## Correlation analysis of EEG and EMG

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# Outline



- 2 EEG and EMG signals
- EEG-EMG processing
- Preliminary results
- 5 Conclusions and future perspectives

### Rationale:

Voluntary movement is controlled by the brain that sends/receives precise signals to/from muscles and nerves.

### Research question:

What is the origin of involuntary movements, like *bursts*? Is that voluntary control?



Healthy EMG, background activity.

Pathological EMG with bursts.

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### EEG: frequency band 0.5-45 Hz; amplitudes of few tens of $\mu V$

EMG: frequency band 5-200 Hz; amplitudes in the range of mV



EEG: typical classification (brain rhythms).

EMG: origin and components.

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Typical behaviours at rest:

Healthy case: amplitudes  $< 10 \mu$ V, frequency band 5-50 Hz. Pathological case: amplitudes  $< 200 \mu$ V, frequency band 5-200 Hz.



Healthy case.

Pathological case.

Given x[n] and y[n] discrete signals, e.g. digitized EEG and EMG: Cross-correlation coefficient:

$$r_{max} = rac{\max(r_{xy}[n])}{\sqrt{E_x E_y}}$$

where  $r_{xy}[n] \triangleq \sum_{m=-\infty}^{+\infty} x^*[m]y[n+m]$  is the cross-correlation function between x[n] and y[n].

Delay:  $lag = argmax(r_{max})$ 

Coherence (absolute value):

$$Coh_{xy}(f) \triangleq rac{\mathcal{P}_{xy}(f)}{\sqrt{|\mathcal{P}_x(f)|} \cdot \sqrt{|\mathcal{P}_y(f)|}}$$

where  $\mathcal{P}_x(f)$  and  $\mathcal{P}_y(f)$  are the power spectral density (PSD) of x[n] and y[n], respectively, and  $\mathcal{P}_{xy}(f)$  is the cross-PSD.

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# Preliminary Results on Correlation





Cross-correlation function maximum.

Cross-correlation delay.

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# Preliminary Results on Coherence



Healthy case (CL = 0.067,  $\alpha = 0.95$ ).

Pathological case (CL = 0.451,  $\alpha = 0.95$ ).

with confidence level, CL:  $CL = 1 - (1 - \alpha)^{\frac{1}{N-1}}$ 

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## Conclusions

- Confirmation of human physiology (maximum of cross-correlation function is about 10 ms).
- Healthy coherence has a peak around 20 Hz (and lower frequencies), in line with literature
- Pathological coherence has a peak around 20 Hz, but also spurious peaks at higher frequencies (35-40 Hz)

## Future Perspectives

- Enlarge the experimental samples
- Comparison with other measures to support the presence of voluntary sensorimotor control.

# Acknoledgments

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