Alternating increase/decrease of speed
No oscillation in equilibrium
Alternating increase/decrease of speed

Oscillations

Amplitude
Frequency
Phase

Magnetic Field 100
Strength (Femtotesla) 1

Spatial Resolution

EGG > MEG > PET > fMRI

Functional brain imaging

Outline

Brain oscillations in action
Joachim Gross, Gregor Thut, Guillaume Rousselet

Outline

1. Introduction
   - Definition of oscillatory behavior

2. Brain oscillations in action
   - Alternating increase/decrease of speed
   - No oscillation in equilibrium

3. Methods
   - Functional brain imaging

4. Results
   - EEG > MEG > PET > fMRI

5. Conclusion
What are we measuring?

Introductory Psychology Concepts: The Neuron and the Synapse

Identify parts of the neuron and synapse and describe how they communicate information.

Introductory Psychology Concepts: Resting Potential and Action Potential
Introductory Psychology Concepts: Resting Potential and Action Potential

Neuronal Oscillations

- ca. 1928

Hans Berger

Brain oscillations

Neuronal oscillations

- Buzsaki & Draguhn, Science, 2004
Mechanisms of generation

We need two opposing forces/effects
In the brain these are: excitation, inhibition

3 mechanisms:
1. Pacemaker cells
2. Local generator
3. Thalamo-cortical generator

Thalamo-cortical system

Input

Cortex

Formatio reticularis mesencephali

Thalamus

Nuc. reticularis thalami

Excitatory connection

Inhibitory connection

Alpha-oscillations

Rest:

Cortex

Thalamic Projections

Nuc. reticularis thalami

Inhibitory feedback of thalamo-cortical signals via Nuc. reticularis thalami.

Beta-oscillations

Active:

Cortex

Thalamic Projections

Nuc. reticularis thalami

Formatio reticularis mesencephali

Formatio reticularis inhibits Nuc. reticularis thalami and excites thalamic projections.

Magnetic fields

H.C. Oersted, 1820:

Deflection of compass needle by electric current
How are we measuring?
SQUIDS
Shielded room
(noise cancellation)

Magnetically shielded room (MSR)

Direct measurement of neural activity with high temporal and good spatial resolution

Magnetoencephalography (MEG)

Sensitivity of MEG system

Single sensor

Sensitivity of whole-head system
MEG Analysis
Preprocessing
Source localization
Analysis in time and frequency domain

Preprocessing
Filtering
Artifact rejection/correction
External: 50Hz line noise, magnetic noise, Jumps
Internal: Eye, heart, muscle, movements
Decimation

Fourier transform – the idea
fitting a function with sinusoids
transformation of time series to frequency domain

Fourier transform – the idea
fitting a function with sinusoids
transformation of time series to frequency domain

How does it look?
Spectral analysis of resting activity

2 s, occipital sensors
From sensors to brain areas

• Mapping signals into the brain
• Computation of power in the entire brain

Ongoing oscillations

Localisation of 10 Hz - and 20 Hz - oscillations

10 Hz
20 Hz

Break

Time-frequency analysis

Why TFR?
FFT assumes stationarity!
no time information

TFR with FFT

Short-time FT

S = spectrogram(x,window,overlap,nfft,fs);
spectrogram(mtlb,hanning(256),200,256,Fs);
Time-Frequency analysis

Phase analysis

aim: detect phase-locking (preferred, non-random phase)
for example: phae locking to stimulus

Pain perception

Pain processing

Evoked components

Next Week

Short presentation of papers:
• Ploner, Gross, et al., ‘Pain suppresses spontaneous brain rhythms’. Cerebral Cortex, 2005
Low-frequency alpha (theta) oscillations
High-frequency gamma oscillations

Lecture 9
New methods in research on oscillations beyond EEG/MEG
– Interventions and techniques

Pitfalls in interpreting oscillatory activity

Covers e.g.:


Oscillations: New findings on the alpha-frequency band
– Role in low-level vision (input control)
– Role in high-level vision (feature binding, and others)

With a focus on predictive oscillations (lectures 8-9)