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Keywords: Stroke; BCI; Rehabilitation; Cerebral plasticity

The idea of using brain computer interfaces (BCI) for rehabilitation emerged less than five years ago. The main objective is to promote the recruitment of selected brain areas involved in particular tasks through BCI which make possible recording and decoding brain activity while achieving motor or cognitive tasks. Basically, BCI for neuro-rehabilitation consists in recording the brain signal generated by the patient, as he/her tries to perform the required task (even if imperfect), or during a mental imagery task.
The received signal can then be used in several ways:
– to generate and/or optimize the desired motor task via a Functional Electrical Stimulation device or a rehabilitative robotic orthosis disposed on patient's leg or arm. Brain interface allows to ‘‘close’’ the sensorimotor loop by giving the patient a sensory feedback (proprioceptive and haptic) of the movement ‘‘supposed to be generated’’;
– to objectify and strengthen work in Mental Imaging by providing the patient a feed back on the mental task provided, for example in a virtual environment;
– to understand cerebral reorganizations after lesion, in order to influence plasticity. For example, applying cerebral stimulation to re-equilibrate inter-hemispheric imbalance as shown by functional recording of brain signal during movement may help recovery.
The place of these very new rehabilitation devices must be specified among our current and less or more validated traditional methods: task oriented rehabilitation, high intensity and repetitive exercises, mental imagery, mirror therapy, constraint induced therapy, mechanized or robotic rehabilitation, virtual reality an video games, modulation of sensory afferents..
The indications of these techniques must also be refined in the light of the wide range of brain damage observed in our patients: this diversity will necessarily complicate the decoding of brain signal and its use in pathological conditions.

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Detecting the user mental states from the NIRS-measured hemodynamic signals

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Keywords: NIRS; Cognitive fatigue; BCI application; Cerebral signals

There is a need to develop brain-computer interface (BCI) systems that are able to remain stable in varying psychophysiological conditions (such as during times of mental fatigue) that can disrupt user capability. Attention resources are finite and how a gradual decrease in attention across time – the so-called time-on-task (TOT) effect – can influence neural signals is yet to be identified. This present study investigated in fifteen male volunteers (i) the time course of cortico-spinal excitability through single-pulse transcranial magnetic stimulation; and (ii) the changes in activity of pre-motor, primary motor, prefrontal cortex and right parietal areas by means of near-infrared spectroscopy (NIRS), during a sustained attention reaction task (RT) of 30 min duration. Applicability of using NIRS-measured cortical activity in order to classify subject attentional state during the sustained attention task was further tested in a sample of 7 subjects.
NIRS measurements were performed using a continuous wave multichannel system (Oxymon Mk III, Artinis, The Netherlands). From the resulting signals, the supervised classification procedure was performed by means of a support vector machines algorithm.
The main results are an observation of (i) a significant increase ($P <$ 05) in lateral prefrontal (right and left) and right parietal areas activity after 10 min of task (ii) and a significant increase in cortico-spinal excitability ($P < .01$) and the primary motor area activity ($P < .05$) after 15 min of task. The TOT effect was observed after 9 min of sustained attention as revealed by a significant increase in RT ($P < .001$). The classification accuracy achieved a value of 80% when a statistically significant increase in RT appears. Further, a significant relationship between classification accuracy and relative increase in RT was found.
We demonstrate that the adaptations of the nervous system to the rise in RT over time is not limited to the attention-related cortical areas but in addition implicates some motor structure involvement. These cortical regions may serve as a readily input for BCI applications. Further these preliminary results demonstrate the potential for exploitation of NIRS-measured hemodynamic signals of the cerebral cortex to monitor attention deficits.

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