Beta activity in SMA signals cognitive demand in motor control

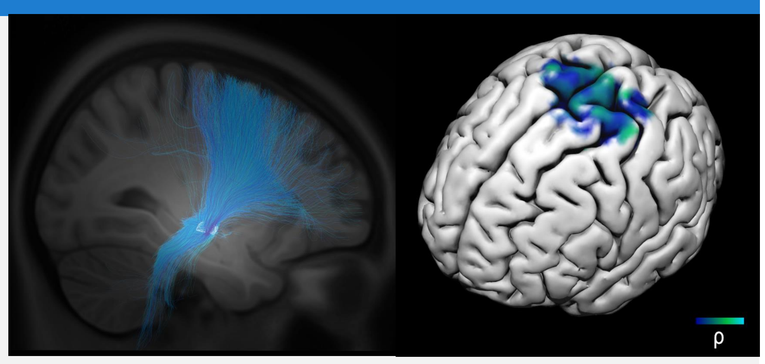
Postigo Alonso B, Galvao-Carmona A, Hofmann M, Kühn AA, Neumann WJ

Charité-Universitätsmedizin Berlin, Movement Disorders and Neuromodulation Unit

BACKGROUND & AIM:

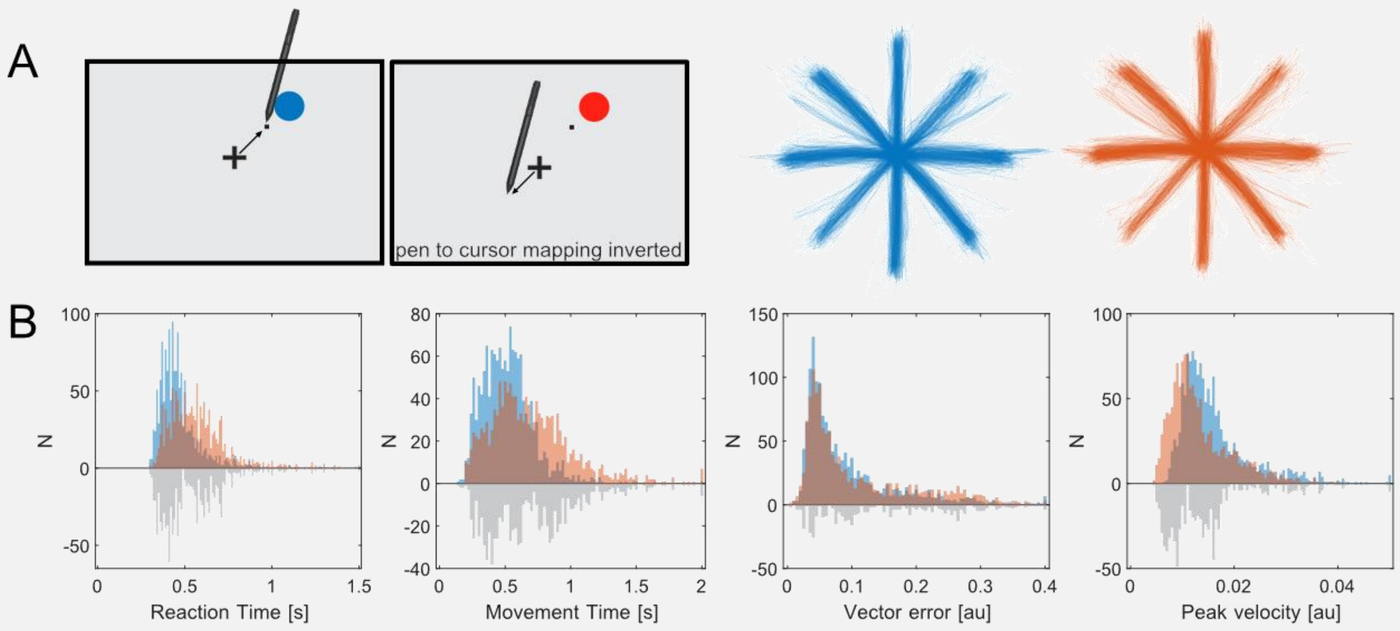
Subthalamic deep brain stimulation alters cognitive motor control through modulation of hyperdirect SMA – STN projections.

Aim: To investigate cortical oscillatory dynamics underlying cognitive control of planned reaching movements with or without pen-to-cursor mapping inversion in 20 healthy controls with 64 channel EEG in source space.



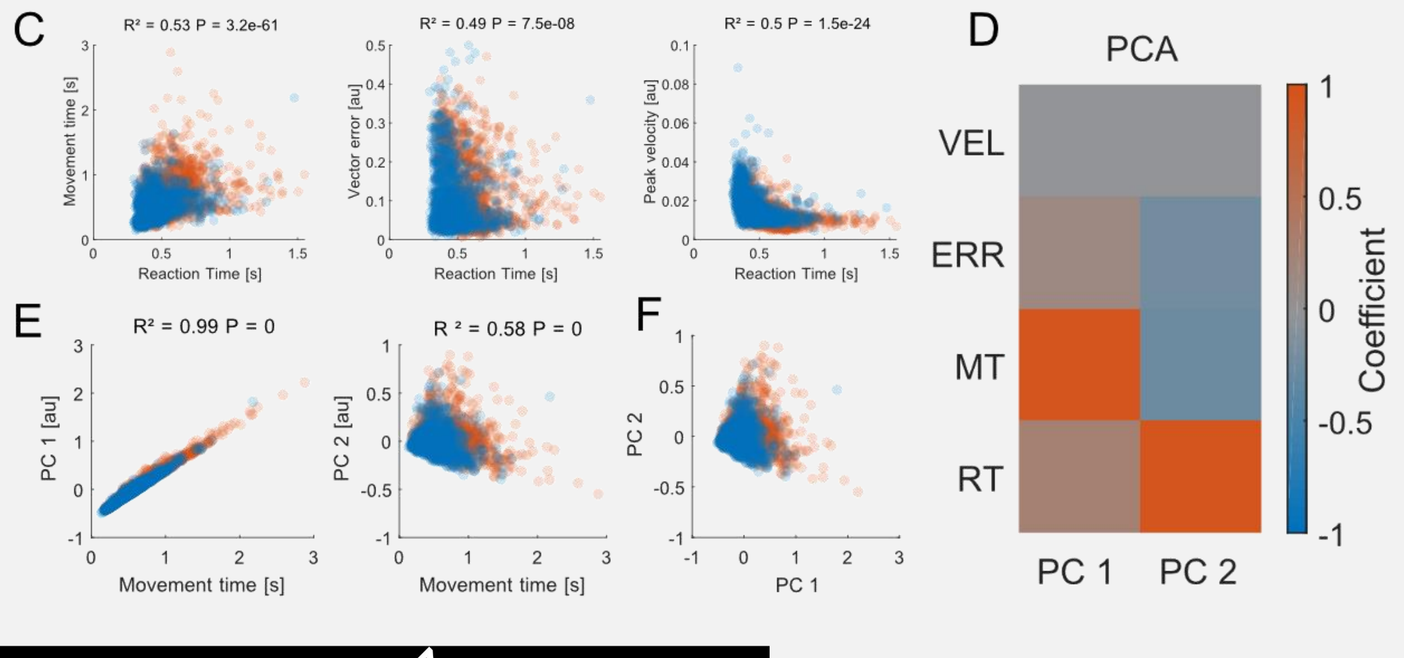
TASK AND BEHAVIOR:

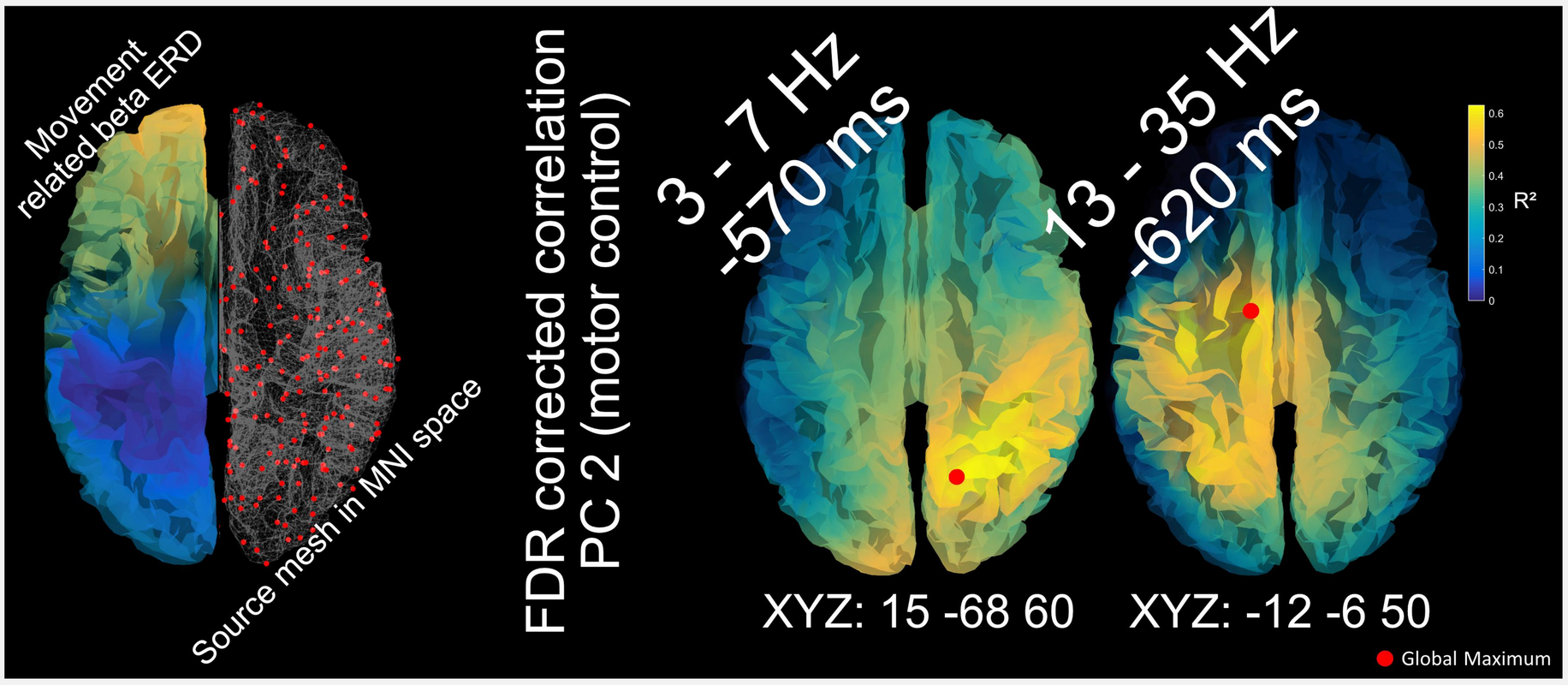
- 20 healthy participants were instructed to operate a cursor on a screen to reach a target-circle by moving a digitizer pen on a tablet (120 trials)
- Contrary to intuition, longer reaction times were not intrinsically correlated with better performance (i.e. faster, more precise movements).
- Principal component analysis was used on all trials to identify a component that is high, when longer reaction times were associated with better motor performance (PC 2).

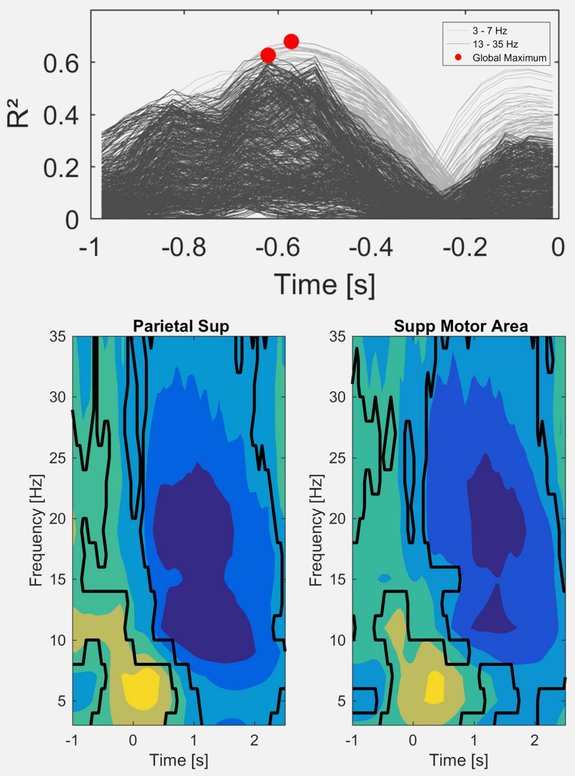


EEG ANALYSIS

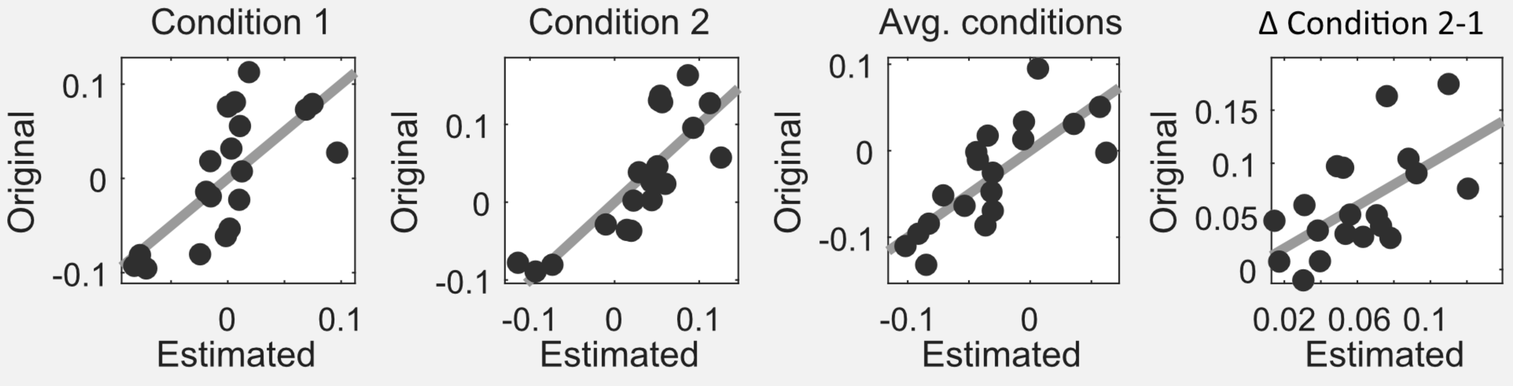
- 64ch BrainAmps acticap at 5 KHz aligned to movement
- LCMV beamforming to downsampled cortical surface mesh in MNI space (413 channels)
- Time frequency analysis with wavelet (8 cycles) averaged across trials and normalization to % average power, smoothed in time, space and frequency.
- FDR corrected mass correlation along all dimensions (time, space, frequency) for theta (3 – 7 Hz) and beta (13 – 35 Hz) across subjects.
- Leave-one out cross validation to predict individual behaviour to demonstrate predictive power of multidimensional oscillatory pattern matching (-1 – 0 s premovement time, 3-7 and 13-35 Hz).







Leave one out cross-validation (LOOM)
of multidimensional pattern matching to predict PC2 (motor control)



β = 0.19
R ² = 0.5 P = 0.0008

β = 0.24
R ² = 0.65 P = 2.9e-05

β = 0.16
R ² = 0.6 P = 9.1e-05

β = 0.16
R ² = 0.36 P = 0.007

CONCLUSION:

- Longer reaction times are not directly associated with better motor performance
- A principal component (PC2) associated with longer RT and better performance was identified
- This component could be predicted across patients from multidimensional cortical oscillatory activity patterns in LOOM cross-validation
- Beta activity in SMA 620 ms and theta activity in parietal cortex 570 ms before movement onset were the strongest predictors of this component

Neumann W-J, Schroll H, de Almeida Marcelino AL, Horn A, Ewert S, Irmen F, et al. Functional segregation of basal ganglia pathways in Parkinson's disease. Brain 2018
Wu T, Hallett M. The cerebellum in Parkinson's disease. Brain 2013; 136: 696–709.

SBN Sektion für Bewegungsstörungen und Neuromodulation

CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN