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Live Talk for BCI Seminar

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The research paper: Visual evoked responses are enhanced when engaging in a video game

Why this research is important

The feedforward visual processing of the brain has been the subject of many studies before, however the potential influences of „downstream“ regions on visual processing are relatively unexplored. In the context of BCIs this is an important field of research to make them more robust.

What we know and don‘t know

- It is commonly agreed on that the visual processing of information is used in guidance of action
- Multiple sources of evidence suggest that the motor system also exerts influence over visual processing. However this effect by itself has never been studied.

The experiment

The study was designed to engage the motor cortex while avoiding somatosensory or motor evoked potentials measuring the visual evoked responses to presented stimuli under different conditions of motor cortex activation.

Hypothesis

It was hypothesized that the presence of a motor task acutely modulates visual processing. Specifically that visual evoked responses are enhanced when accompanying engagement of the motor cortex.

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Design and Methods

Design

Study population

- Inital study: 18 healthy human subjects aged 20 +/- 1.56 years
- Follow-up: new cohort of 24 healthy subjects aged 20+/- 3.01 years

Video game stimulus

- Open-source car racing game, with stripped down visuals
- Nonparticiant played 4 races, which were recorded and later used as stimuli

Setup

- 60 Hz Monitor in a dark room
- Game sound muted

Conditions

- Active play
- „Sham“ play (deceive participants into thinking that they controlled the car by left and right hand motor imagery)
- Passive viewing of recording
- Viewing of recording + counting task (follow-up study)

Survey

- Upon completion
- Self-reported „engagement“ during the task
- Afterwards participants were asked if they were aware of the deception during game play

Data Acquisition & Feature Extraction

Sham play protocol

- Mock calibration of a BCI
- Modified set of instructions

EEG acquisition

- 96 electrode cap (dense coverage of occipital region)
- Sampling rate of 500 Hz

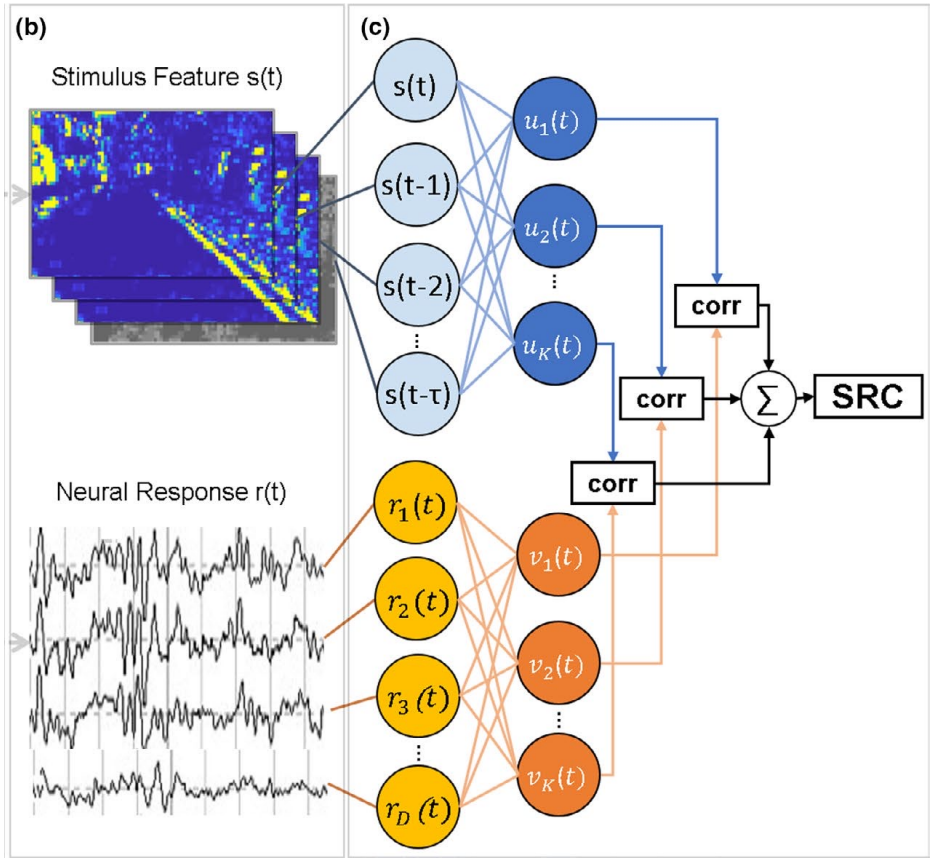
EEG preprocessing

- Downsampled to 30 Hz (Nyquist rate)
- 1 Hz high-pass filtering
- Robust PCA to remove gross artifacts
- Reduction of eye movement artifacts by linearly regressing out four virtual electrodes
- Further steps rejecting outliers

Stimulus feature extraction

- Video frames downsampled to 320x180 pixels
- Converted to grayscale images
- Optical flow computed by Horn-Schunck method

Calculation of the SRC



Further Analysis

Alpha Power Analysis

- Similar to the lecture

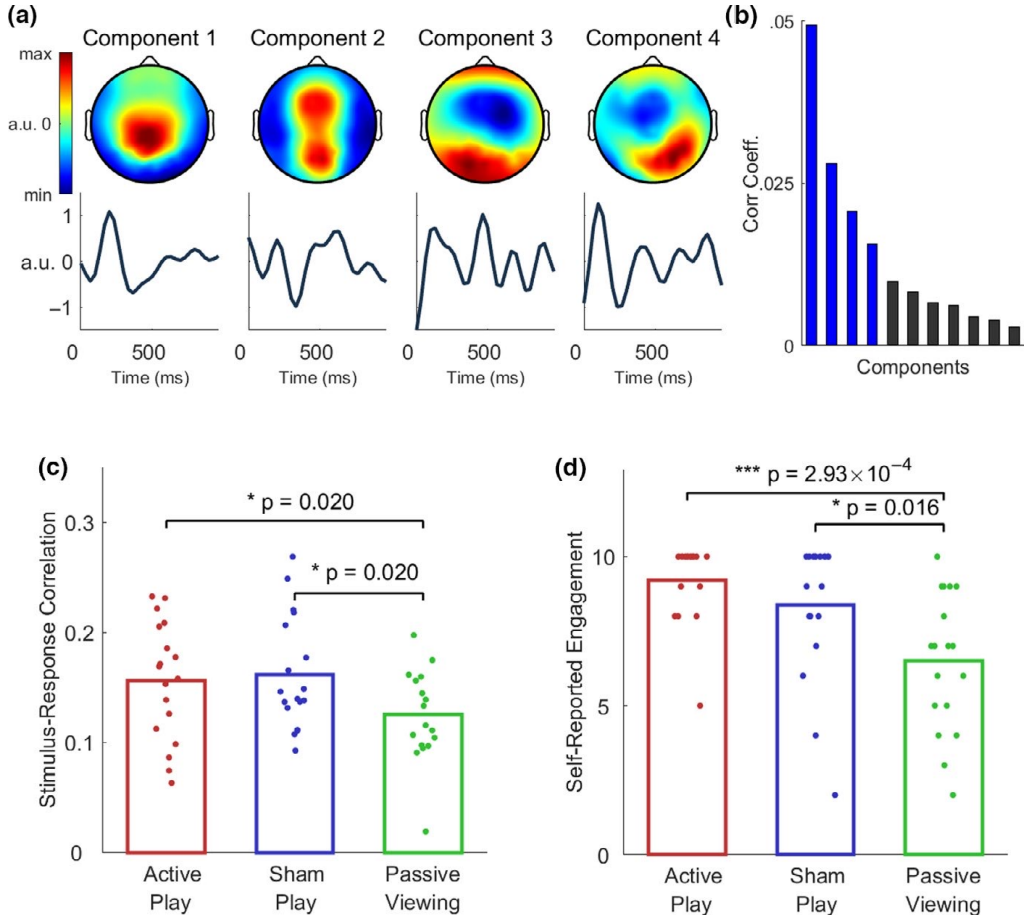
Comparing spatial and temporal responses across conditions

- Seperately compute response function for all conditions
- Comparing the strongest components of the spatial and temporal response functions respectively
- Test for statistical significance

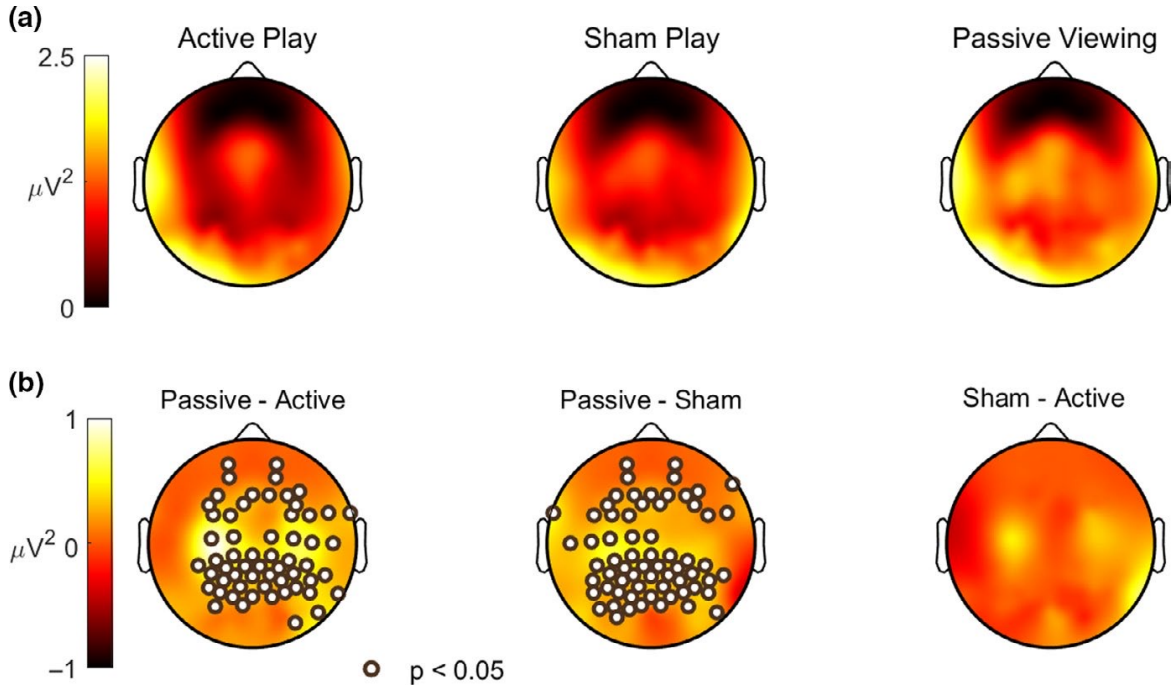
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Results

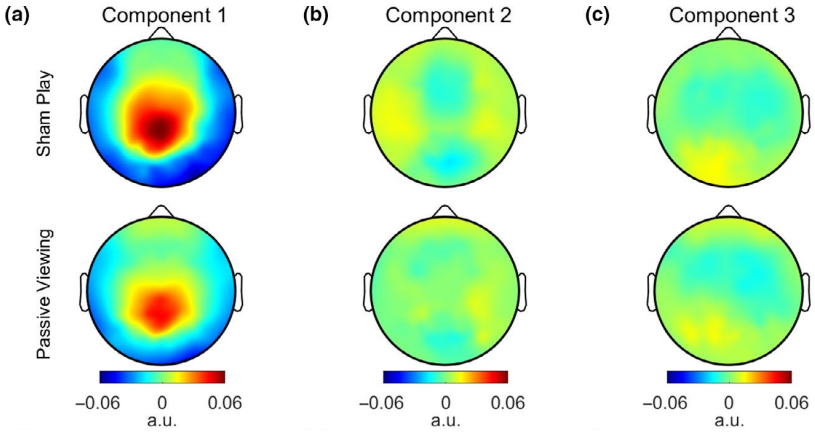
Enhanced stimulus-response correlation during active and sham play

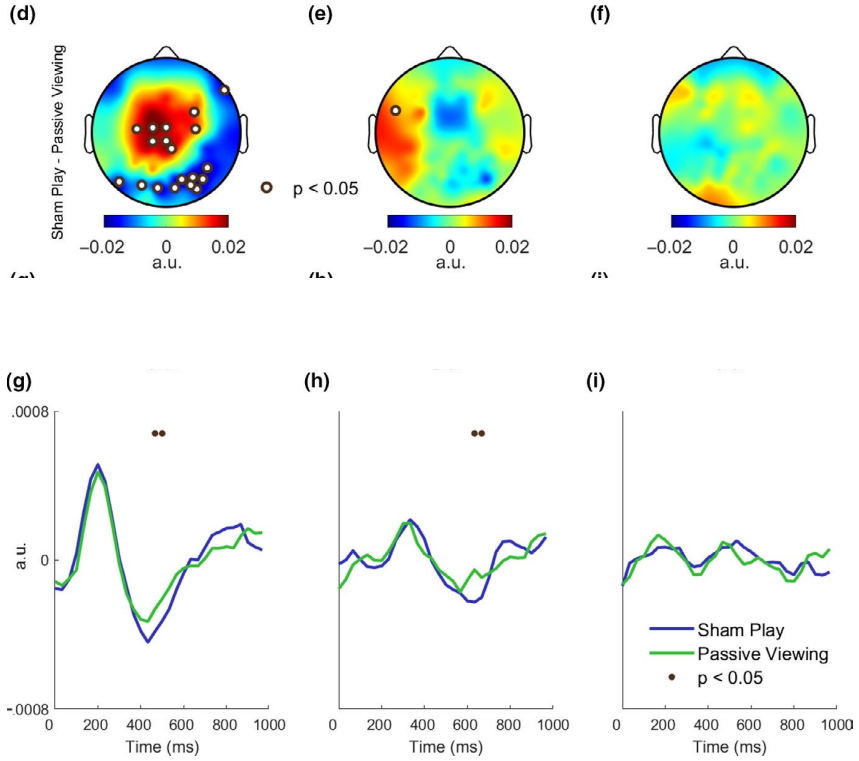


Alpha desynchronization over motor cortex indicates motor engagement during sham play

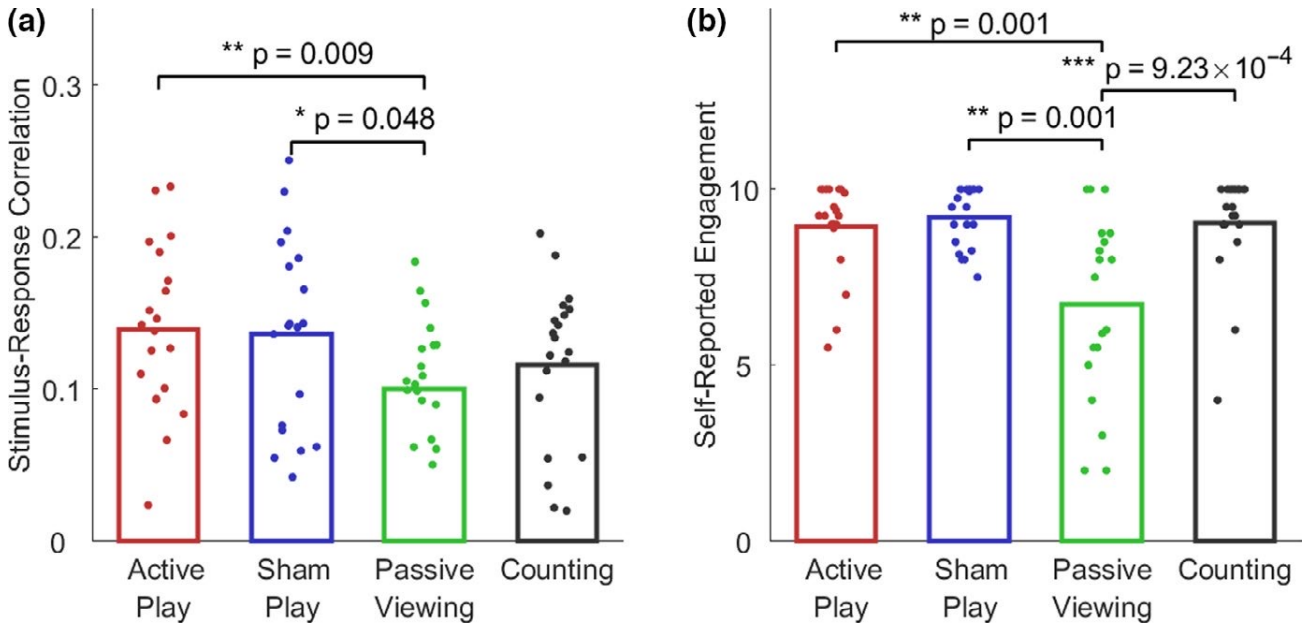


Sham play elicits stronger late evoked responses over parietal cortex

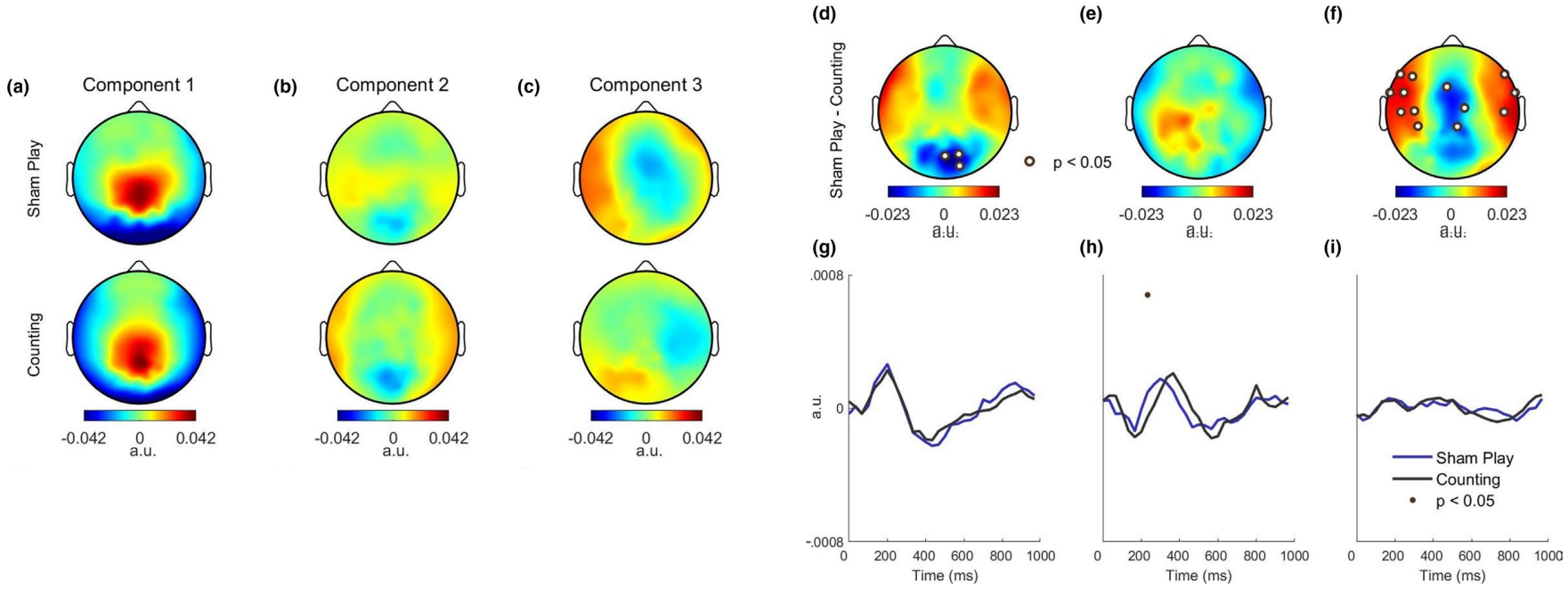




No SRC difference between counting task and passive viewing



Sham play elicits stronger late evoked responses over parietal cortex



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Discussion

Conclusion

- Indeed sham play enhanced visual responses over passive viewing, but counting did not
  - However, difference between sham play and counting fell short of significance
  - It can‘t be fully ruled out that heightened attention contributed to the visual responses during sham play

- Main limitation of the study was the disability to fully disentangle the effects of engaged motor system from increased top-down attention

- Difficulty in deceiving subjects throughout the longer experiments (Due to addition of fourth condition) likely contributed to this
  - Only 6 of 20 participants were fully deceived, these six did not report a significantly higher engagement during sham play

Despite this there were still significant increases in the amplitudes of the spatial and temporal responses measured during sham play relative to counting!

Next steps

- Due to the difficulties in recovering cortical sources from EEG, especially when averaging over multiple subjects as implicitly done in this study, a natural extension of this work is to replicate the experiment with fMRI
  - Gain insight into the brain areas driving the enhancement of visual evoked responses
  - Poor temporal resolution may affect the ability to measure the fast evoked responses to the dynamic stimulus though
  - Possibly infeasible

- Further extension of the work can also be done regarding the SRC
  - SRC was measured here at a scale of 3-min trials - can also be computed in finer time intervals and tracked continuously
  - SRC represents natural technique for gleaning information about brain states in real time
  - Maybe possible to decode spatial attention by computing the SRC seperately for multiple areas of the visual field or directions of incoming sounds

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Thank you for your attention!