”Awake Surgery” of Slow-Growing Tumors and Cortical Excitability Measured by EEG Recordings. Preliminary Results

François Bonnetblanc, Guillaume Herbet, Pom Charras, Mitsuhiro Hayashibe, David Guiraud, Hugues Duffau, Bénédicte Poulin-Charronnat

« Awake surgery » of slow-growing tumors and cortical excitability measured by EEG recordings. Preliminary results.

F Bonnetblanc , G Herbet, P Charras, M Hayashibe, D Guiraud, H Duffau and B Poulin-Charronnat

Abstract—**To investigate interhemispheric imbalance following "awake surgeries" of slow-growing tumors we recorded EEG in a visuo-manual RT paradigm. Increase of cortical excitability within the ipsilesional hemisphere was signed by increased ERPs amplitude for two patients. The cortical excitability in the lesioned hemisphere may be increased to maintain performances and cerebral plasticity.**

I. Introduction

USING direct electrical stimulation, real-time functional mapping of the brain can be used to perform resections of slow-growing infiltrative tumors in awake patients and to prevent the resection of essential areas near the tumor [3]. Functional recovery is considerably better in the context of slow-growing injuries than after acute lesions [1,2]. For slow-growing tumors, the impressive reorganization capacity of the brain allows the patients to recover rapidly, within a few days after the surgery, sometimes in only a few minutes [4]. One explanation for the impressive and rapid compensations observed is that with the slow growth of the lesion, the contralesional hemisphere may be progressively prepared, by the uncovering of contralesional redundant networks that have been slowly developing due to the gradually invading tumor [1,2,4]. When the tumor is surgically removed contralesional homologue networks could be rapidly unmasked. However, some level of functional asymmetry between both hands has been observed for these patients post-operatively (+ 4 to 5 days). Longer visuo-manual reaction times (RTs) were observed for the impaired hand [5]. This may sign some interhemispheric imbalance and especially post-lesional changes in cortical excitability. To investigate this hypothesis, we recorded the electroencephalographic activity (EEG) and measured the Event-Related Potentials (ERPs) of four patients before (for two of them) and 3 to 6 months after (for all patients) their surgical operation in a visuo-manual RT paradigm with different locations for the stimulus appearance (after a visual go-signal appearing on a screen patients had to press a button with one or two hands).

This study was supported by the 'Association pour le Recherche sur le Cancer' (ARC-France Subvention Libre no. 3184). We gratefully thank the patients for their participation to this study.

F Bonnetblanc, P Charras, M Hayashibe and D Guiraud are with Universite Montpellier 2 – LIRMM – DEMAR Team, France.

F Bonnetblanc, is with INSERM, U-1093, « Cognition, Action, et Plasticité Sensorimotrice » », UFR STAPS, Dijon, F-21078, France (francois.bonnetblanc@u-bourgogne.fr)

G Herbet, H Duffau are with Institut des Neurosciences de Montpellier INSERM U1051, France.

B Poulin-Charronnat is with Université de Bourgogne

LEAD - CNRS UMR5022, France.

II. Material and Methods

The electroencephalogram was recorded from 64 scalp sites of a 10-20 system using a BioSemi ActiveTwo apparatus. Horizontal eye movements were recorded with electrodes placed on the outer left and right canthus. Vertical eye movements were recorded with an electrode placed under the right eye. Two additional electrodes were placed on the left and right mastoids (A1, A2). During recording, the reference electrode was the CMS electrode of the BioSemi system. Electrophysiological signals were digitized at a 2048-Hz sampling rate and acquired with ActiView software. EEG signals were analyzed using the EEGLab toolbox for Matlab. The data were re-referenced to the mean of A1 and A2, down sampled to 500 Hz and high-pass filtered with a cut off frequency of 1Hz. Independent Component Analyses (ICA) were run using the EEGLab's binica routine in order to correct for eye movement artifacts. ERPs were averaged within conditions for each participant, with a selected latency window from -1,000 ms prestimulus to 400 ms poststimulus.

III. Results

Post-operative results (+3 to 6 months) revealed some level of functional asymmetries with longer RTs for the impaired hand. Amplitudes of ERPs after the go-signal were increased for the two patients with a right temporo-parietal lesion. It occurred within the ipsilesional hemisphere but for different regions of interest (Fig. 1 and 2). Basal activity remained the same. Interestingly, excitability was more impressive and extended for the patient with the smallest lesion. Traces of excitability in the ipsilesional sites were less obvious for the patients with right frontal lesions (n=2). Data for healthy subjects are in process: a normalized index will be used to verify a more limited right-left imbalance of excitability.

IV. Discussion

It has been shown that the contralesional hemisphere may participate to the recovery. However, cortical excitability in the lesioned hemisphere may be increased to maintain task performances and cerebral plasticity for at least 3 months after the surgery. It may be illustrative of some hypotheses about functional recovery in which the more important is the lesion size the more the contralesional hemisphere is involved. Conversely, the less important is the lesion size the more the ipsilesional hemisphere may participate.

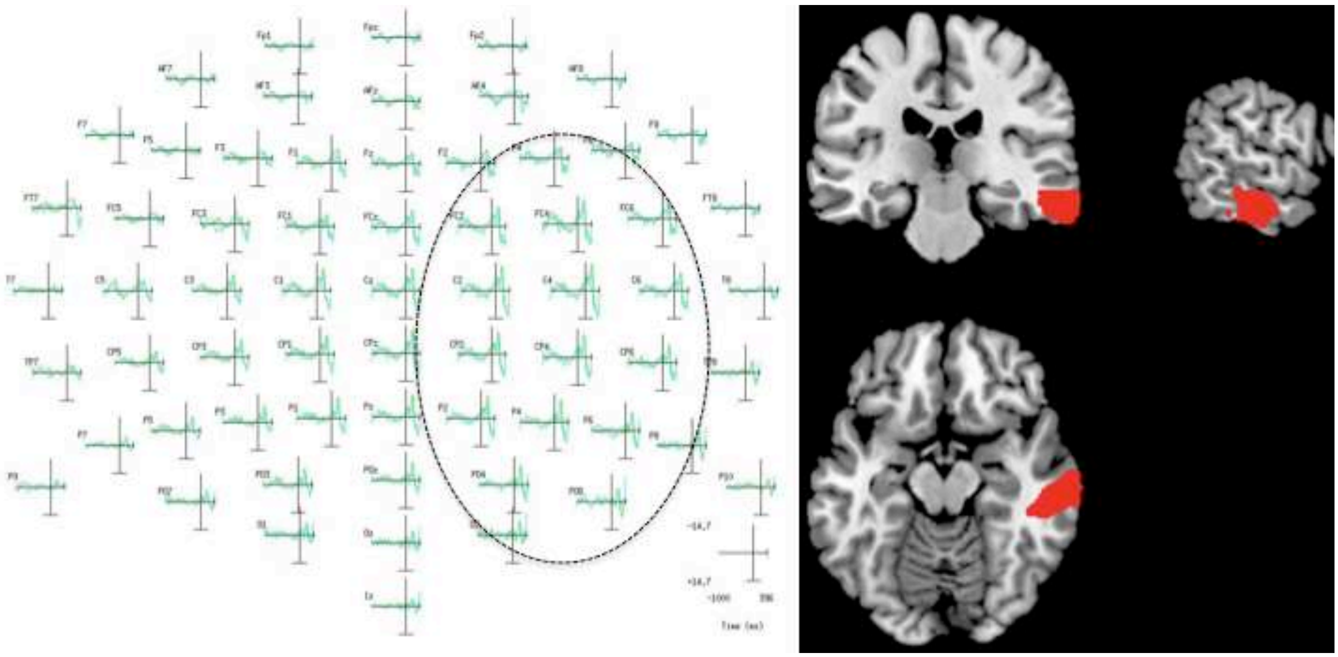

Fig. 1. A) Post-operative Event-Related Potentials (ERPs) for Patient 1. Increased ERPs amplitude can be seen in the right ipsilesional hemisphere (ellipse) in comparison to the contralesional hemisphere and homologous recording sites. The patient had to respond to visual stimuli occurring in the right or left hemifield with his right hand. The vertical line on each ERP indicates the occurrence of the visual go-signal B) Lesion mapping for the same patient after the surgery.

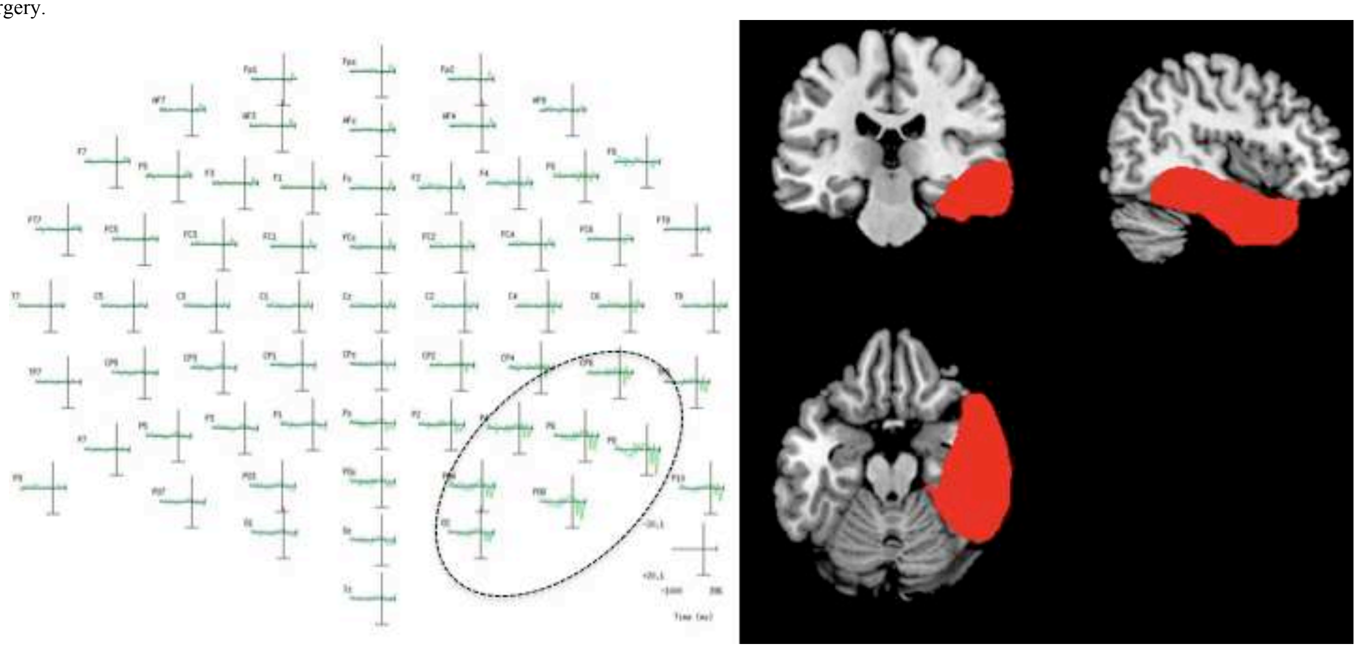

Fig. 2. Post-operative ERPs and lesion mapping for Patient 2. Note that the region with increased ERPs amplitude is smaller and located more posteriorly than the lesion which is bigger for this patient.

This imbalance of excitability between both hemispheres is opposite to what is observed for stroke lesions especially during the acute phase.

V. Conclusion

Slow growing lesions induce different recovery processes that should be further investigated to better understand brain plasticity [1,2].

References

[1] Bonnetblanc, F., Desmurget, M., & Duffau, H. (2006). Low grade gliomas and cerebral plasticity: Fundamental and clinical implications. Medical Science (Paris), 22, 389–394.

[2] Desmurget, M., Bonnetblanc, F., & Duffau, H. (2007). Contrasting acute and slow-growing lesions: A new door to brain plasticity. Brain, 130, 898–914.

[3] Duffau, H. (2005). Lessons from brain mapping in surgery for low-grade glioma: Insights into associa- tions between tumour and brain plasticity. The Lancet Neurology, 4, 476–486.

[4] Sallard, E., Duffau, H., Bonnetblanc, F. (2012a). Ultra-fast recovery from right neglect after 'awake surgery' for slow-growing tumor invading the left parietal area. Neurocase, 18, 80-90.

[5] Sallard E., Barral J., Duffau H., Bonnetblanc F. (2012b). Manual reaction times and brain dynamics after 'awake surgery' of slow-growing tumours invading the parietal area. A case report. Brain Inj. DOI: 10.3109/02699052.2012.698792.