Spatio-temporal characteristics of somatosensory-evoked 50-70 Hz high-gamma activity of the EEG

Laura Levike Kahle[1,2,3], Lukas Dominique Josef Fiederer *,[1,2,3,4,5], Simon Contzen *,[3], Martin Voelker[1,2,3,6], Tonio Ball[1,2,3,5]

[1] Epilepsiy Center,University Medical Center, Albert-Ludwigs-University, Freiburg, Germany | [2] Excellence Cluster 'Brain Links-Brain Tools', Albert-Ludwigs-University, Freiburg, Germany | [3] Translational Neurotechnology Lab, Albert-Ludwigs-University, Freiburg, Germany | [4] Faculty of Biology, Albert-Ludwigs-University, Freiburg, Germany | [5] Bernstein Center Freiburg, Albert-Ludwigs-University, Freiburg, Germany | [6] Faculty of Engineering, Albert-Ludwigs-University, Freiburg, Germany | *These authors contributed equally to this project.

Objective

❖ Cortical gamma activity is associated with
- movement tasks
- different sensory modalities (visual, auditory, somatosensory)
- higher cognitive functions (memory, attention, learning)

❖ Reports of robust 50-70 Hz high-gamma band (HGB) activity during somatosensory median nerve stimulation exist for intracranial electroencephalography (EEG) recordings but not for the noninvasive EEG.

Open question

Can robust HGB activity in the noninvasive EEG be identified during somatosensory median nerve stimulation?
- Reproducibility
- Influence of ocular movements on the neuronal data
- Spatio-temporal characteristics of the responses
- Evoked or induced content of the neuronal response

Methods

❖ **Experiment**
- EEG recordings of 15 subjects
- 1200 left median nerve stimulations per subject
- Stimulus: 500-µs square-wave pulse , motor threshold (mt) + max. 100 % of mt

❖ **Purpose-built EEG set-up to measure HGB activity**
- Electromagnetically shielded cabin
- 128-Ag/AgCl-channels high density EEG
- High-resolution (24 bits/sample), high sampling (5 kHz) low-noise amplifiers
- Binocular eye tracking

❖ **Data Processing**
- Butterworth 1 Hz High Pass Filter
- Common average Re-referencing
- Short-time Fourier Transformation (STFT) (Blackman-Harris window 100 ms, time step 10 ms)
- Rejection of artifact-contaminated trials, channels, subjects (5)

❖ **Phase-locked evoked Respone**
- STFT of the trial average

❖ **Random-phase induced Respone**
- first step: subtracting the trial-averaged EEG signal from the signal of each single trial, second step: STFT

❖ **Significance Test**
- FDR-corrected sign test (p(EEG)<0.01, p(eye-tracking) <0.05)

Results

❖ Somatosensory-evoked HGB activity in the EEG

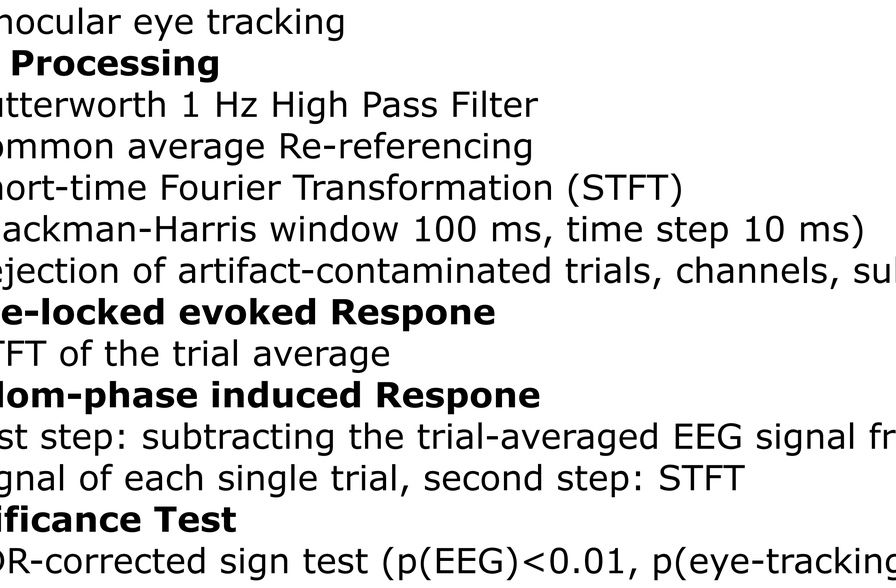

Fig.2-Topography of HGB activity, single subject

❖ Highly reproducible significant somatosensory-evoked 50-70 Hz high-gamma responses across subjects

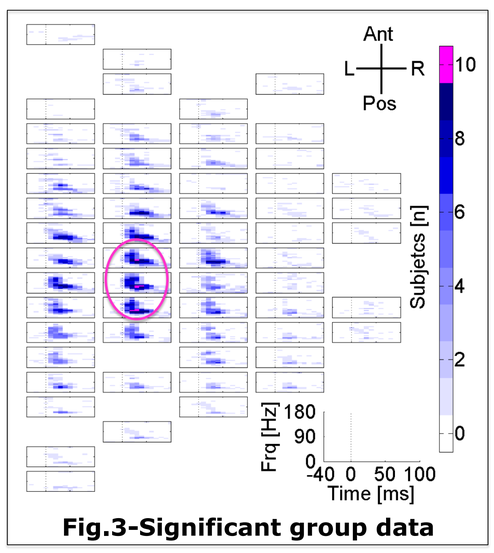

Fig.3-Significant group data

- Significance power changes of the single subjects
- FDR-corrected sign test (p<0.01)

- **Significant power increase in all analyzed subjects** at electrodes
  CCP4h (70 Hz)
  CP4 (50-60 Hz)
  CPP4h (60-70 Hz)

❖ Influence of ocular movements on the neuronal data

- Microsaccades' quantity decreases after onset to approx. 140 ms
- Statistical significance at the time bins of 70, 80 and 90 ms
- mean value from all trials of each single subject, sign test (p<0.05)

→ **HGB activity is not caused by occular artifacts**

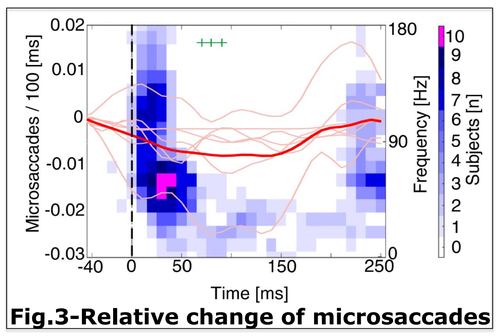

Fig.3-Relative change of microsaccades

❖ Spatio-temporal characteristics of the responses

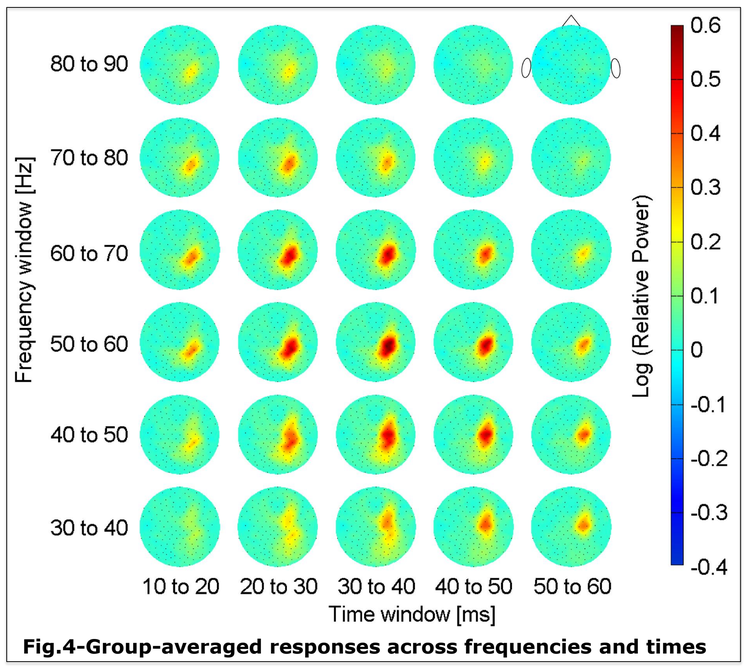

Fig.4-Group-averaged responses across frequencies and times

- **Early high-frequent activity** at contralateral, centro-parietal and parietal electrodes (10-20 ms, 40-90 Hz)
- **late low-frequent activity** at contralateral frontal electrodes (20-60 ms, 30-50 Hz)
- **most pronounced effects** at
  CCP4h
  CP4
  C4 (30-40 ms, 50-70 Hz)

❖ Evoked or induced content of the neuronal response

- 2 contents of the HGB activity during SEP-stimulation
- **high-power phase-locked response** (50-70 Hz, 30-60 ms, CP4, CCP4h and CPP4h)
- **low-power non-phase-locked response** (similar overall time-frequency pattern)

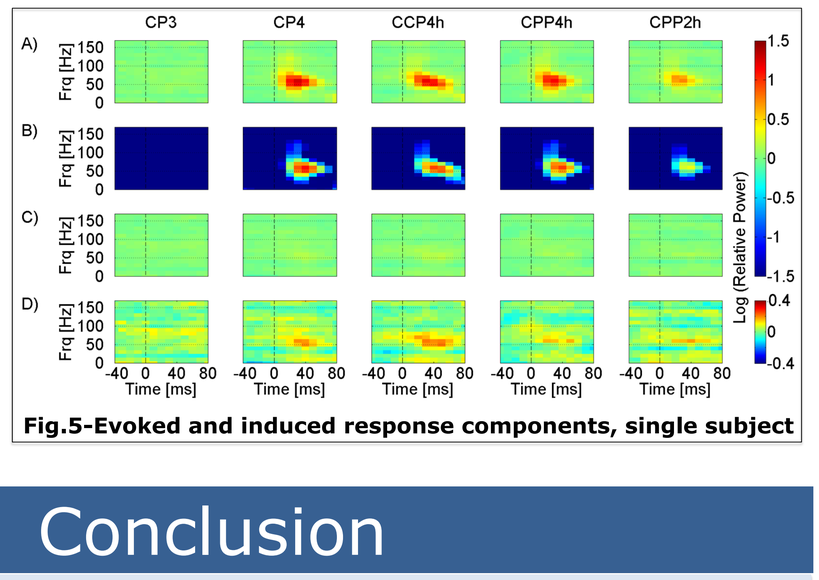

Fig.5-Evoked and induced response components, single subject

Conclusion

In agreement with previous intracranial SEP studies, we show that median nerve stimulation is a well suited method to elicit robust 50-70 Hz HGB activity also in noninvasive EEG.

Contact
Laura Levike Kahle, laura.kahle@uniklinik-freiburg.de
iEEG and Brain Imaging Group, *https://www.ieeg.uni-freiburg.de/*
University Medical Center Freiburg, Engelbergerstr. 21, 79106 Freiburg, Germany

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