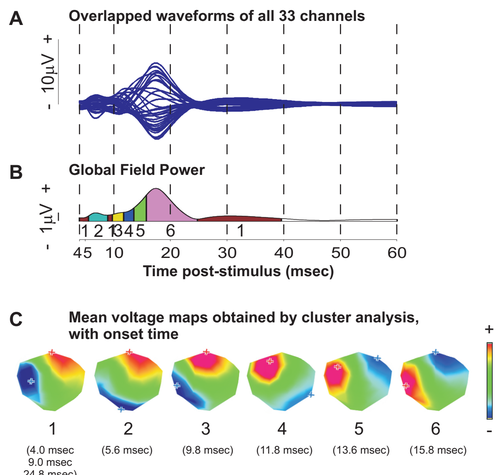


Post-craniotomy SSEPs

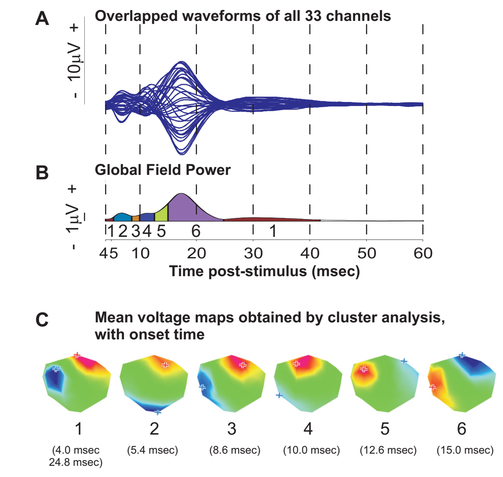
Left median nerve stimulation
(Grand average of 8 recordings)



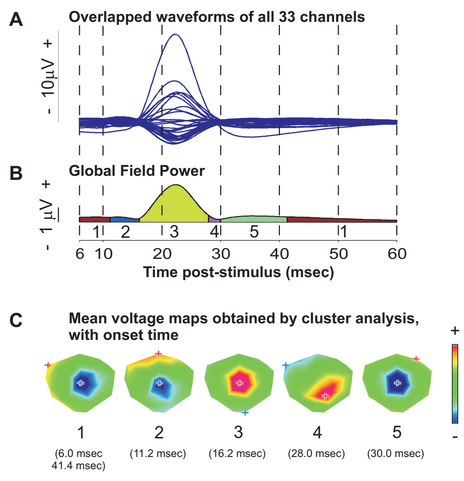
Right median nerve stimulation
(Grand average of 30 recordings)



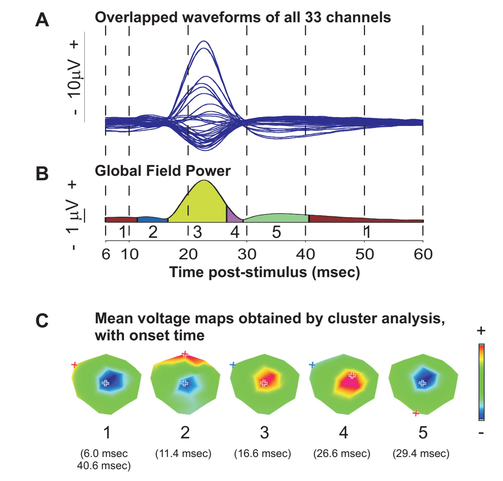
Right median nerve stimulation
(Grand average of 8 recordings)



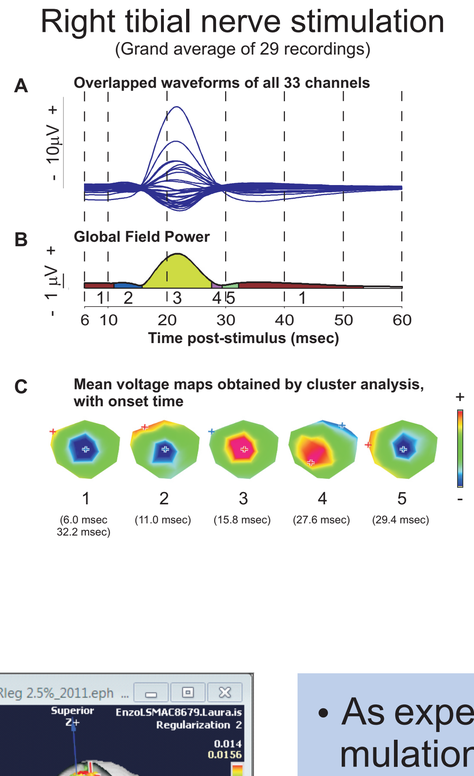
Left tibial nerve stimulation
(Grand average of 31 recordings)



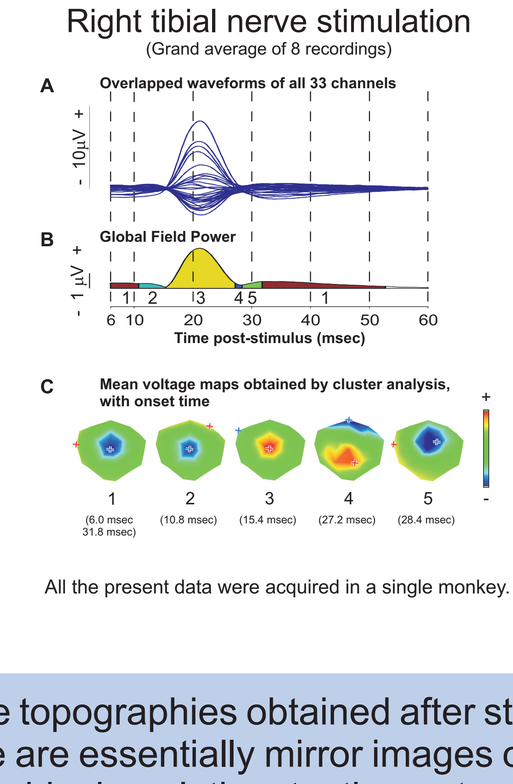
Left tibial nerve stimulation
(Grand average of 8 recordings)



Right tibial nerve stimulation
(Grand average of 29 recordings)



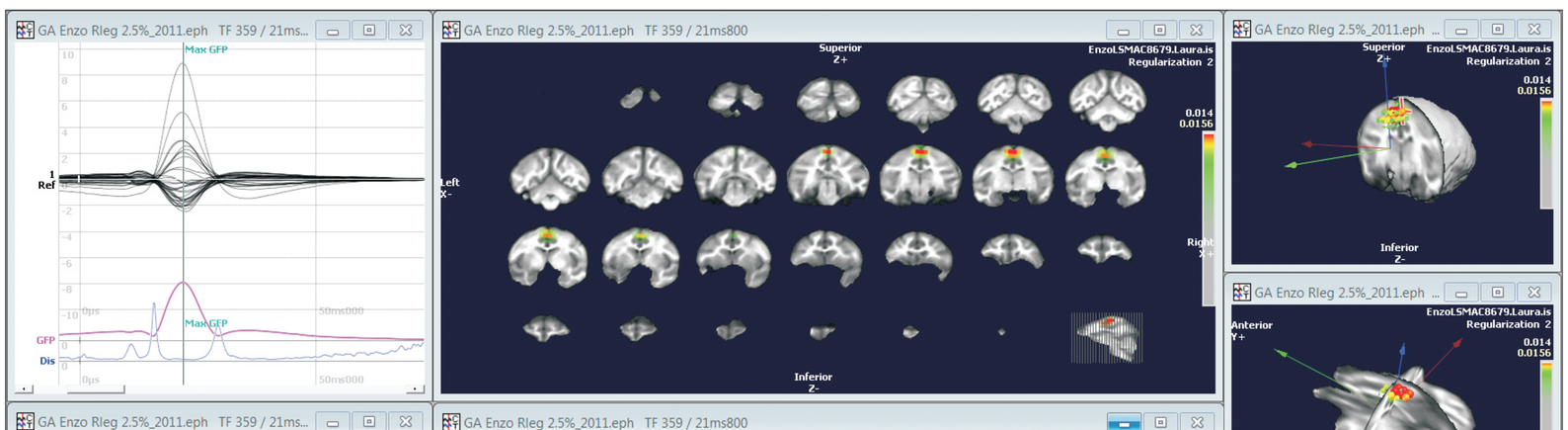
Right tibial nerve stimulation
(Grand average of 8 recordings)



All the present data were acquired in a single monkey.

First data of inverse solution

Grand average of pre-lesional right tibial nerve SSEPs in a single monkey



Overlapped waveforms and the 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.

- As expected, voltage topographies obtained 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 the responses obtained after either median or tibial nerve stimulations is in line with the somatotopical organisation of the sensorimotor cortex.
- Similar pre-lesional data were obtained in two other animals.
- Post-craniotomy voltage topographies do not show any artefact and are similar to pre-lesional maps, indicating that the craniotomy itself does not have any strong adverse effect on the recorded SSEPs.
- The first version of the inverse solution model shows an appropriate localisation of the main cortical activity after tibial nerve stimulation, that is to say in the leg representation of the sensorimotor cortex.

Conclusion

These data show that SSEPs can be successfully and reproducibly recorded from a high-density EEG cap in macaque monkeys. Moreover, the inverse solution algorithm allowing source localisation seems to be a very promising tool to better understand the different mechanisms involved in cortical reorganisation. The experiment will continue with the permanent cortical lesion performed in the near future in a first monkey, followed by regular post-lesional SSEP recordings in parallel with motor performance assessment in the acute phase and in the recovery phase until the animal reaches a post-lesional behavioural plateau.

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