

Multimodal analysis of human emotions : a Neuro-Physiological and facial dynamics approach

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Hypotheses

- **Induced gamma-frequency band** power will be differ in **emotional face perception**.
- Different brain regions and waves will be involved in the perception of different stimulations.

Brainwave

- High frequency EEG oscillations have **smaller amplitudes** compared with the lower frequencies.
- Faster oscillations in the human EEG between **30 and 80 Hz** could later be identified and were named as **gamma** activity

Chatrian et al., 1960

- The interest for these oscillations depends on the fact that **gamma activity** is closely correlated with **cognitive functions**

Engel et al 2001

- The cognitive functions in humans: state of **readiness** and **attention**, providing of **sensory indentification**, **perception** and **memorizations**, **decision-making**, management of **psychomotor** response, **emotional** and **semantic processing** of an information

Usp Fiziol Nauk 2006

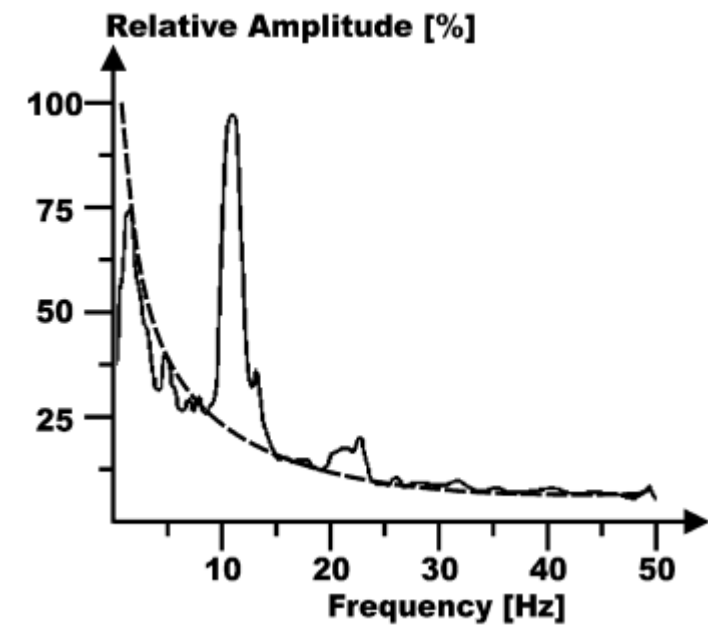


Fig. Relationship between the amplitude and the frequency of brain electrical oscillations

| Band | Frequency (Hz) | Wave |
|-------|----------------|------|
| Delta | < 4 | |
| Theta | 4 – 7 | |
| Alpha | 8 – 15 | |
| Beta | 16 – 31 | |
| Gamma | > 32 | |

① Spontaneous gamma oscillations :

Reflect the **consciousness level**.

Spontaneous activity

Thalamocortical resonant synaptic interactions

Llinas and Ribary, 1992

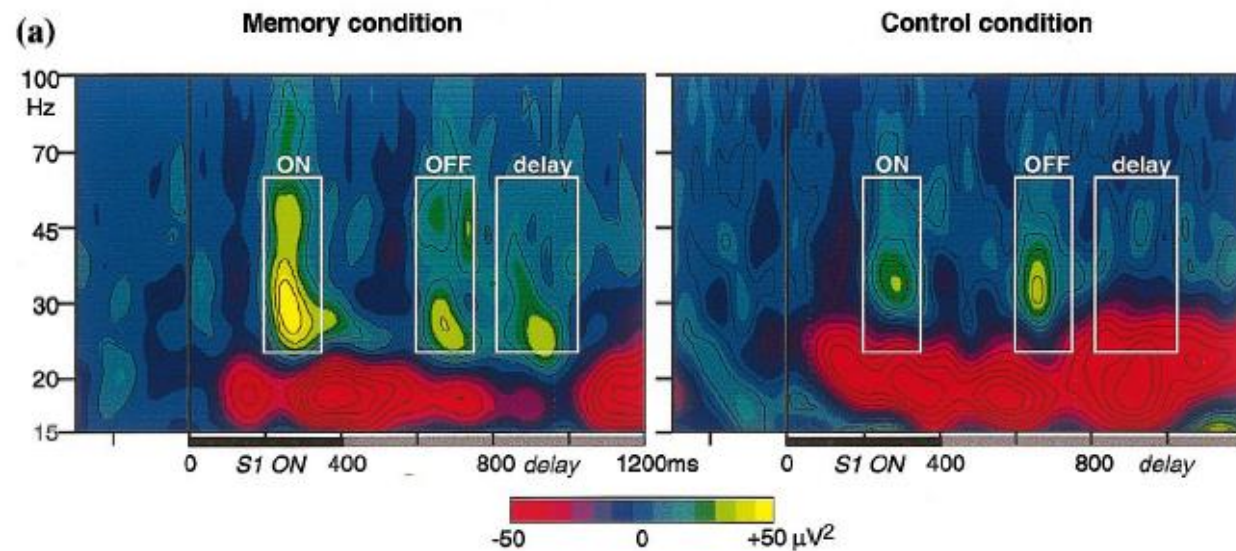
② Induced gamma oscillations : **Not phase-locked to** the stimulus

Engel et al., 1992

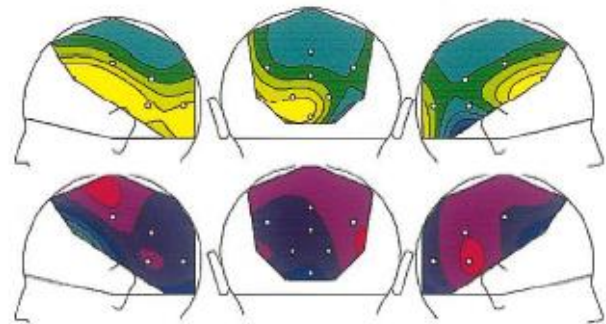
③ Evoked gamma responses : **Phase-locked** to the stimulus

④ Steady-state gamma oscillations : The driven electrical responses, of the brain obtained by the application of repetitive stimuli like clicks (40Hz).

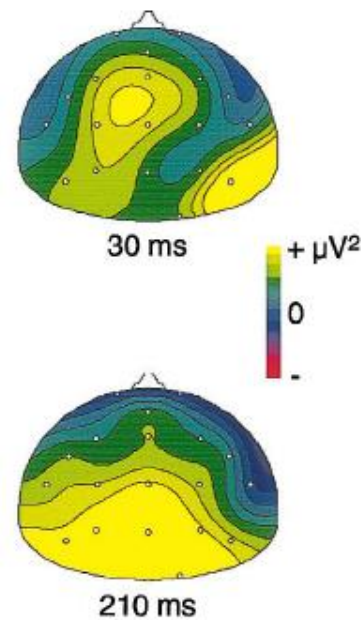
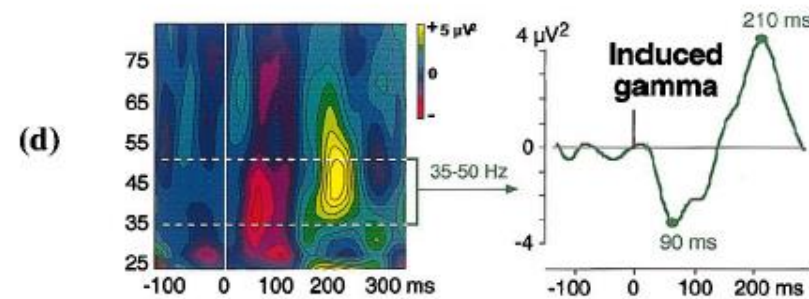
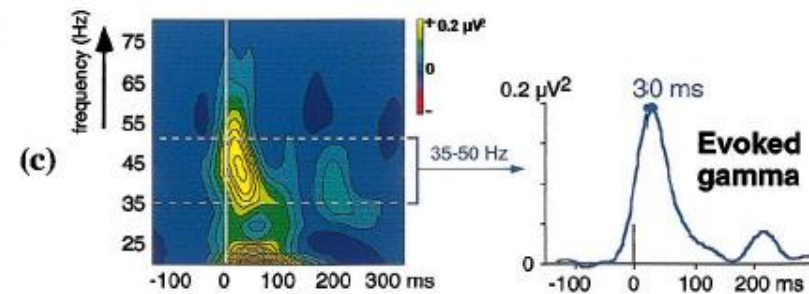
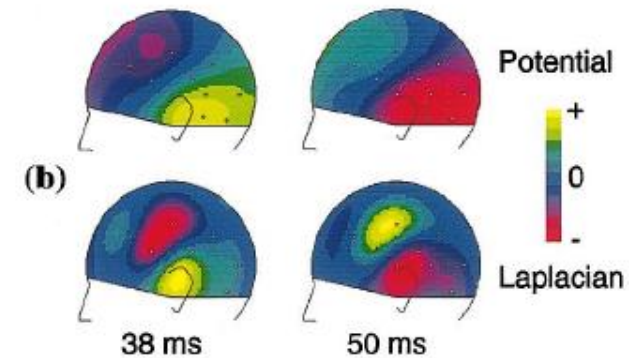
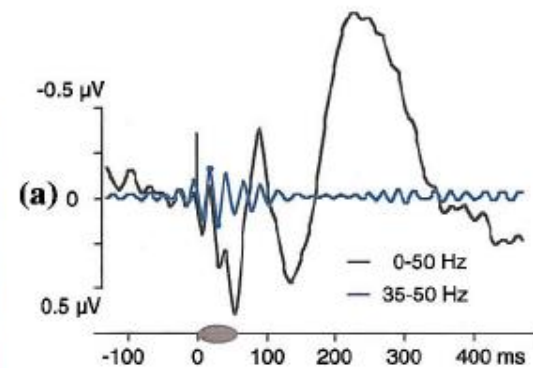
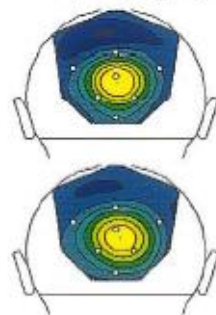
Galambos et al., 1981

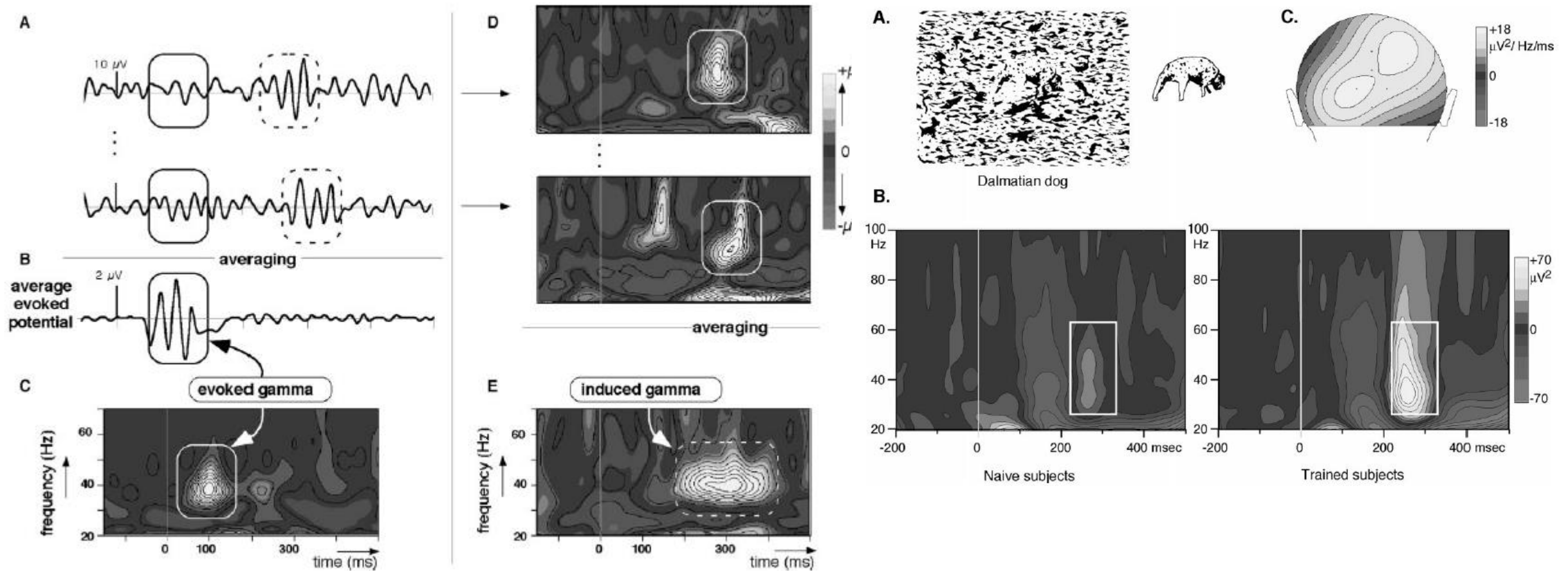


(b) Gamma activity (24-60 Hz); $\pm 15 \mu\text{V}^2/\text{Hz}/\text{ms}$



(c) Alpha activity (8-12 Hz); $\pm 1200 \mu\text{V}^2/\text{Hz}/\text{ms}$





- Gamma activity is assumed to reflect an integration mechanisms of the brain

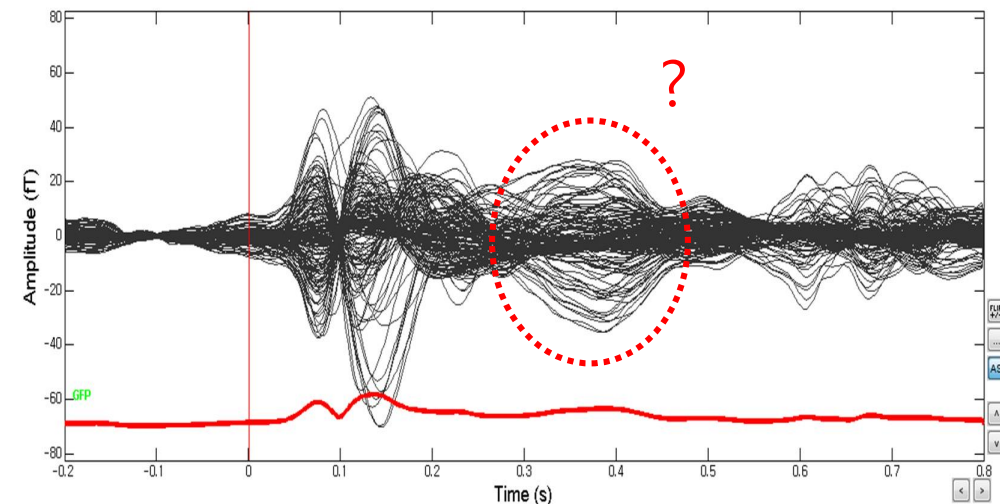
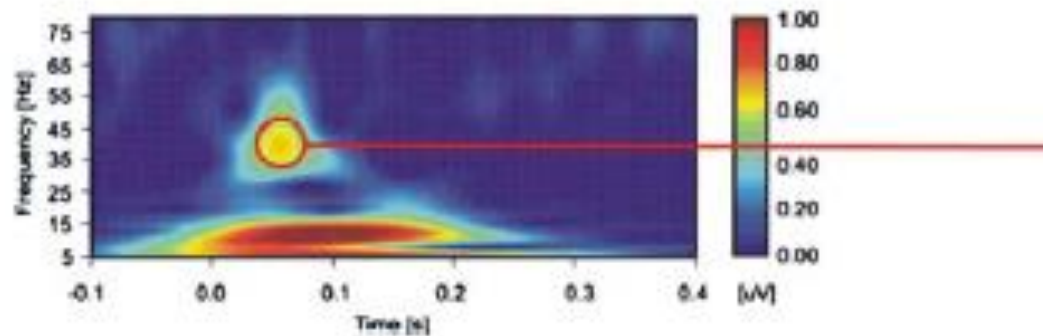
Herrmann et al., 2004

- While gamma activity is generated through the interaction of the **glutamatergic pyramidal cells** and **GABAergic interneurons**, **dopamine** can modulate the gamma activity significantly. Ex.

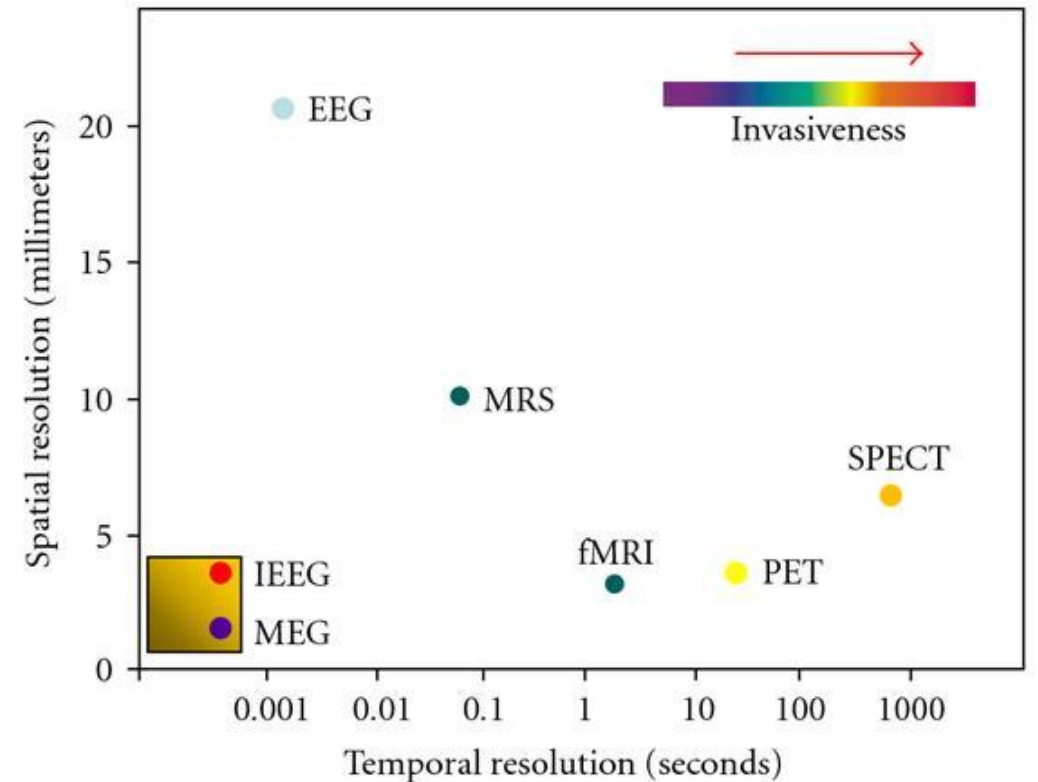
Traub et al., 1999, Schu ¨tt and Basar 1992, Ma and Leung, 2000

- *For evoked activity*, single epochs are first averaged and the ERP is then transformed into the time–frequency plane.
- *For induced activity*, single epochs are first transformed into the time– frequency plane and then the magnitudes of the transform are averaged to cancel out the phase differences among the single trials.
- Evoked activity is often limited to a specific region of the brain, e.g. primary sensory cortices, while **induced activity** is more **widespread**. Therefore, it is helpful to view evoked gamma activity in single sensors or averages over few sensors, while induced activity is often visible in averages over many sensors.

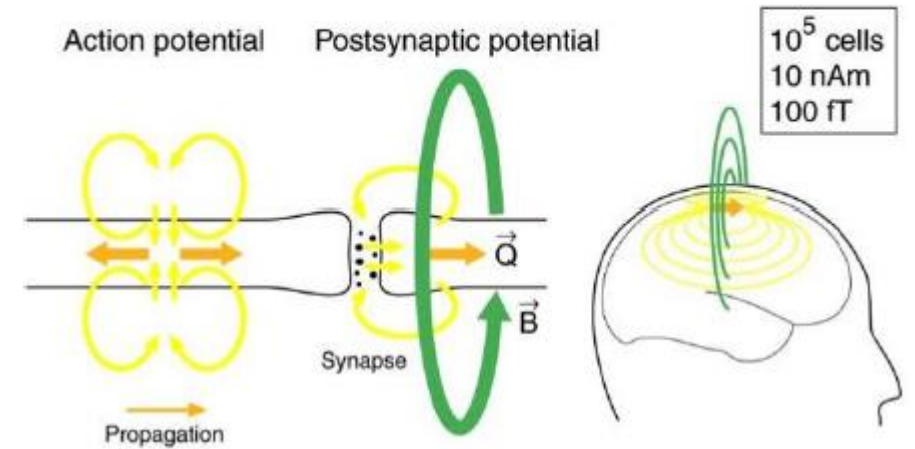
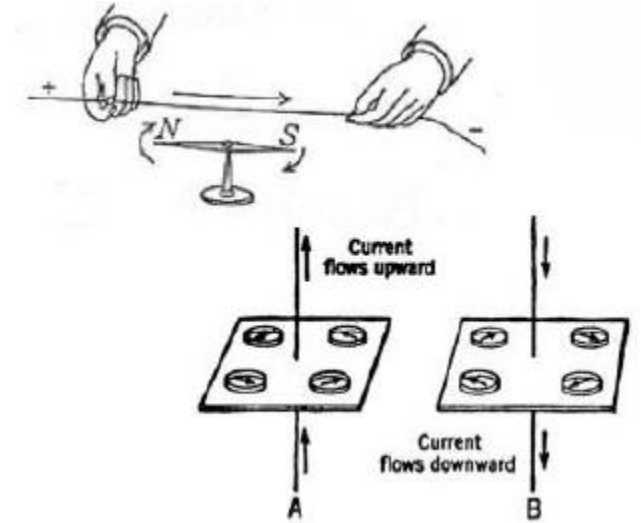
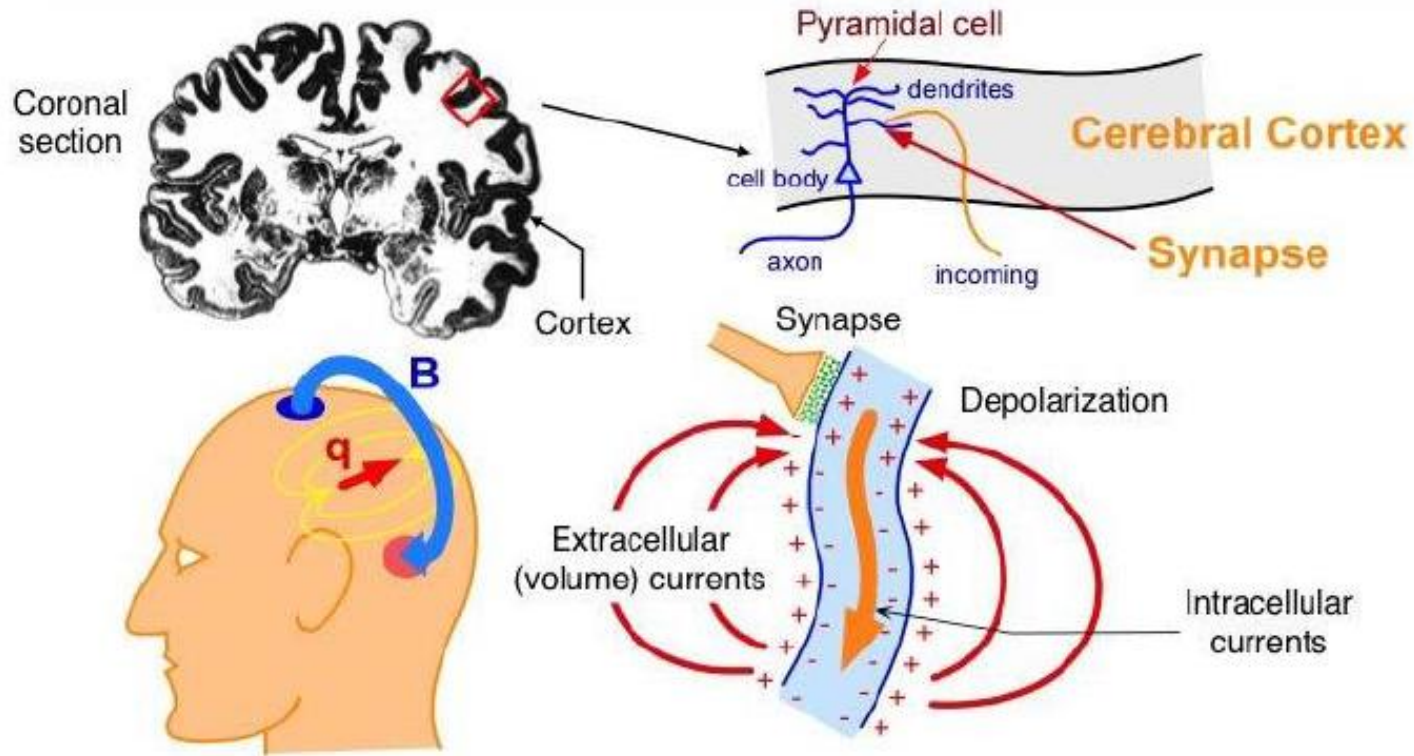
- A second type of event-related oscillations that are termed **‘induced’ responses** show an amplitude increase **in single trials**, however, **do not occur** with a constant phase lag after the triggering event.
- Therefore, **they are not observable in the averaged response**, in case many trials have been averaged.
- However, they can be quantified by **transforming the single trials into the frequency domain first**, and then averaging the transformed data after removing the phase information.
- Due to their different temporal dynamics, both types of event related oscillations may correspond to different functions, although their generation might depend on the same or similar circuits.



Magnetoencephalography (MEG)



Origin of the Magnetic field

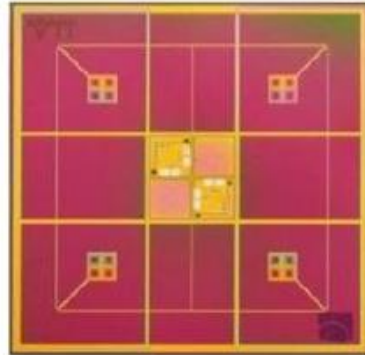


Electromagnetism: electric current always generates a magnetic field

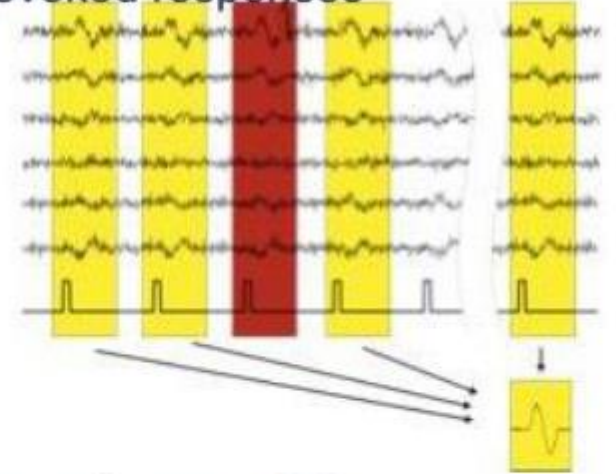
SQUID Sensor



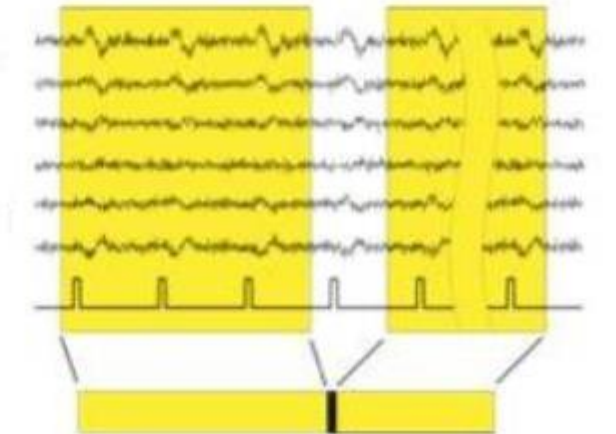
- Superconducting quantum interference device(SQUID): recording extremely small neuronal activity(10^{-15}T)



- evoked responses



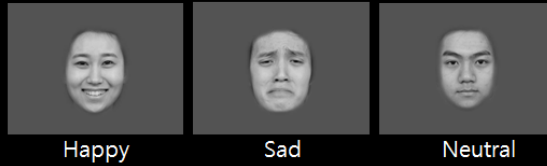
- spontaneous data



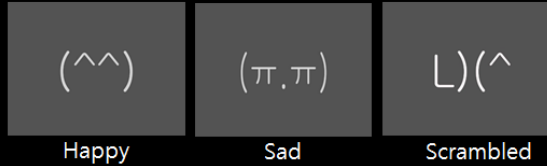
Data

Methods: Stimuli and paradigm

Korean Facial Expressions of Emotion(KOFEE) 2014

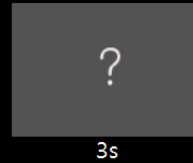


Text-based Emoticons

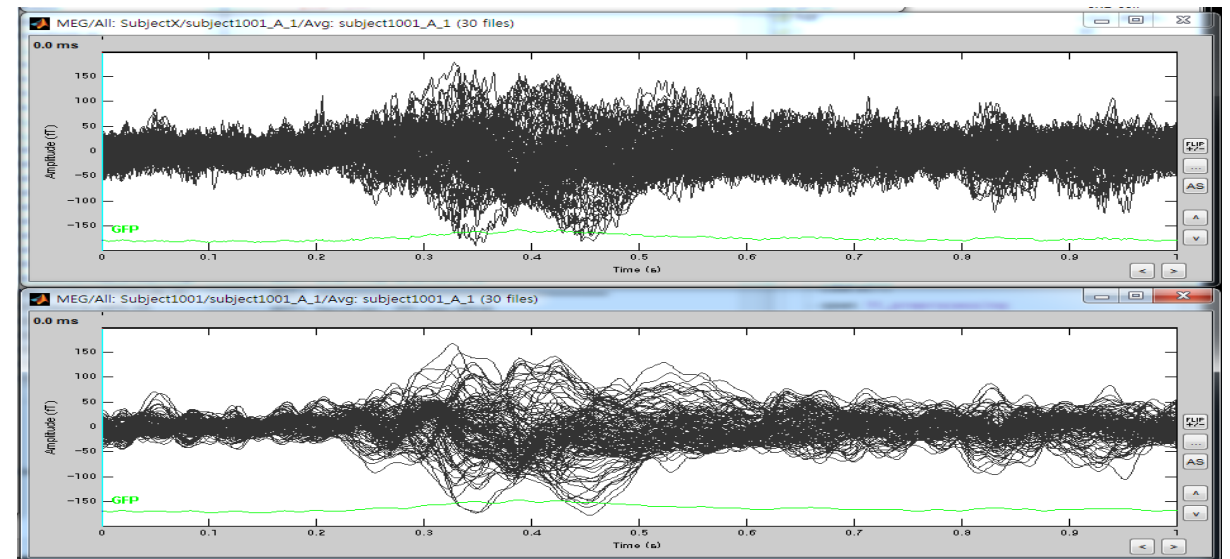
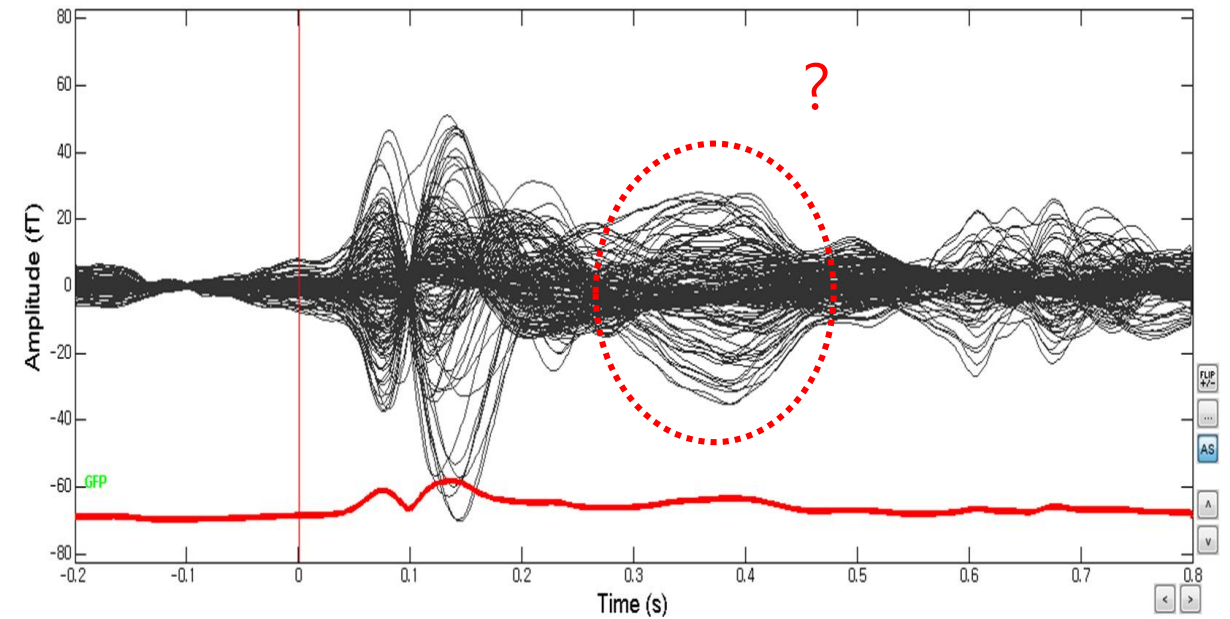


| | Stimulus | ISI |
|------|----------|-----------|
| fMRI | 1s | Jittering |
| MEG | 0.5s | 1s |

Random response trial



- 40 subjects (F:M=19:21)
- Age = 24.0 ± 3.3



Data processing

Matlab

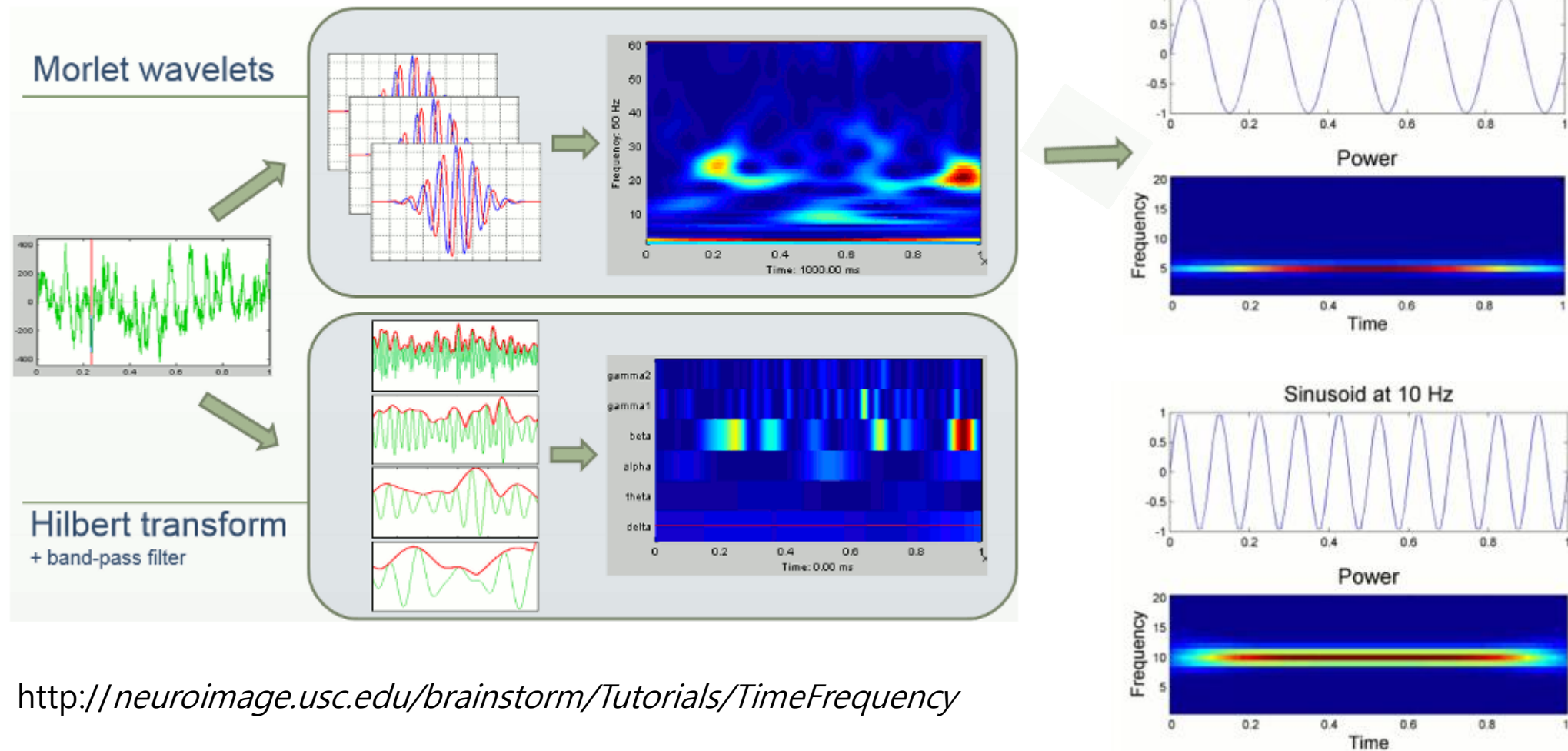
- Preprocessing of example dataset
Header, bandpass filtering, define & redefine trial
- Epoching
Define & redefine trial
- Trial select rejection: remove artifact trial
- ICA
- Visualize results
- Remove the bad components
- Trial filtering and redefine trials

Matlab > Brainstorm3

- Source
Head model -> KRISS and overlapping spheres
Noise covariance
Compute source -> wMNE
Scout time series
- Frequency map
Destrieux method -> ROI (ant.insular, OC-temp-lat-fusiform)
Molet wave method
Average
- Normalization
Zscore or ERSD

Preprocessing - Time-frequency analysis

Computing time-frequency decomposition (TF)



<http://neuroimage.usc.edu/brainstorm/Tutorials/TimeFrequency>

Statistics

- Non-parametric t-test on time-frequency maps
 - Multiple comparison (cluster correction, alpha 0.05)
 - Monte-carlo randomizations (10000)
 - Two tailed, paired t-test