Looking for neurophysiological correlates of brain-computer interface learning

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Résumé

Non-invasive Brain-Computer Interfaces (BCIs) can exploit the ability of subjects to voluntary modulate their brain activity through mental imagery. Despite its clinical applications, controlling a BCI appears to require a skill acquisition that can last several weeks to reach relatively high-performance in control, without being sufficient for 15 to 30 % of the users. This gap has motivated a deeper understanding of mechanisms associated with motor imagery (MI) tasks. Here, we expected that MI-BCI training is associated with the recruitment of areas distributed across the cortex beyond those targeted by the BCI.
Twenty BCI-naive subjects (aged 27.45 ± 4.01 years, 12 men) participated to four BCI sessions each. Power spectra and imaginary coherence between each pair of region of interest in the source space were used to study respectively, the evolution of the activations and of the functional connectivity during the training from electroencephalographic signals.

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We found a progressive involvement of distributed sources in the cortical hemisphere contralateral to the movement corresponding to a significant power decrease ($p < 0.025$) within both alpha and beta ranges that tended to focus more on the pre-and postcentral gyri at the end of the training. Power changes significantly predicted BCI scores in in alpha and beta ranges. A progressive decrease of task-related connectivity in both alpha and beta ranges across sessions was also observed, notably in associative regions. Better performance was associated with the decrease of regional connectivity in associative areas but also in the fronto-marginal gyrus, known to be involved during decision making and memory consolidation. Notably, we observed significant predictions of BCI learning rate from regional connectivity in the precuneus, involved during motor imagery and working memory.
We elicited cortical changes associated with a dynamic brain reorganization during BCI training. These changes were characterized by an increase of the desynchronization rate and by a decrease of the connectivity that can be used as predictors of BCI performance. Taken together, our results offer insights into processes underlying BCI training.

Mots-Clés: BCI, MI, EEG, MEG, Functional connectivity