A NOVEL METHOD TO GENERALIZE TIME-FREQUENCY COHERENCE ANALYSIS BETWEEN EEG OR EMG SIGNALS DURING REPETITIVE TRIALS WITH HIGH INTRA-SUBJECT VARIABILITY IN DURATION

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Background

- Analysis of coherence between two electrophysiological signals as EMG or EEG can give information about synchrony between brain and muscle activities or within the brain. It is a powerful tool to investigate neural mechanisms underlying motor control[1].
- Calculation and quantification of coherence require pooling of signals of same length[2]. Although this requirement is easily met with calibrated isometric contractions, dynamic contractions are an issue because of the high inter-trial variability.
- **This study proposes a novel preprocessing method to properly calculate coherence between EEG or EMG signals of different durations. This method is illustrated with both simulated and real data from a post-stroke subject.**

Methods

Datasets: simulated & experimental

- 30 pairs of signals sharing common 10 and 30 Hz components of different lengths were simulated.
- EEG, EMG and kinematic data were collected from a post-stroke subject performing repeated flexion/extension of the paretic arm.

Processing: time-normalization

- All were aligned, setting each component of interest start 1 second after the beginning of the signal.
- Time-normalization was achieved by resampling aligned simulated signals and EMG/EEG signals

Coherence analysis

- Coherence was computed[2] between the two signals of each pair for simulated data and between the EMG from the triceps brachii and the EEG from the C3 electrode in β band (13-30 Hz) for experimental data

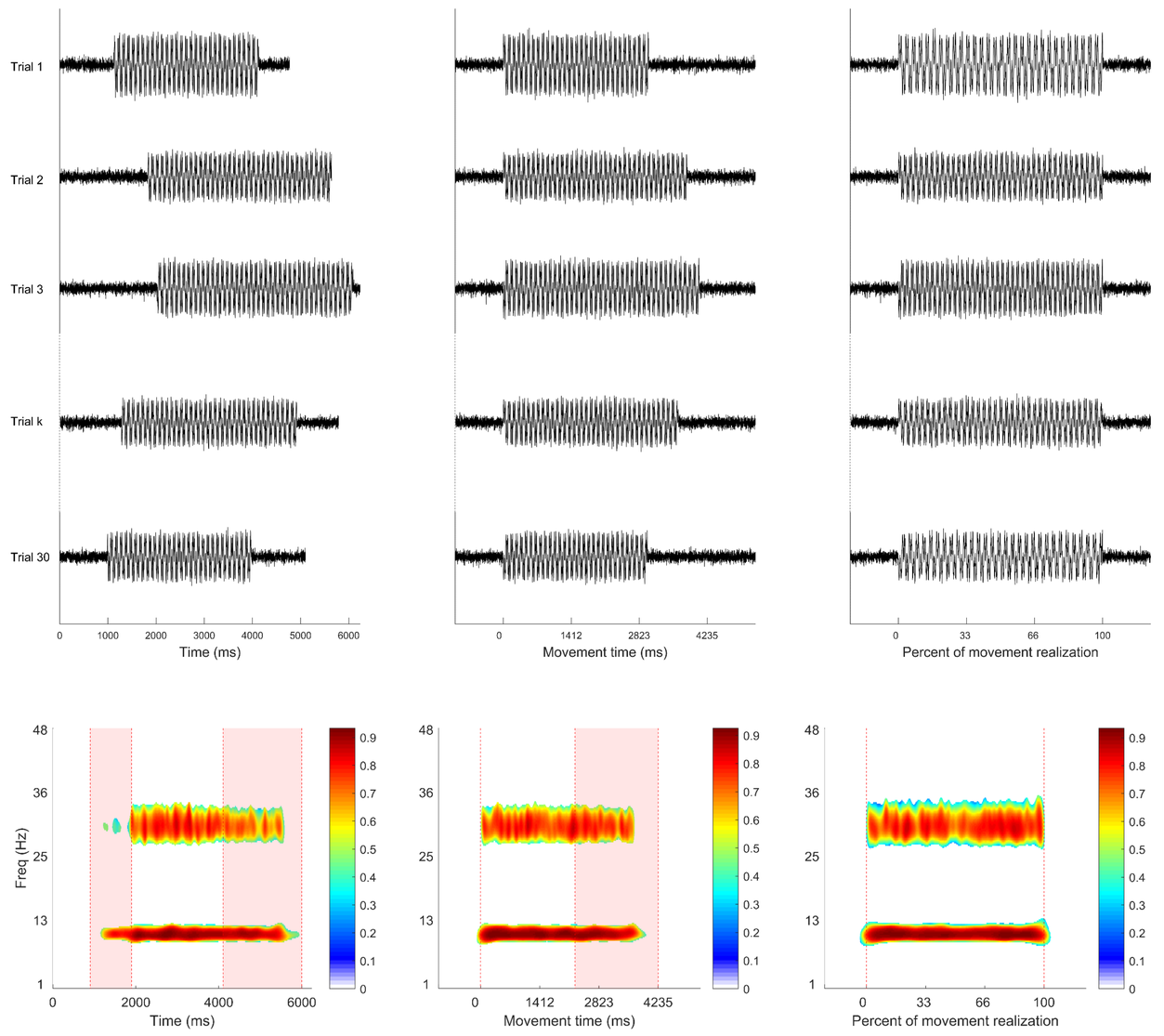

Figure 1: Coherence detection from simulated signals. Upper panel: preprocessing steps of signals of different lengths. Left column: raw simulated signals. Middle column: raw aligned signals. Right column: resampled signals (sampling rate from 1000 HZ to ≈3800 Hz. Lower panel: time-frequency maps of coherence from simulated signals. The left map is calculated from raw signals, the middle map from aligned signals and the right map from resampled signals. Doted lines and red shaded area show signals' length variability.

Results & Discussion

Simulated data

In 28-32 Hz band, mean coherence for raw signals is 0.52±0.29, 0.66±21 for aligned signals and 0.72±0.11 for time-normalized signals.

Coherence detection is less precise for raw and aligned signal.

The time-normalization of simulated signals allows a better calculation and quantification of the coherence.

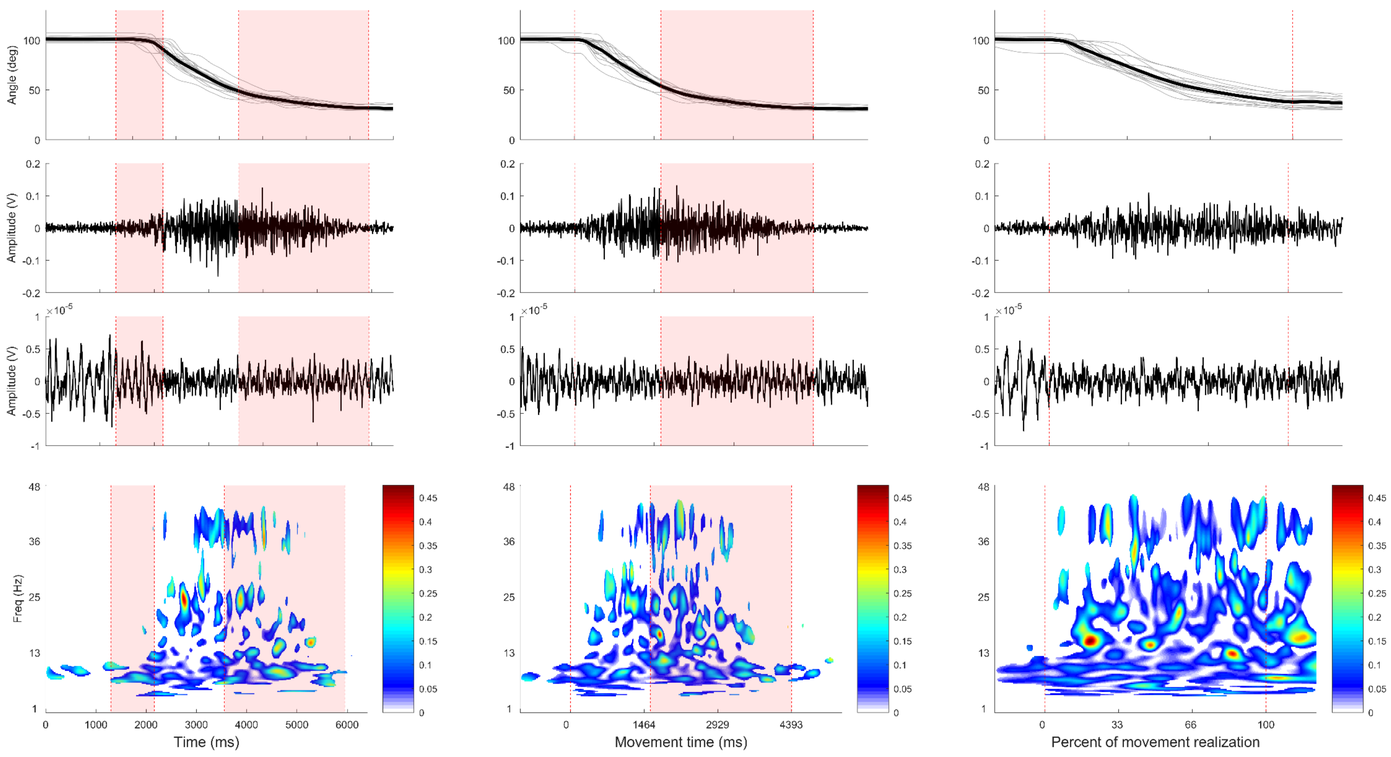

Figure 2: Kinematic, EMG, EEG data and time-frequency maps from 20 movements of the subject (read from top to bottom). Left column: raw trials, middle column: aligned trials, right column: time-normalized trials. Doted lines and shaded area show movement's duration variability.

Experimental data

Coherence is 0.08±0.07 in β band for raw trials, 0.10±0.05 for aligned trials and 0.12±0.04 for time-normalized trials.

Coherence detection is not consistent for raw and aligned trials.

Coherence variability decreases after each processing step.

The time-normalization reduces variability of coherence quantification for trials of different lengths.

The time-normalization processing step appears to be an appropriated method for coherence analysis of signals with high inter-trials variability.

References: [1] **Negro & Farina** (2011) The *Journal of Physiology*, 589, 629-637 [2] **Bigot et al.** (2011) *NeuroImage*, 55, 1504-1518