Behavioural and neural consequences of closed eyes during attentive listening

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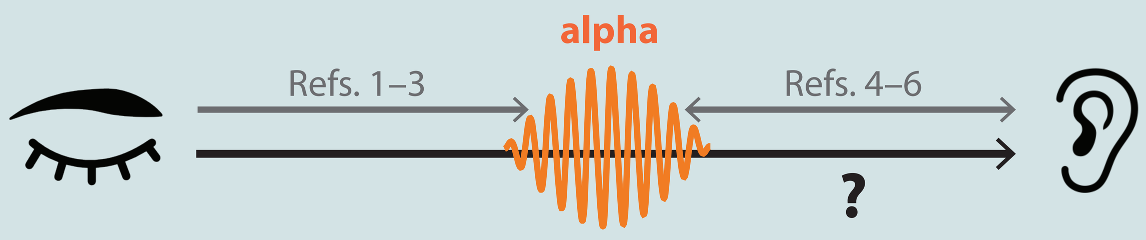
Background

A common human listening strategy when confronted with a noisy speech signal is to close the eyes. But does **closing the eyes** actually benefit **comprehension and memory of speech**?

Closing the eyes and attentive listening induce the same electrophysiological response:

Neural alpha power (8–12 Hz) increases in parieto-occipital cortex regions, reflecting the inhibition of visual processing.



In how far does closing the eyes affect the modulation of alpha power during attentive listening?

Methods

Selective listening task

- 22 students alternately attended to and ignored successively spoken digits with open and closed eyes.
- Behavioural performance measure: discriminability index d' [7]

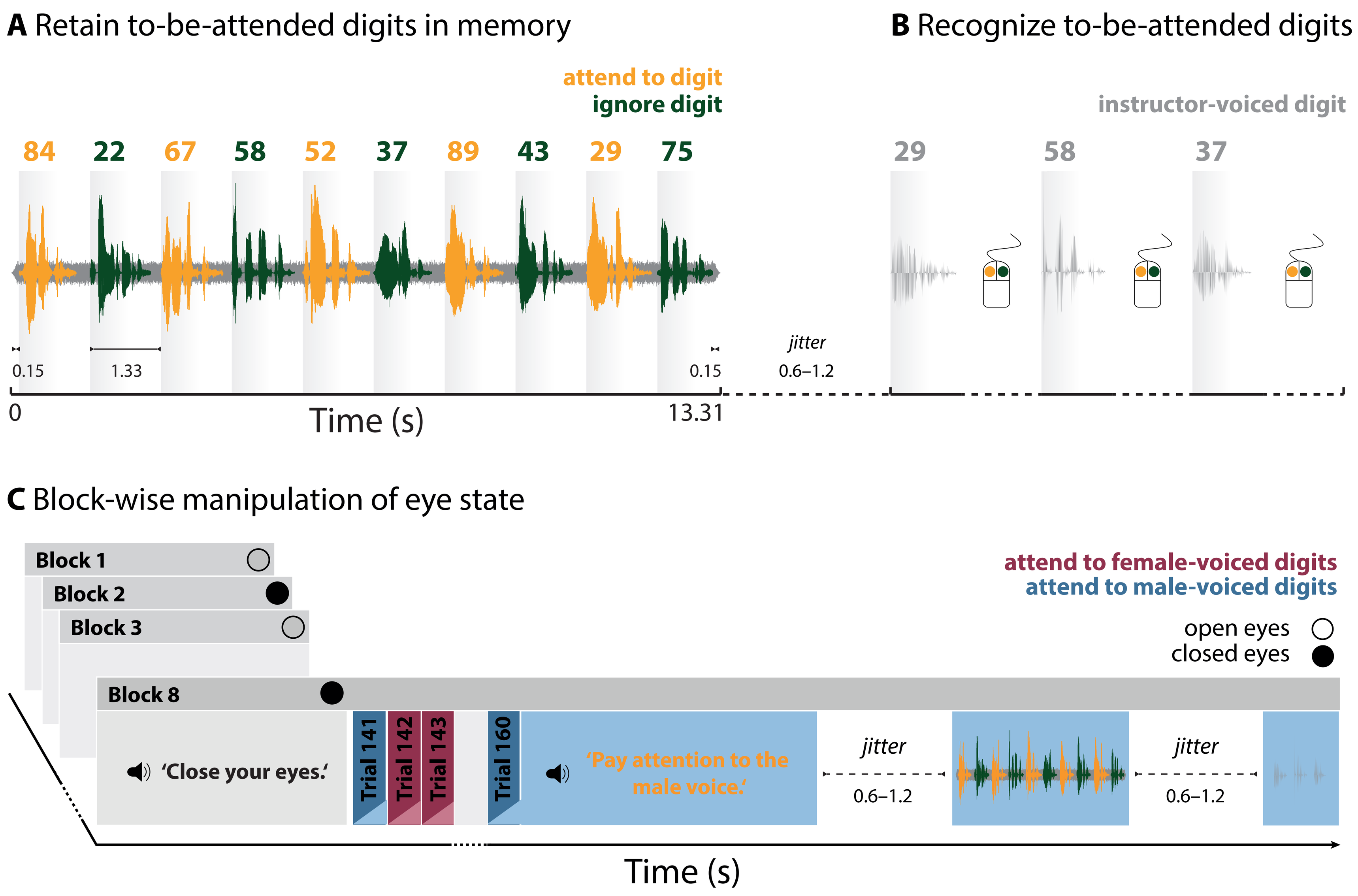


Figure 1. Design of the attentive listening task and manipulation of eye state. (**A**) During the encoding period, 10 digits embedded with white noise (+10 dB signal-to-noise ratio) were alternately spoken by a female and a male voice at a digit-presentation rate of 0.75 Hz. Participants had the task to either retain the female or male-voiced digits in working memory. (**B**) During the retrieval period, 3 digits of the encoding period were repeated by a neutral voice. After each probe, participants indicated via button press whether a digit was amongst the to-be-attended or to-be-ignored digits. (**C**) Trials were performed block-wise with open and closed eyes in complete darkness.

EEG recording & analysis: 64 scalp electrodes (actiCHamp); 1000 Hz sampling rate; 1–100 Hz offline filter; average reference; time-frequency analysis using moving window (1 s, Hanning taper) followed by Fieldtrip cluster permutation tests [8].

Behavioural profiteers and sufferers of closed eyes

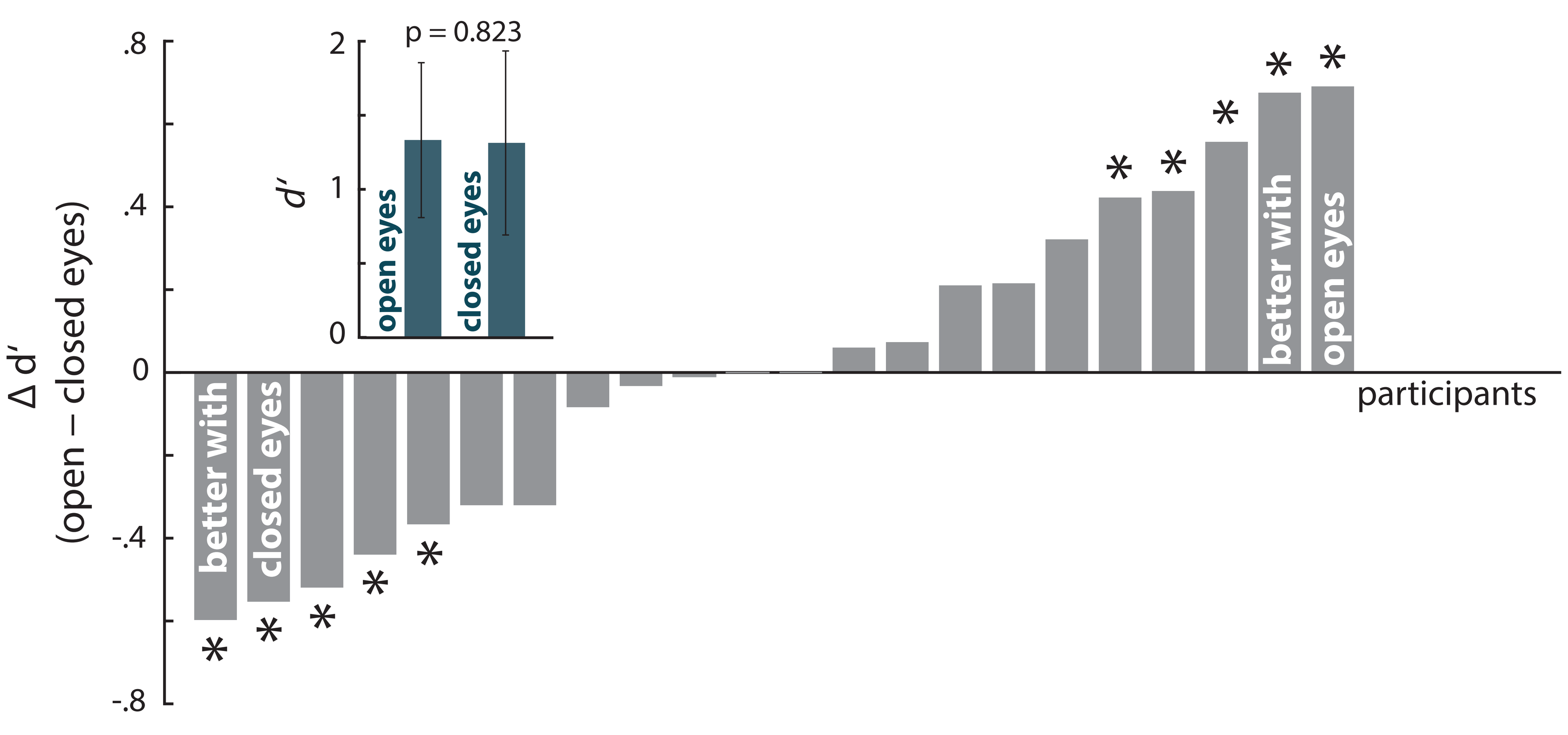


Figure 2. Behavioural task performance. Blue bars show the discriminability index d' with open and closed eyes averaged across all participants. Error bars show ±1 between-participants standard error of the mean (SEM). On the group level, recognition of to-be-attended digits was unaffected by eye state. Grey bars show the differences of d' with open and closed eyes for single participants sorted by size. Stars beneath/above bars indicate that permutation tests revealed significant effects of eye state on behavioural performance for the respective participants. On the single-participant level, participants could be evenly divided into profiteers (performance benefit from closed vs. open eyes) and sufferers of closed eyes (performance decline under closed eyes).

Attention modulates alpha power

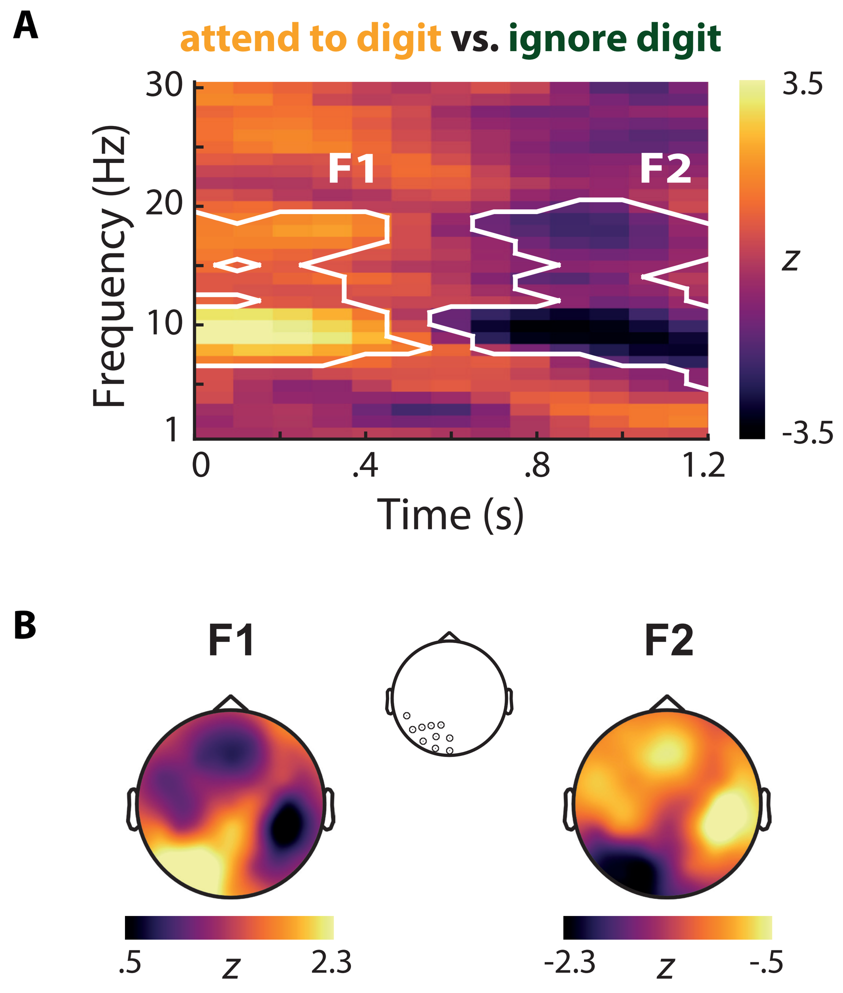


Figure 3. Time-frequency representations of oscillatory power in the attentive listening task. (**A**) Oscillatory power difference between time intervals of the encoding period corresponding to the presentation of to-be-attended vs. to-be-ignored digits relative to the onset of single digits (0–1.3 s; i.e. relative change baseline) averaged across all electrodes, shown as z-values resulting from cluster permutation tests. Significant clusters indicate a relative increase of alpha (and lower beta) power at the onset of to-be-attended digits (F1: p < 0.001; 0–0.5 s; 7–19 Hz) and an decrease before to-be-ignored digits (F2: p < 0.001; 0.6–1.2 s; 5–20 Hz). (**B**) Topographic maps show z-values for the significant clusters F1 and F2, indicating that the attentional modulation of alpha power was strongest in parieto-occipital cortex regions. An electrode mask was created by selecting those electrodes exhibiting the strongest attentional alpha power modulation.

Closing the eyes boosts alpha power fluctuations

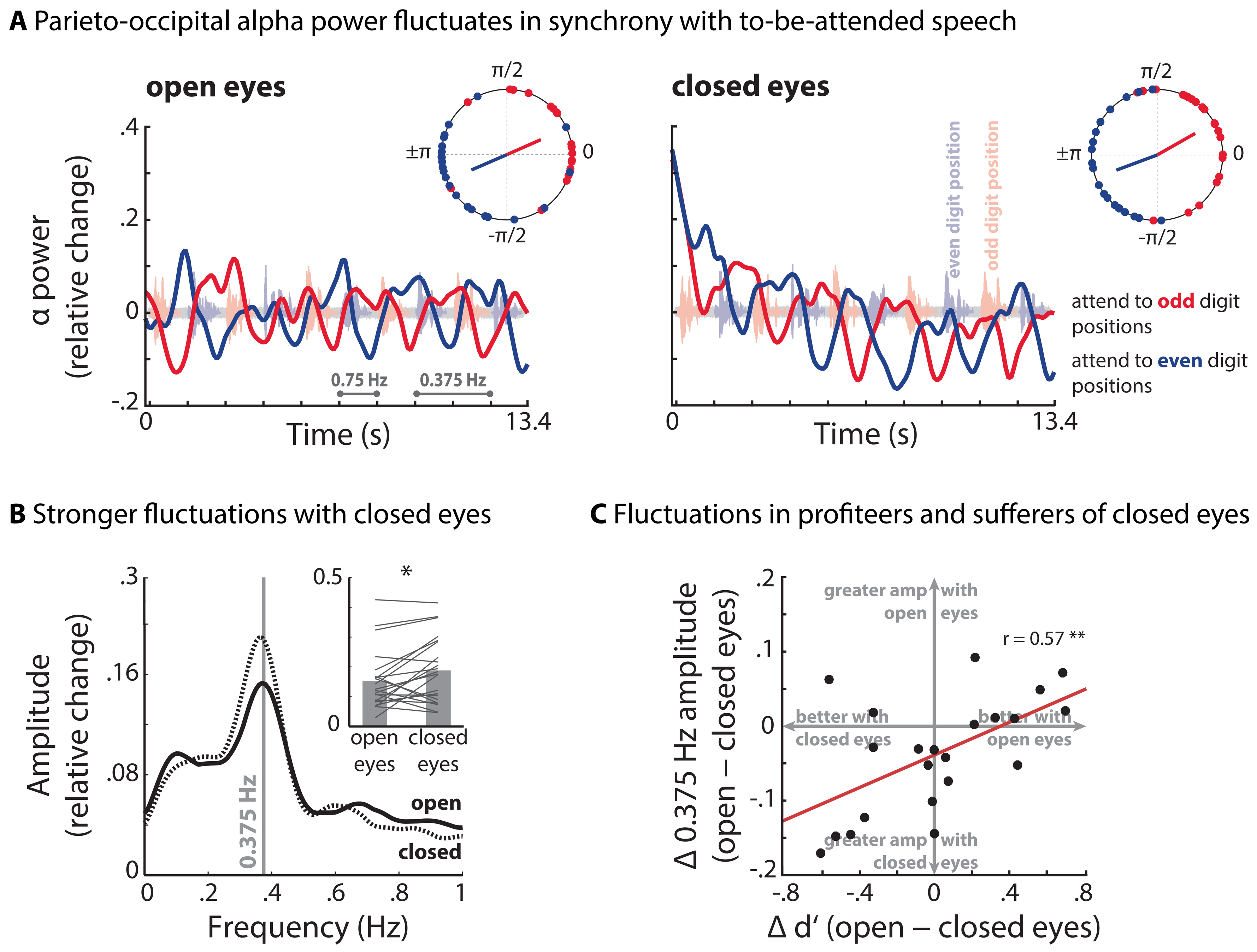


Figure 4. Spectral analysis of alpha power fluctuations with open and closed eyes. (**A**) During the encoding period, parieto-occipital alpha power fluctuated at a rate of 0.375 Hz when attending to odd (red) and even digit positions (blue), peaking before the onset of each to-be-attended digit (red waveform: odd digit position, blue waveform: even digit position). Phase angles of the 0.375-Hz fluctuations for attending to odd (red) and even digit positions (blue) were almost anti-cyclical in open (p < 0.001) and in closed eyes conditions (p < 0.001). Dots show single participants' phase angles; lines show phase angles averaged across participants. Eye state did not affect the phase of alpha power fluctuations (p = 0.625). (**B**) The amplitude of 0.375 Hz fluctuations was stronger with closed eyes (dashed line) when compared with open eyes (solid line). Bars at the top right show the mean 0.375-Hz amplitude for open and closed eyes. Grey lines connect single participants' 0.375-Hz amplitude for open and closed eyes. * p < 0.05. (**C**) The difference between d' with open vs. closed eyes as a function of the difference between the 0.375-Hz alpha power amplitude with open vs. closed eyes. Alpha power fluctuations with closed eyes were stronger in listeners behaviorally benefitting more from closed eyes. ** p < 0.01.

Conclusions

Closing the eyes either increased or decreased the memory of speech (Fig. 2).

Parieto-occipital alpha power fluctuated in synchrony with to-be-attended speech (Fig. 4).

- Alpha power is known to act as a **dynamic temporal filter** of distracting sensory information [9].
- The present increase of alpha power shortly before to-be-attended speech might reflect an **anticipatory allocation of attention** to the task-relevant auditory modality [4;10].

Parieto-occipital alpha power fluctuations with closed eyes were stronger in listeners behaviourally benefitting more from closed eyes (Fig. 4).

- Closing the eyes only helps listeners who increase their attentional alpha power under closed eyes.

References

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