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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 corticomusuclar/ 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 frontomesial 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 between12-25 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.