



Mirror movements of upper limbs are correlated with attentional and executive functions in healthy subjects and brain injury patients

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Background: Mirror movements (MM) refer to the involuntary contractions occurring in homologous muscles contralateral to the voluntary movements, particularly in the distal upper limb muscles. In healthy adults, MM can be observed during complex rhythmic or effortful tasks. Persistent MM are also present in pathological cases such as hemiplegic patients following stroke or traumatic brain injury, especially in the non-paretic limb. Furthermore, MM can be modulated by higher order cognitive control such as focused attention. Based on the analysis of mirror electromyographic (EMG) activity, the present study aims to investigate (1) the amount of MM on each limb in healthy subjects and brain-injured patients (BIP) and (2) the link between the amount of MM and attentional and/or executive functions involved in the inhibition of MM in healthy subjects and BIP.

Methods: 24 right-handed control volunteers (15 men and 9 women; mean age: 31 ± 17 years) and 8 chronic brain injury patients (7 men and 1 woman; mean age: 54 ± 13 years) participated in the study. MM were evaluated during a switching motor paradigm. Participants performed rhythmic bimanual power grip contractions in synchronization with an auditory metronome and were asked, when the metronome's tone changed after random time duration, to switch to unimanual rhythmic power grip contraction at the same rhythm. Surface EMG of flexor and extensor muscles of the forearm were recorded for both limbs. The number and amplitude of post-switching EMG peaks in the non-active hand were considered as "occurrence" and "intensity" of MM, respectively. For each participant, seven neuropsychological tests were performed to assess attentional and executive functions, including, attentional flexibility, verbal and motor inhibition, interhemispheric transfer time, as well as focused, preparatory and sustained attention. ANCOVAs Group x Limb with Age as covariate were performed on the occurrence and intensity of MM. Moreover, the correlation between the average occurrence and intensity of MM of both limbs and the variables evaluating attentional and executive functions was tested with stepwise regression models with backward elimination. Significance was set at $p < 0.05$.

Results: Irrespective of age and regardless of the limb, a significant Group effect indicated that the occurrence ($p < 0.001$) and the intensity ($p = 0.001$) of MM were significantly higher in BIP compared to healthy adults. Moreover, among the seven neuropsychological scores, the score of Trail Making Test (TMT) was the only significant predictive variable of the occurrence ($r^2 = .252$; $p = 0.003$) and the intensity ($r^2 = .281$; $p = 0.001$) of MM in all participants.

Conclusions: As in previous studies, we found a greater amount of MM in BIP compared to healthy subjects. More interestingly, the occurrence and intensity of MM were predicted by attentional flexibility (TMT). This result could be explained by the fact that MM were evaluated by a switching motor task that requires flexibility. The present study is the first to highlight the strong link between MM and executive and motor functioning in post-stroke patients, leading to possible implications in terms of rehabilitation.