

Independent component analysis of the neural correlates of action awareness

Arrighi P.¹ - Sotgiu E.² - Borelli L.² - Bonfiglio L.¹ - Carboncini M.¹

Cantore N.¹ - Rossi B.¹ - Frisoli A.² - Andre P.³

¹ *Neurorehabilitation Unit, University of Pisa, Pisa, Italy*

² *PERCRO Laboratory, TECIP, Scuola Superiore Sant'Anna, Pisa, Italy*

³ *Department of Physiology, University of Siena, Siena, Italy*

It is assumed that while performing a goal-oriented movement a matching process occurs between its predicted and actual sensory consequences that may contribute to the feeling of oneself as the agent of one's own actions, that is the "sense of agency". If the matching process detects a discrepancy which exceeds a certain threshold then awareness of action discrepancy or a perturbed sense of agency appears. In a previous study we demonstrated that both these perceptions are associated with changes in movement-related high α /low β desynchronization in the parietal cortex. To localize the source/s of such desynchronization we used independent component analysis (ICA) computed on 64 channel EEG recordings of normal subjects performing center-out cued reaching movements under a variable degree of perturbation of the visual feedback. Briefly, the output of an electromagnetic motion-tracking system, whose sensor was located on the subject right finger, was processed by a computer and projected on a mirror where the subjects saw their virtual finger as a cursor, having their hand hidden by the mirror. Computer processing used an algorithm for adding a linear directional bias in clockwise/counterclockwise direction of varying amplitude or for producing a randomly-generated distortion (d). Thus, four experimental conditions were presented pseudorandomly: 0°d, visual displacement of 7.5° or 18°, which were under or above the threshold for conscious detection, respectively, and no correspondence between the actual and the seen movement (other's). After each movement subjects reported whether they felt like to be in control or out of control of the movement viewed and, in the former case, whether feedback was congruent or distorted with respect to their actual movement. As expected, a discrepancy was detected in $4 \pm 3\%$, $23 \pm 15\%$, $79 \pm 11\%$ and 100% of 0°d, 7.5°d, 18°d and other's movements, respectively. Time-frequency analysis computed on the activity of two clusters of ICs located in the mesial portion of precuneus and in the right angular gyrus demonstrated that movement-related $\alpha 3$ and $\beta 1$ desynchronization was significantly higher in 18°d as compared to 0° and 7.5°d conditions. In case of altered sense of agency (other's), desynchronization in the same frequency bands was similar to that associated with 18°d in the first 500 ms since the exit from the starting point, then it partially recovered towards pre-movement values although movement was still ongoing. We speculate that during distortion the computational cost needed to incorporate/select afferent signals such as the incongruent visual and the veridical proprioceptive signals in the monitoring/matching process leads to an

increase of movement-related $\alpha 3$ and $\beta 1$ desynchronization at the level of precuneus and right angular gyrus. According to this speculation, a reduced need of monitoring, which occurs when subjects became aware that visual feedback is not related to their own movement, is associated with a partial recover of α/β rhythms in these brain areas.