Time-delayed EEG causality analysis: prospects to analysis of DBS cortical effects

Arthur Valencio1, Tiago F. Gonçales2, Renata Prôa3, Thamires Rocha2, Daniele Salgado2, Sigride Thome-Souza4, Fernando A. Najman5, Rubens G. Cury2, Jorge Stolfi1

1 University of Campinas, Institute of Computing, Campinas, Brazil

2 University of São Paulo, Medical School, São Paulo, Brazil

3 University of São Paulo, Institute of Mathematics and Statistics, São Paulo, Brazil, and Hospital Israelita Albert Einstein, São Paulo, Brazil

4 University of São Paulo, Medical School, Department and Institute of Psychiatry, Video-EEG unit, São Paulo, Brazil

5 University of São Paulo, Institute of Mathematics and Statistics, São Paulo, Brazil

Deep brain stimulation (DBS) is a well-recognized treatment for Parkinson’ disease motor symptoms, where brain electrodes emit localized high frequency pulses of current to the affected area. It is open to investigation whether and how the localized changes in the inner brain produces functional changes to the outer layers. In particular, it is expected the DBS would induce changes to the motor/pre-motor areas when the treatment is used for Parkinson’s disease. Electroencephalography (EEG) is a standard non-invasive procedure providing high-temporal resolution data of the neocortex and already used as a routine exam for these patients. Hence, we propose an experiment where a volunteer with Parkinson’s disease and bilateral subthalamic DBS has the EEG monitored while watching a video of a sequence of point-light displays in the shape of a human standing still or walking. According to the mirror neuron hypothesis, the video depicting the walking condition should induce more motor/pre-motor activity than that of the standing condition. The net transfer entropy can be used for inferring the functional connectivity between cortical regions and different time-delays be considered for cause and effect. The differential map of connectivity with walking or standing still visual stimulus is thus obtained for when the volunteer has the DBS switched on or off, and these are compared. The results obtained for a proof-of-concept experiment showed an increased connectivity when the delay considered between the EEG channels is in the order of 200ms. Different locations had causal transfer entropy flow when the DBS is activated or not, and the specific channels pairs are presented in functional connectome form. We conclude with plans to increase the number of volunteers and suggest a new visual stimulus sequence, based on comparing different human movements and scrambled motion, which eliminates memory bias.