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Cortical representation of voluntary and non-voluntary motor rhythms

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Background: Coupled bilateral cortical activity seems to be the basis for intermanual coordination, but its direct relation to the peripheral bimanual movements is still unclear.

Methods: We analyzed corticomuscular coherence between 64-channel EEG and bilateral hand/ finger extensor and flexor EMG and intermuscular coherence between left and right muscle activity in 18 healthy subjects during unilateral and bilateral fast rhythmic hand/finger movements and isometric contractions on both sides.

Results: Partial coherence between two separated coherent areas and muscle and corticomuscular/ cortico-cortical delays were calculated.

Bilateral voluntary rhythms of each hand showed coherence with lateral cortical areas on both sides in 60-80% of the recordings and occasionally with the frontal midline region (10-30%). They were always coherent between both hands. Unilateral rhythmic movements were represented in the ipsilateral cortex in only 20%-30% of the recordings tending to be more frequent with the left hand, paralleled by more frequent left-right muscle coherence. Partial corticomuscular coherence was most often abolished ($p < 0.05$) when the cortical signal contralateral to the coherent muscle was used as the predictor indicating that the ipsilateral and occasional fronto-mesial connection with the muscle was mainly indirect via the contralateral cortex. Cortico-cortical delays showed mainly bidirectional interaction

at the movement frequency and were bimodally distributed ranging between 1- 10 ms and 15-30 ms indicating direct cortical and subcortical routes. Corticomuscular delays ranged mainly between 12-25 ms indicating fast corticospinal projections, and musculocortical feedback showed similar delays. These corticomuscular delays were not significantly different for the 15-30 Hz coherence encountered in 60-70% of the recordings during isometric contractions. However this involuntary corticomuscular rhythm was strictly unilaterally represented and did not show coherence between left and right muscles.

Conclusions: We conclude that there is a fundamental difference between the complex bilateral cortical network representing and controlling a voluntary motor rhythm and the cortical representation of non-voluntary 15-30 Hz rhythm as well as pathological non-voluntary rhythms like organic tremors.