Can alpha oscillations in the brain protect speech signals against interfering distractors?

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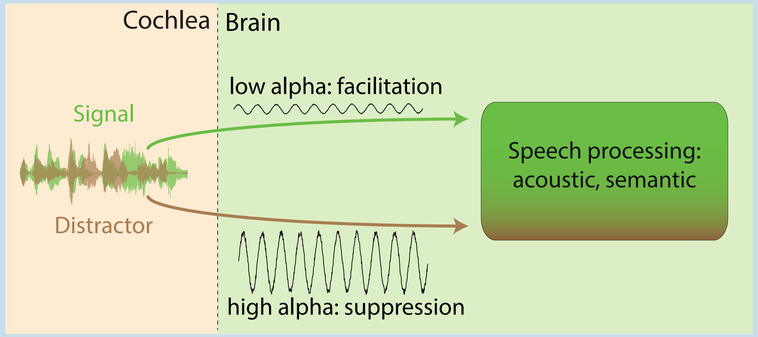
Introduction

- Listening to one talker in the presence of interfering speech- and non-speech noise is demanding and error-prone.
- During the last years, a number of brain imaging studies revealed that brain oscillations at **alpha** (~ 10 Hz) frequency might **inhibit brain areas processing task-irrelevant or distracting materials** [1–4].
- We presume that alpha activity also plays an important role for speech processing in noisy environments:
  - **High alpha** activity in brain regions associated with distractor processing could suppress the distractor from interfering with the signal on later processing stages.
  - **Low alpha** activity in brain regions associated with signal processing could facilitate speech processing.
- We have investigated whether alpha activity is enhanced when acoustic distractor interference increases (Experiment I) and will investigate whether alpha activity might serve a functional role in auditory distractor suppression (Experiment II, preliminary data).

Hypothetical distractor suppression by alpha oscillations



Methods

Experiment I

- **Auditory number comparison**: 38 participants listened to two spoken numbers (S1, S2) while ignoring a distracting talker.
- **Task**: Indicate whether second number was smaller or larger than first.
- **Acoustic degradation**: Materials were divided in 16 channels between 0.08 and 10 kHz. Signals in higher channels were **tone-vocoded** to degrade **spectral detail** (temporal fine structure, TFS) while lower channels were left intact [5].
- **Distractor interference** was intended to increase with the number of channels with degraded TFS.
- **Material adjustments**: Absolute intensities were adjusted to hearing thresholds (CAMEQ, [6]); relative intensity of numbers was adjusted to equalise accuracy for materials without TFS to ~71 %.

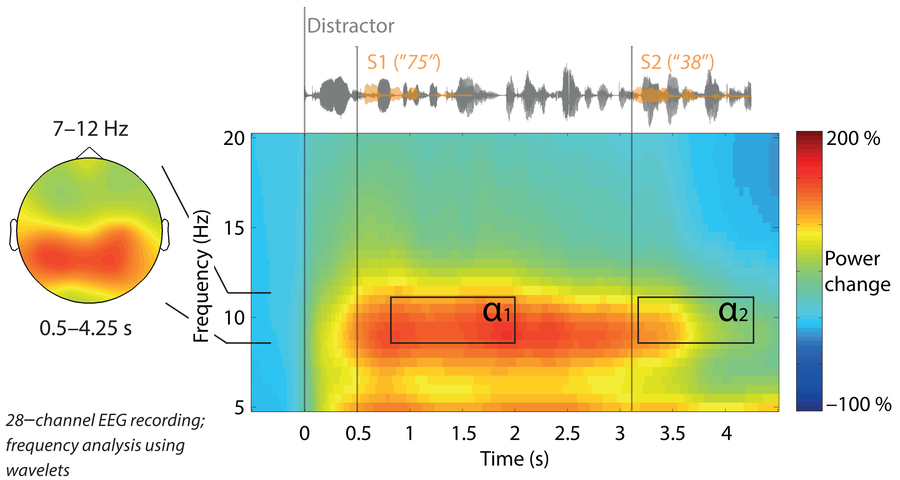
Experiment II

- **Dichotic listening** [7]: Six participants listened to four spoken numbers on one ear while ignoring four simultaneously presented numbers on the other ear (presentation rate: 0.67 Hz; broadband background noise, SNR: 5 dB).
- **Cueing:** To-be-attended ear was cued with 1 kHz tone.
- **Task:** Select numbers from the attended ear in a subsequently presented array of probes.
- **Response types**: **Target**: select number from to-be-attended ear; **Distractor**: select number from to-be-ignored ear; **"False alarm"**: select number not presented on either ear.

Results

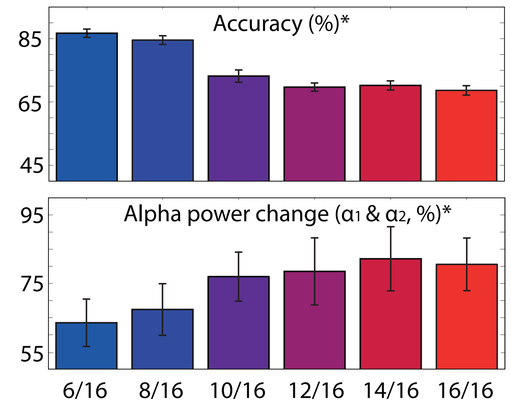
Experiment I

Time–Frequency representation during auditory distractor interference



28–channel EEG recording; frequency analysis using wavelets

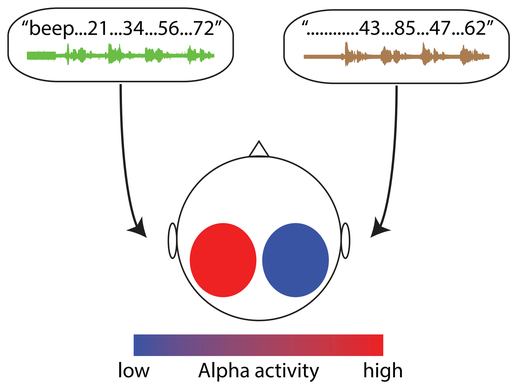
Effects of acoustic degradation



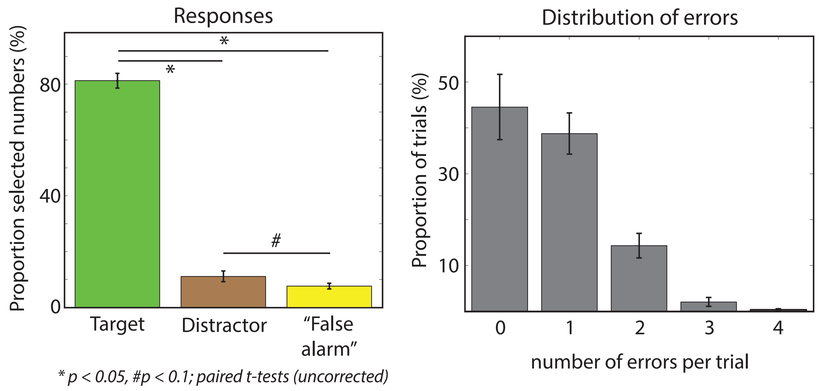
** $p < 0.05$; linear change with TFS degradation*

Experiment II (preliminary data)

Dichotic listening paradigm and hypothetical alpha lateralization



Behavioral Results



** $p < 0.05$, #$p < 0.1$; paired t-tests (uncorrected)*

Discussion

Experiment I

- A strong increase of parietal alpha activity during auditory number comparison suggests an important role of alpha oscillations for speech processing in complex noise.
- Alpha activity increased stronger during the encoding of the to-be-attended numbers (during α1 & α2) when distractor interference (TFS degradation) was more severe.
- Findings support the hypothesis that alpha oscillations inhibit processing of interfering distractors to facilitate processing of task-relevant signals (here: numbers).

Experiment II

- Approx. 80 % of selected numbers were targets, showing that participants were well able to selectively listen to and recall numbers from the to-be-attended ear.
- Participants' tendency to select distractors rather than to make "false alarms" ($p = 0.085$) demonstrates the vulnerability of the signal on the attended ear for distractor interference.
- In almost half of the trials (~ 45 %) participants performed without errors, while (mostly one or two) errors were committed in the remaining trials, presumably due to an insufficient protection of targets via alpha oscillations.

References

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