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Editorial

Boosting neural activity in cortical motor areas through neurofeedback in Parkinson's Disease

In Parkinson's Disease (PD), functional changes in the cortico-striato-thalamo-cortical circuit secondary to dopaminergic neuronal degeneration in the substantia nigra lead to motor symptoms such as bradykinesia, rigidity and tremor (DeLong and Wichmann, 2007). Bradykinesia in PD mainly consists of slowness of voluntary movements and progressive deterioration over time of motor performance during sequential movements (i.e. the finger tapping task). Early movement studies in PD have demonstrated that when patients perform complex motor tasks consisting of simultaneous/sequential movements, motor execution deteriorates significantly over time owing to the "sequence effect". PD patients not only take longer to complete each sequential sub-movement compared to the same motor task performed independently, but the time lapse between one sub-movement and the next is also significantly prolonged. Overall, these clinical and neurophysiological findings have strongly supported the hypothesis that in PD bradykinesia mostly reflect impaired motor preparation processes (Berardelli et al., 2001).

Neural activity underlying motor preparation processes can be investigated in humans by recording movement related cortical potentials (MRCPs) (Shibasaki and Hallett, 2006). During self-triggered voluntary movements, MRCPs are commonly recorded in the form of Bereitschaftspotentials (BPs). BPs consist of an early component (BP1), occurring 1.5–0.5 s before movement onset, and a late component (BP2) preceding movement onset at 0.5 s or less. The BP1 is thought to arise from the supplementary motor area (SMA) and then spread to involve the lateral premotor areas, bilaterally. By contrast, the BP2 component is known to reflect neural activity in the primary motor cortex (M1) contralateral to the movement (Shibasaki and Hallett, 2006). Previous studies investigating MRCP in parkinsonian patients have demonstrated that the BP1 but not the BP2 component is reduced in amplitude compared to age-matched healthy subjects (Dick et al., 1989) supporting the hypothesis of SMA underactivity in PD.

The present issue of Clinical Neurophysiology includes a recent study from Fumuro et al., aimed at verifying whether in PD the decreased activity in neural generators of BP1 can be boosted and restored by using the Neurofeedback (NFB) training technique (Fumuro et al., 2013). NFB consists of a brain–computer interface (BCI) approach characterized by control and manipulation of endogenous brain rhythms through real-time visual feedback (Fetz, 2007). The authors recorded and compared BPs preceding a self-paced simple motor task with the right thumb in a small cohort of PD patients and age-matched healthy subjects, before and after NFB training. As a measure of NFB training-induced learning processes, the authors compared BP amplitudes before and after NFB and then divided PD patients in "good" and "poor" performance groups. The authors found that after NFB training, the "good" performance group of parkinsonian patients was able to increase BP1 in amplitude significantly, whereas the "poor" performance group did not. The authors concluded that NFB training is potentially useful for restoring BP1 amplitudes in PD.

The interesting study of Fumuro et al. (2013) provides experimental evidence supporting NFB training as a new non-pharmacological strategy possibly helpful for increasing neural activity in cortical motor areas responsible for motor symptoms in PD. Current knowledge on the pathophysiology of PD attributes several parkinsonian symptoms to underactivity of midline cortical motor areas including SMA and pre-SMA which are known to play a crucial role in motor planning and execution of self-paced voluntary simple and complex (simultaneous/sequential) movements. In addition, SMA is thought to receive prominent projections from the basal ganglia (Dum and Strick, 1992; Akkal et al., 2007). Accordingly, the hypothesis of Fumuro et al. (2013) that parkinsonian symptoms can be improved by boosting endogenous neural activity in SMA and other cortical areas responsible for motor preparation processes is reasonable. However, several aspects concerning the effect of NFB training on BPs in PD patients remain unclear. The neurophysiological criteria for dividing patients in "good" and "poor" performance groups are questionable. The authors did not clarify which clinical variable (disease severity, total L-Dopa daily doses, attentional processes) or neurophysiological measure (functional connectivity between primary and non-primary motor areas) (Suppa et al., 2010) might predict the subsequent "good" or "poor" performance at the NFB training in PD. Moreover, although it has been previously reported that L-Dopa may improve BP1 amplitudes significantly in PD (Dick et al., 1989), in the present study, the authors did not investigate the impact of dopaminergic therapy on NFB training-induced learning processes.

In conclusion, before considering NFB training as a new non-pharmacological therapeutic strategy for improving parkinsonian symptoms in PD, a number of clinical and neurophysiological variables possibly contributing to BP generation and modulation in PD should be further investigated. Finally, given that several recent studies have elicited plasticity processes in cortical motor areas contributing to MRCP (Ortu et al., 2009; Thabit et al., 2010; Ros et al., 2010; Mrachacz-Kersting et al., 2012; Suppa and Papazachariadis, 2013), further important advances in PD might arise from future studies investigating whether new BCI approaches including the NFB-training technique here proposed by Fumuro et al. (2013) can boost plasticity mechanisms in cortical motor areas and then in turn improve parkinsonian symptoms.

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