UNIVERSITÄT LEIPZIG

Faculty of Life Sciences
Experimental Psychology and Methods

Dynamics of neural oscillations and early sensory processing during voluntary finger tapping

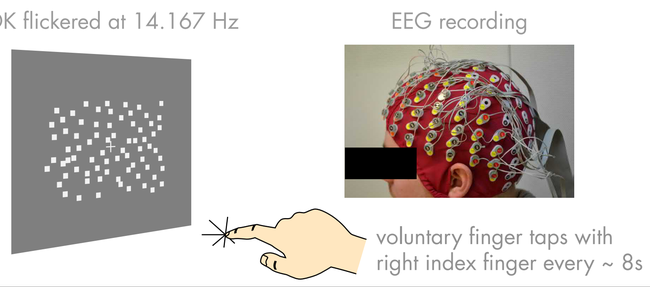
C. Gundlach & M. Müller

Introduction

Perception plays a crucial role in adaptive behavior. Perceived environmental information underlie motivated behavior and simultaneously function as feedback for the evaluation and adaptation of motor processes during the interaction with the environment. How exactly perception and motor function interact is not yet completely understood and in the scope of current research.
Earlier work from Makeig et al. (1996) revealed, that simple, voluntary finger tapping movements were accompanied by a modulation of neural signals of non-task relevant auditory stimuli measured in the EEG. In the current study we examined whether voluntary finger tapping is also accompanied by a modulation of visual processing.

Methods

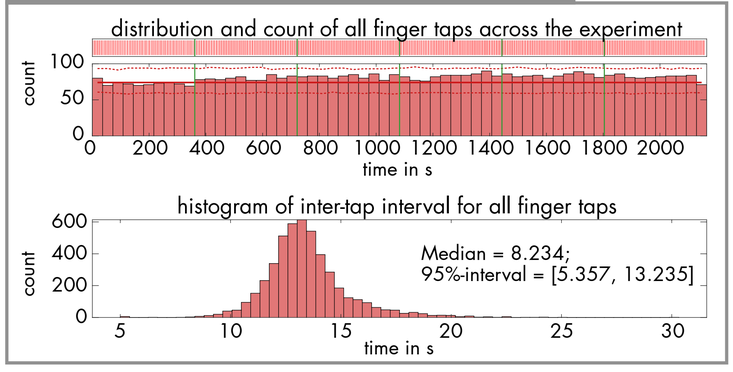
Fig 1 Experimental Procedure



Participants
19 subjects (12 female, Age: $M = 26.11$, $Std = 6.70$)

Task
- 6 blocks of voluntary finger tapping, self paced every ~ 8 s (Fig 2)
- block length = 6 min
- presentation of task irrelevant flickering Random Dot Kinematogram (RDK) (on/off flicker at 14.167 Hz) on CRT screen
- recording of EEG and keyboard presses (see Fig 1)

Fig 2 Distribution of Finger Taps



Analysis
- analysis of current source density (CSD) transformed EEG data in a time window ± 3.5 s around each finger tap
- epochs with blinks were discarded (total trials: $M_{trials} = 146.11$; $Std_{trials} = 49.90$)

Analysis of dynamics of different signals around finger taps in relation to pre-movement baseline [-3250 -3000] ms:

1. **Steady-State-Visual-Evoked-Potentials (SSVEP)** (Regan, 1989)
   - index of early visual stimulus processing of flickering RDK
   - signals extracted from single spatial component (SNR optimized by rhythmic entrainment source separation, RESS: Cohen & Gulbinaite, 2016)
   - extraction of amplitude timecourse via Gabor-filter (filter bandwidth: $FWHM_{frequency}$: ±1 Hz; $FWHM_{time}$: ±220.636 ms)
2. **visual alpha-oscillations**
   - marker of visual excitability/processing
   - timecourse extracted via Gabor-filter-based transformation (as above) of signals from parietal and occipital EEG electrode cluster
3. **somatomotor alpha- and beta-oscillations**
   - as marker of (somato-) motor activity
   - timecourse extracted via Gabor-filter-based transformation of signals from left somato-motor EEG electrodes

Results

Amplitude dynamics of neural visual and somatomotor activity around voluntary finger taps were analyzed.
- extensive amplitude decreases before, followed by extensive increases after finger taps for somatomotor neural activity in the **alpha-band (10 to 14 Hz)** and **beta-band (18 to 30 Hz)** (Fig 3, 7, 8)
- no modulation of **early visual stimulus processing (SSVEPs)** (Fig 6, 7)
- Visual activity in the **alpha band (8 to 12 Hz)** as well as parietal **beta band (15 to 23 Hz)** activity increased prior to finger taps (Fig 4, 5, 7, 8)

Fig 3 Somatomotor Dynamics

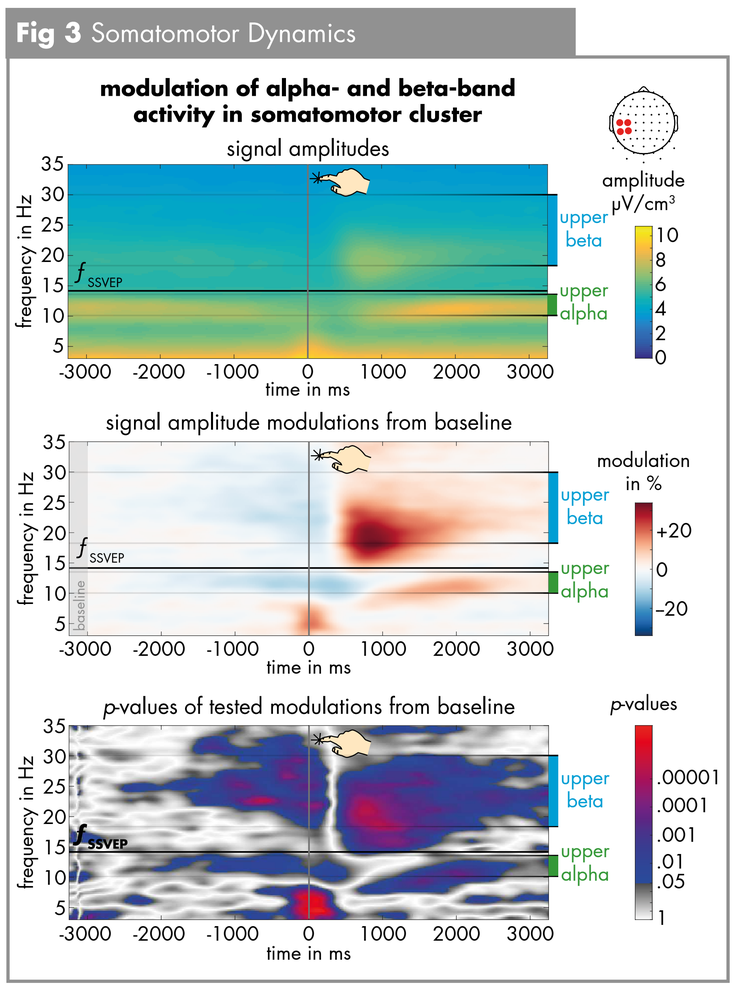


Fig 4 Occipito-Temporal Dynamics

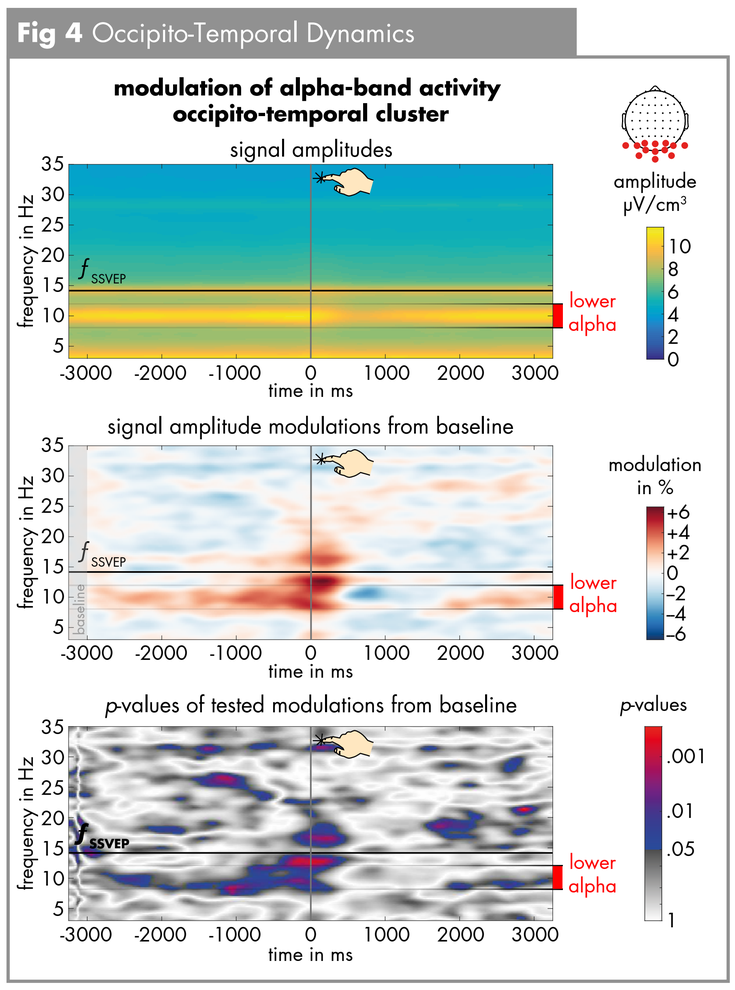


Fig 5 Parietal Dynamics

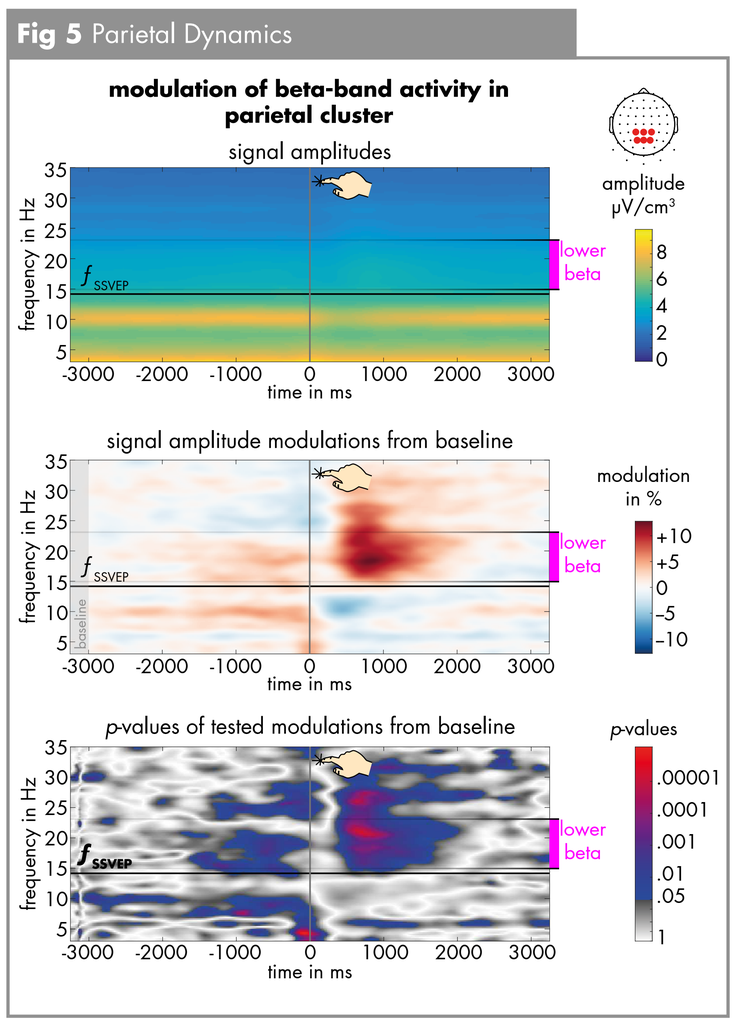


Fig 6 Dynamics of Early Visual Processing

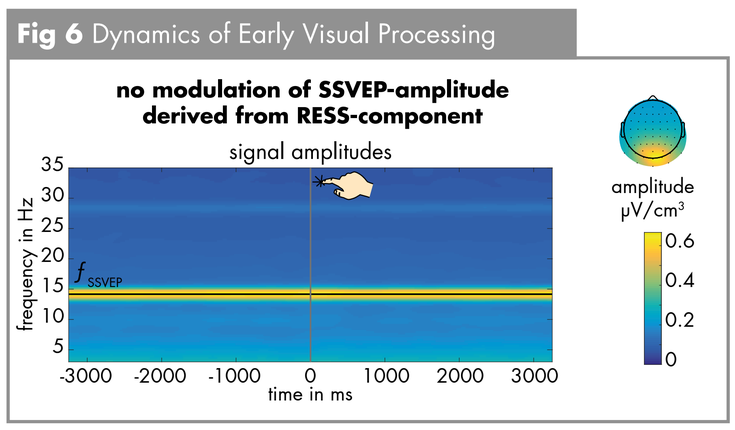
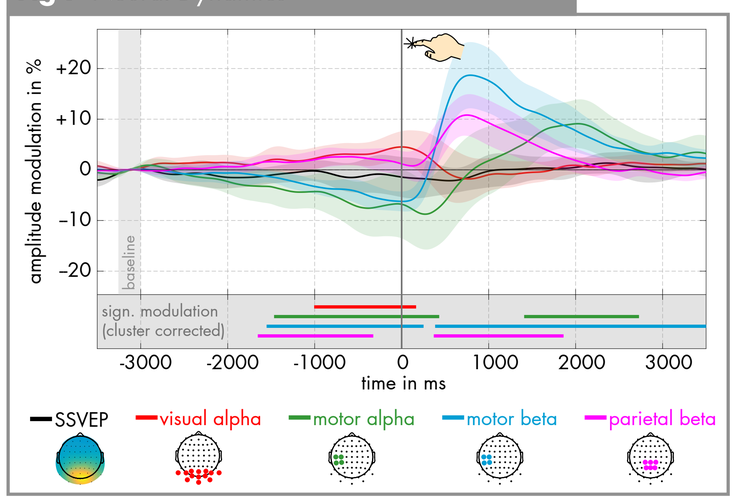
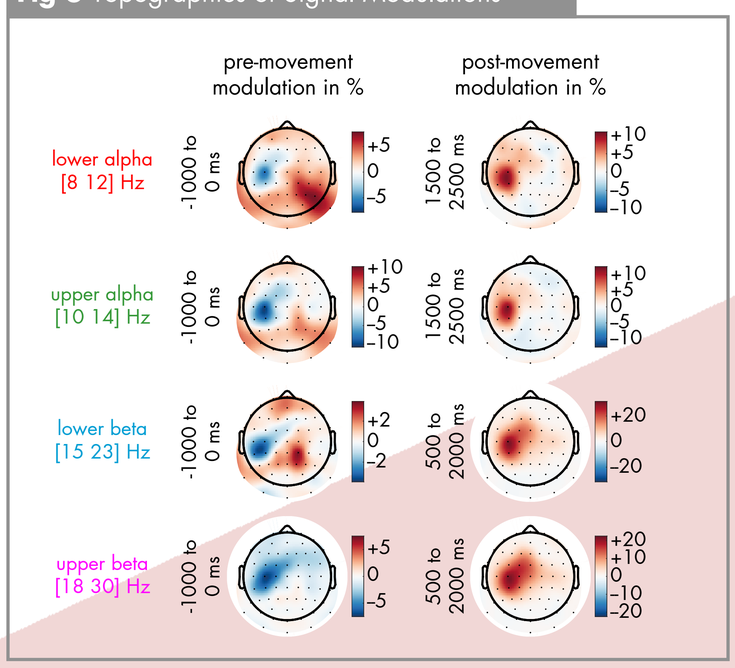


Fig 7 Neural Dynamics



Colored shading represents 95%-CI of pointwise *t*-test against baseline (shaded in grey) for each signal; Thick lines represent timepoints for which a significant modulation from baseline was found (cluster corrected); Note: no modulation of SSVEP-amplitude; Gray vertical shading represents baseline window

Fig 8 Topographies of Signal Modulations



Discussion and Summary

We found modulation of somatomotor-related activity in the alpha- and beta-band around voluntary finger movements. These modulations are in line with known motor patterns (Pfurtscheller et al., 1997) with decreases in amplitude preceding and increases in amplitude succeding single voluntary, self paced taps of the right index finger. These movement related dynamics are mirrored by increases in amplitude of visual alpha-band and parietal beta-beta band activity preceding the actual finger tap. However SSVEPs, as a neural marker of continous representation of visually presented stimuli, were not modulated. Interestingly increased alpha oscillations, which are seen as an inhibitory mechanism of neural information processing (Jensen & Mazaheri, 2010) do not affect early visual processing here.
While behavior affects visual information processing, as seen in modulated visual alpha- and beta-band activity, it seems not to affect early neural stimulus processing. It therefore remains open at which processing level motor related modulations of visual activity may be of relevance for visual processing, whether they may be behavioral relevant at all and why this may be different for the auditory system.

References

Cohen, M. X., & Gulbinaite, R. (2016). Rhythmic entrainment source separation: Optimizing analyses of neural responses to rhythmic sensory stimulation. NeuroImage, 147, 43–56. https://doi.org/10.1016/j.neuroimage.2016.11.036

Jensen, O., & Mazaheri, A. (2010). Shaping functional architecture by oscillatory alpha activity: gating by inhibition. Frontiers in Human Neuroscience, 5, 12. https://doi.org/10.3389/fnhum.2010.00186

Makeig, S., Müller, M. M., & Rockstroh, B. (1996). Effects of voluntary movements on early auditory brain responses. Experimental Brain Research. Experimentelle Hirnforschung. Experimentation Cerebrale, 110(3), 487–492. https://doi.org/10.1007/BF00229149

Pfurtscheller, G., Neuper, C., Andrew, C., & Edlinger, G. (1997). Foot and hand area mu rhythms. International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology, 26(1-3), 121–135. https://doi.org/10.1016/s0167-8760(97)00760-5

Regan, D. (1989). Human brain electrophysiology: evoked potentials and evoked magnetic fields in science and medicine. New York: Elsevier.

Dr. Christopher Gundlach

Experimental Psychology and Methods
Faculty of Life Sciences
Universität Leipzig
Neumarkt 9-19 | 04105 Leipzig

christopher.gundlach@uni-leipzig.de