EEG-based brain-computer interface in chronic tetraplegics to actuate a robotic arm device as assistive technology – clinical survey and long term post trial follow-up

Running Title: Brain-computer interface in chronic tetraplegics

Prof. Gelu Onose, MD, PhD\textsuperscript{1,2}, Cristian Grozea, Inf., PhD\textsuperscript{3}, Assist. Prof. Aurelian Angehelescu, MD, Postgrad\textsuperscript{1,2}, Univ. Assist. Cristina Daia, MD, Postgrad\textsuperscript{1,2}, Prof. Crina Julieta Sinescu, MD, PhD\textsuperscript{1,2}, Prof. Alexandru Vladimir Ciurea MD, PhD\textsuperscript{1,2}, Prof. Tiberiu Spircu, PhD\textsuperscript{2}, Univ. Prep. Andrada Mirea, MD\textsuperscript{1,2}, Ioana Andone, MD, Postgrad\textsuperscript{1}, Aura Spânu, MD, Postgrad\textsuperscript{1}, Cristina Popescu, MD, Postgrad\textsuperscript{1}, Kt Anca-Sanda Mihăescu\textsuperscript{1}, Siamac Fazli, Med. Neurosci, MSc\textsuperscript{4}, Márton Danóczy, Biophys. Dipl.\textsuperscript{4}, Florin Popescu, Eng., PhD\textsuperscript{3}

\textsuperscript{1} The Teaching Emergency Hospital “Bagdasar-Arseni” (TEHBA), Bucharest, Romania
\textsuperscript{2} The University of Medicine and Pharmacy “Carol Davila” (UMPCD), Bucharest, Romania
\textsuperscript{3} The Fraunhofer FIRST Institute, Berlin, Germany
\textsuperscript{4} The Technical University Berlin, Machine Learning Group, Berlin, Germany

Abstract

Study Design: Clinical survey and interviews/ correspondence within long term post-trial follow-up, on 9 chronic, post spinal cord injury tetraplegics.

Objective: To assess efficiency of the use of an Electroencephalography-based Brain Computer Interface (EEG-BCI) for reaching/ grasping assistance in tetraplegics, through a robotic arm.

Settings: Physical and (neuromuscular) Rehabilitation Medicine, Cardiology, Neurosurgery Clinic Divisions of TEHBA and UMPCD, in collaboration with “Brain2Robot” (composed of the European Commission-funded Marie Curie Excellence Team by the same name, hosted by Fraunhofer Institute-FIRST), in the second part of 2008.

Methods: The enrolled patients underwent EEG-BCI training sessions. Statistics entailed multiple linear regressions and cluster analysis. Follow-up - including questionnaire on patients' perception upon their EEG-BCI control capacity - continued up to 14 months after the experiments.

Results: EEG-BCI performance/ calibration-phase classification accuracy averaged 80.99 %; feedback training sessions averaged 70.51% accuracy, for 8 subjects who completed at least one feedback training session; 7 (77.7%) of the 9 subjects reported having had the feeling to control the cursor; 3 (33.3%) subjects felt they were also controlling the robot through their movement imagination.

BCI performance was positively correlated with beta (13-30 Hz) spectral power density (coefficient 0.432, standardized coefficient 0.745, p-value=0.025); with possible influence was also the sensory AIS score (range: 0 min to 224 max, coefficient -0.177, std. coefficient -0.512, p=0.089).

Conclusion: Potential self-assistance for chronic tetraplegics by EEG-BCI actuated mechatronic devices we herein observed, was mainly related to density of EEG in the beta range, positively (increasing therewith) and to AIS sensory score (negatively).

Keywords: spinal cord injury, brain computer/machine interface, electroencephalogram, mechatronic/robotic arm device, quality of life.