Oscillations

Mads Jensen, PhD

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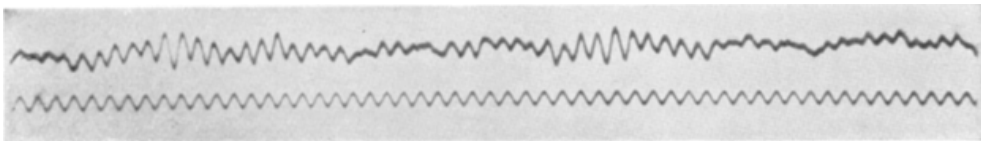
AARHUS UNIVERSITY

IMC
INTERACTING MINDS CENTRE
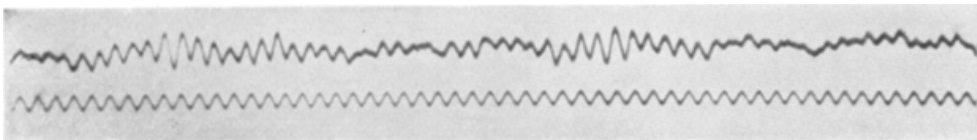
CFIN

Contents

Cognition as brain rhythms

Cognition as brain rhythms

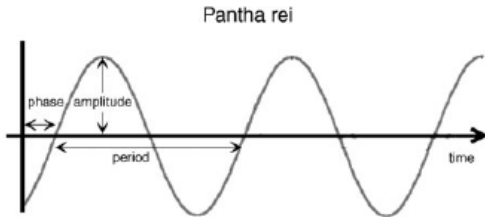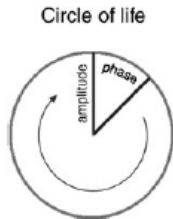(Figure from Berger, 1929)

Cognition as brain rhythms

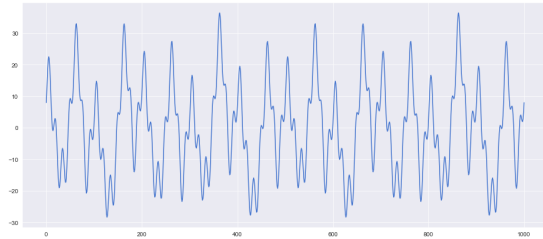
(Figure from Berger, 1929)
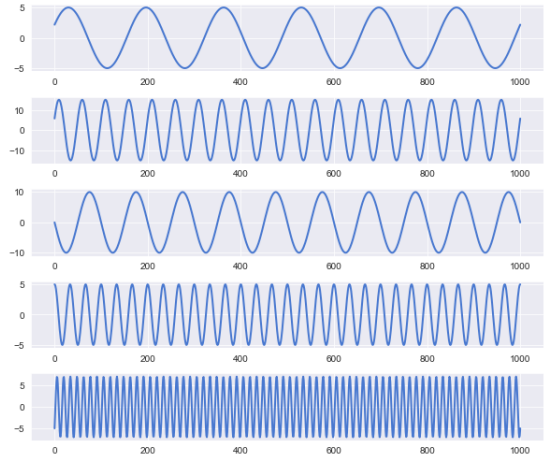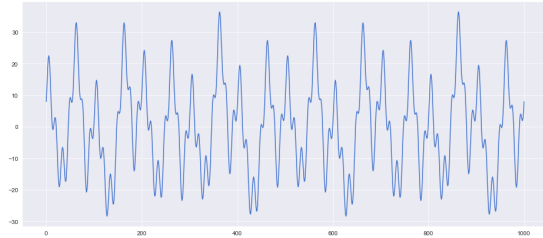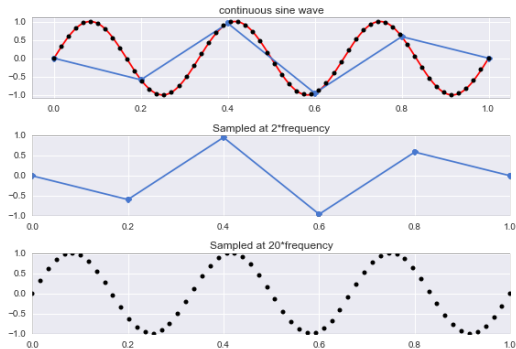

(Figure from Buzsáki, 2006)

Sine waves

Sine waves

(Figure from https://github.com/lyndond/Analyzing_Neural_Time_Series/blob/master/chapter11.ipynb)

Sampling rate matters

(Figure from

https://github.com/lyndond/Analyzing_Neural_Time_Series/blob/master/chapter06.ipynb)

Sampling rate matters
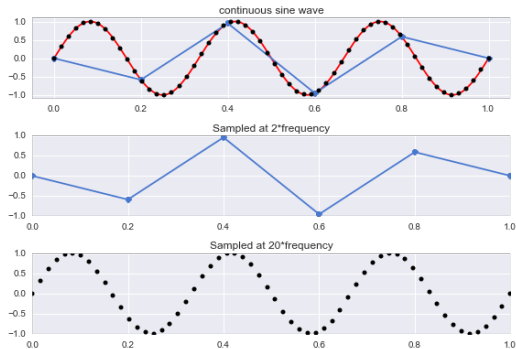
- **Nyquist frequency** is half of the temporal sampling rate.
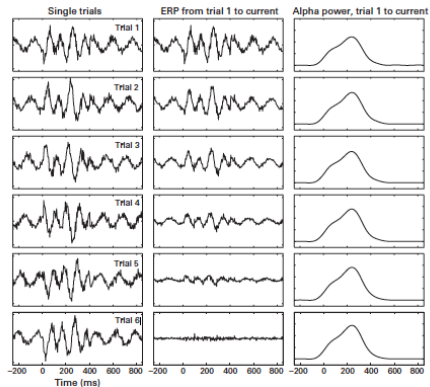- **Rayleigh frequency** is the spacing between discrete frequencies

(Figure from

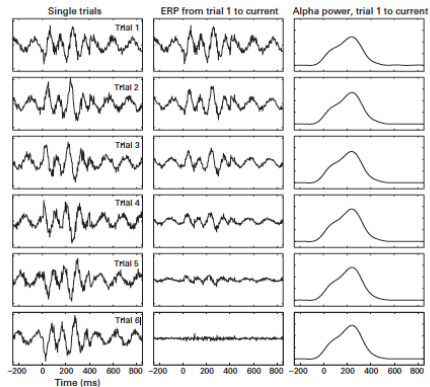https://github.com/lyndond/Analyzing_Neural_Time_Series/blob/master/chapter06.ipynb)

Information in ERPs & Oscillations

(Figure from Cohen, 2014)

Information in ERPs & Oscillations

(Figure from Cohen, 2014)
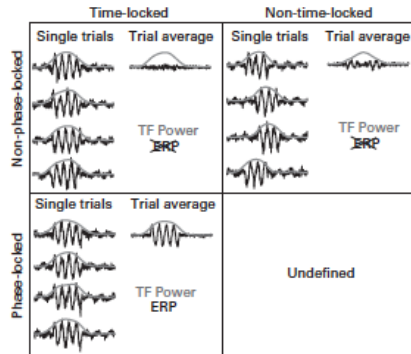
(Figure from Cohen, 2014)

Frequency bands

Name	Frequency range[1]
α (Alpha)	8 - 12 Hz
β (Beta)	14 - 30 Hz
γ (Gamma)	30 - 100 Hz
θ (Theta)	4 - 8 Hz
δ (Delta)	1 - 4 Hz

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[1]As defined in Jensen et al., 2014

Physiological origin of oscillations
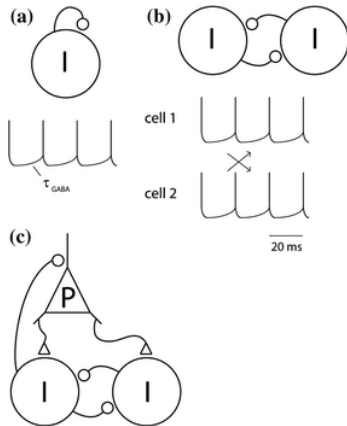
(Figure from Jensen et al., 2014)

Quantifying brain waves

Power spectrum density

(Figure from Jensen et al., 2014)

Power spectrum density

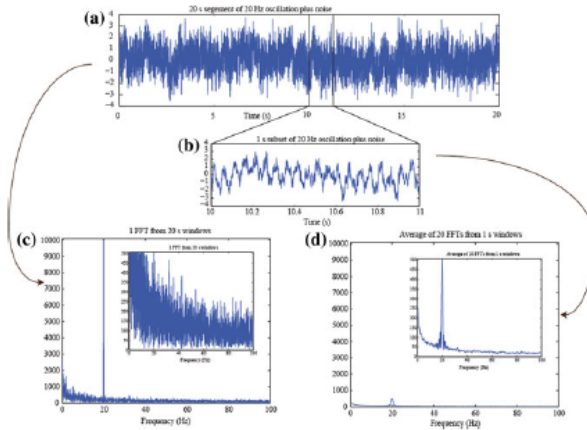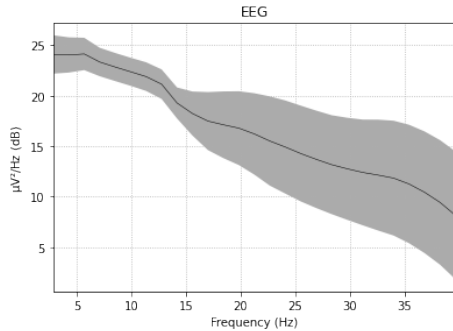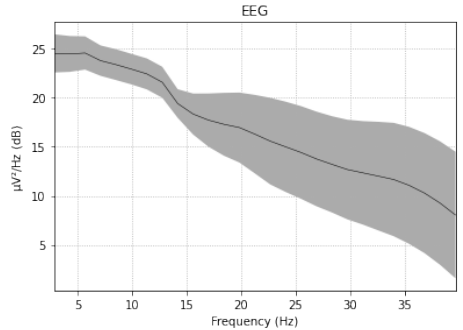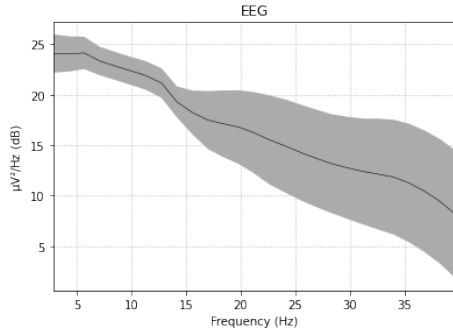# Power spectrum density

Wavelets

Wavelets

(Figure from http://www.fieldtriptoolbox.org/tutorial/timefrequencyanalysis/)
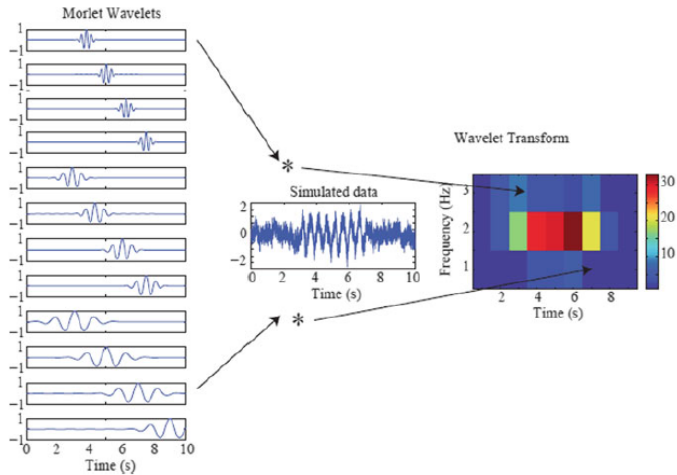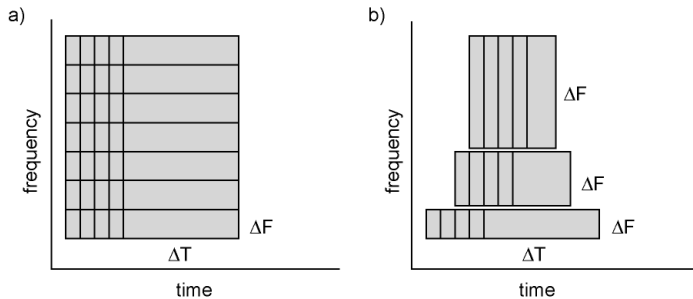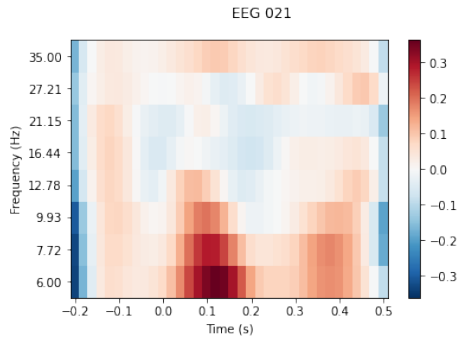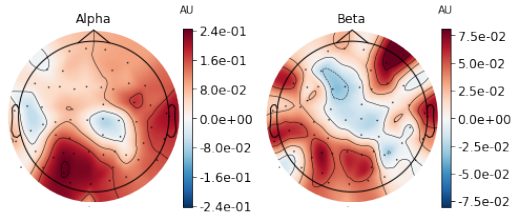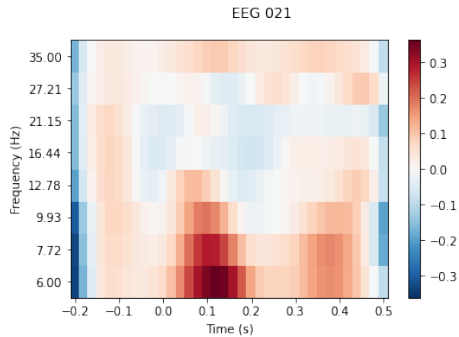
Wavelets

Wavelets

Hilbert transform

Hilbert transform

- Band pass filter for the frequency bands of interest

Hilbert transform

- Band pass filter for the frequency bands of interest
- Apply Hilbert transform

Hilbert transform

- Band pass filter for the frequency bands of interest
- Apply Hilbert transform
- Extract amplitute/power and/or phase

Hilbert transform

α

β
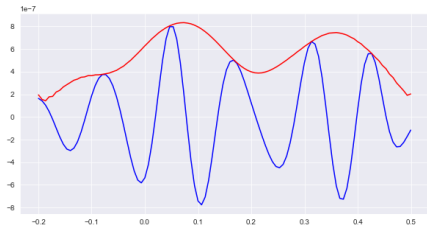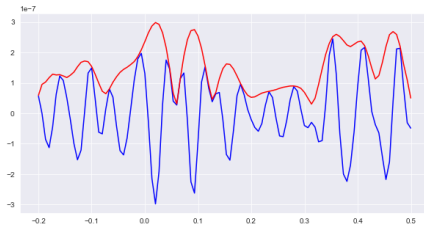
Hilbert transform
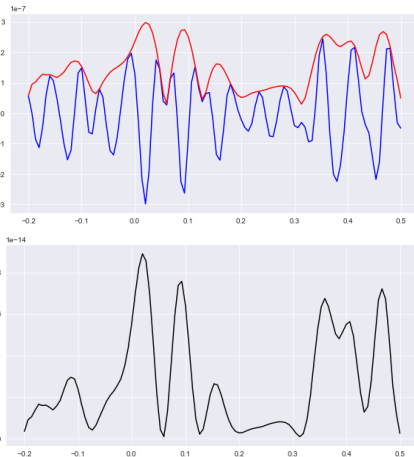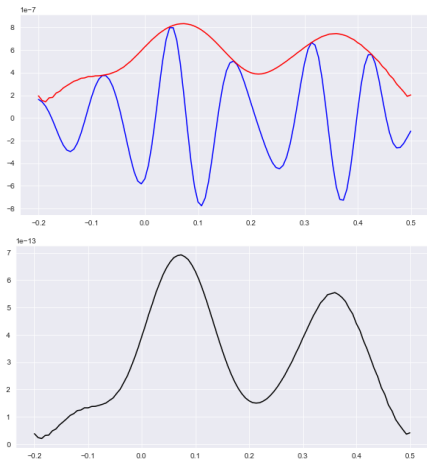
Frequency bands

Name	Frequency range	Function
α (Alpha)	8-12 Hz	Inhibition
		Attention
		Inter-regional communication
β (Beta)	14 - 30	Sensory motor
γ (Gamma)	30 - 100 Hz	Information processing
		Feedforward-drive
θ (Theta)	4 -8 Hz	Error processing
		Inter-regional communication
δ (Delta)	1 - 4 Hz	Excitability of a network

Filters
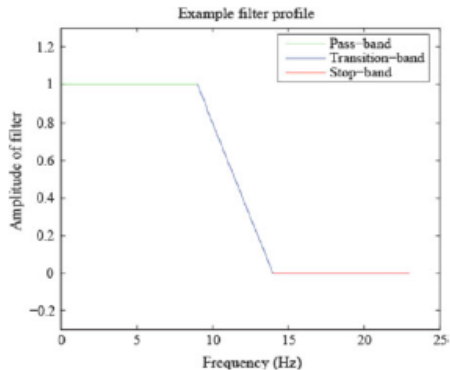
(Figure from Jensen et al., 2014)

Filters

Example filter profile
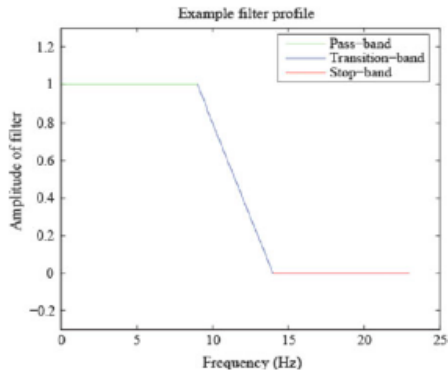
```
epochs_30.filter(0, 30)

Setting up low-pass filter at 30 Hz

FIR filter parameters
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Designing a one-pass, zero-phase, non-causal lowpass filter:
- Windowed time-domain design (firwin) method
- Hamming window with 0.0194 passband ripple and 53 dB stopband attenuation
- Upper passband edge: 30.00 Hz
- Upper transition bandwidth: 7.50 Hz (-6 dB cutoff frequency: 33.75 Hz)
- Filter length: 67 samples (0.446 sec)
```

(Figure from Jensen et al., 2014)

Gating by inhibition

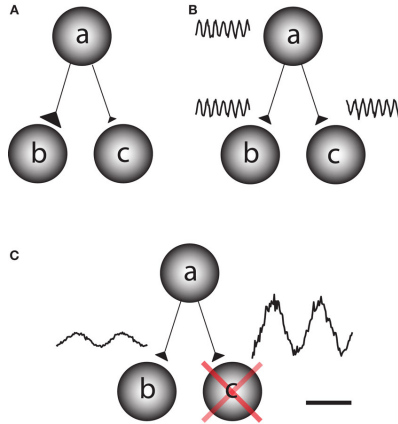# Shaping functional architecture by oscillatory alpha activity: gating by inhibition
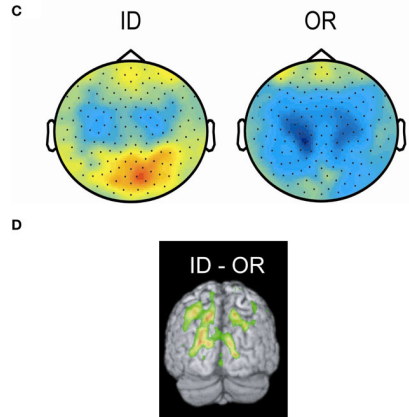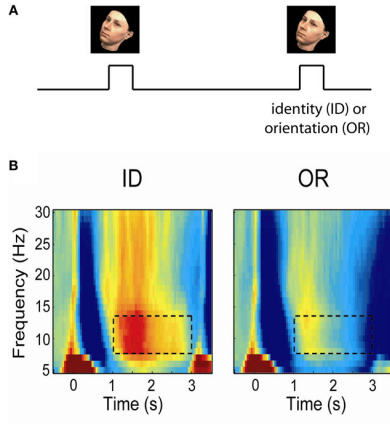
Ole Jensen* and Ali Mazaheri

Donders Institute for Brain, Cognition and Behavior, Radboud University, Nijmegen, Netherlands

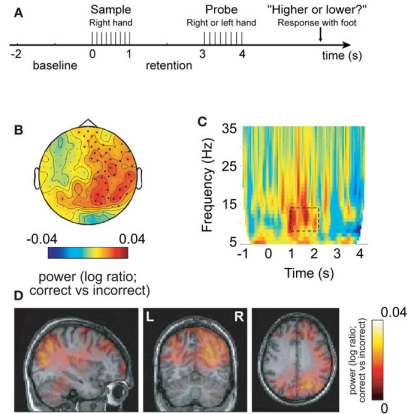# Gating information

(Figure from Jensen & Mazaheri, 2010)

Gating information

(Figure from Jensen & Mazaheri, 2010)

Gating information

(Figure from Jensen & Mazaheri, 2010)

References I

Berger, H. (1929). Über das Elektrenkephalogramm des Menschen. *Archiv für Psychiatrie und Nervenkrankheiten*, *87*(1), 527–570. https://doi.org/10.1007/BF01797193

Buzsáki, G. (2006). *Rhythms of the Brain*. Oxford University Press. Retrieved July 25, 2020, from http://www.oxfordscholarship.com/view/10.1093/acprof: oso/9780195301069.001.0001/acprof-9780195301069

Cohen, M. X. (2014). *Analyzing neural time series data: Theory and practice*. The MIT Press.

Jensen, O., & Mazaheri, A. (2010). Shaping Functional Architecture by Oscillatory Alpha Activity: Gating by Inhibition. *Frontiers in Human Neuroscience*, *4*. https://doi.org/10.3389/fnhum.2010.00186

Jensen, O., Spaak, E., & Zumer, J. M. (2014). Human brain oscillations: From physiological mechanisms to analysis and cognition. In S. Supek & C. J. Aine (Eds.), *Magnetoencephalography: From signals to dynamic cortical networks* (pp. 359–403). Springer Berlin Heidelberg.