

Co-Varying Eye Movements and Power Modulations of Alpha Oscillations during Working Memory

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There is an inconsistency in the literature regarding the direction of the association between the extend of synchronized oscillatory activity in the alpha band (~ 8-14 Hz, i.e. alpha power) and working memory (WM) load (see Fig. 1).^[1] Previous studies postulated that differences in alpha power varied with the variability in oculomotor activity.^[2] Increased gaze variability is associated with a reduction in alpha power, and vice versa. Here, we propose that **different gaze patterns during commonly used WM tasks** (i.e., Sternberg and N-back) **can explain the task-specific discrepancies between alpha power and WM load**.

We hypothesize that although fluctuations in alpha power in relation to WM load appear to be associated with the cognitive demands of the task, these modulations likely evolved primarily to facilitate/support oculomotor control.

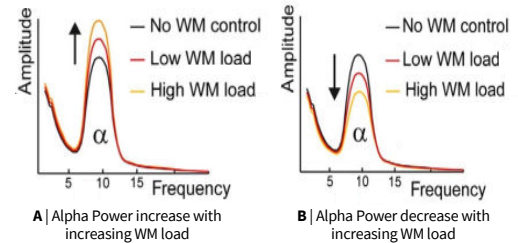


Fig. 1: WM load dependent increase (A) or decrease (B) of posterior alpha power, showcasing the inconsistency in the literature regarding the direction of the association between alpha power and WM load in different WM tasks. Adapted from van Ede, 2018.

Methods

Sample

N = 120 participants (M = 24.13, SD = 3.23, 71% f.)

N-back Task

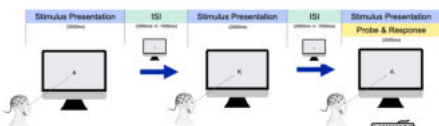


Fig. 2: N-back task. A block consisted of the sequential presentation of 100 letters (i.e., trials; 2s each). Depending on the condition (1-back, 2-back and 3-back), participants were instructed to indicate by button press whether they thought the currently presented letter was a match to the letter N-back.

Sternberg Task

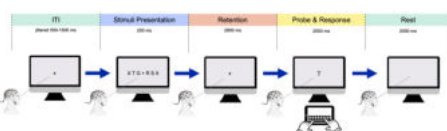


Fig. 3: Sternberg task. A trial consisted of a simultaneous presentation of 2, 4, or 6 letters for 200 ms. The letters and the load were randomized. After a retention interval of 2.8 s, another letter was presented. Participants were instructed to indicate by button press whether they thought it was a match or not. A block consisted of 50 trials.

Behavioral Data

- Reaction time (ms)
- Accuracy (%)

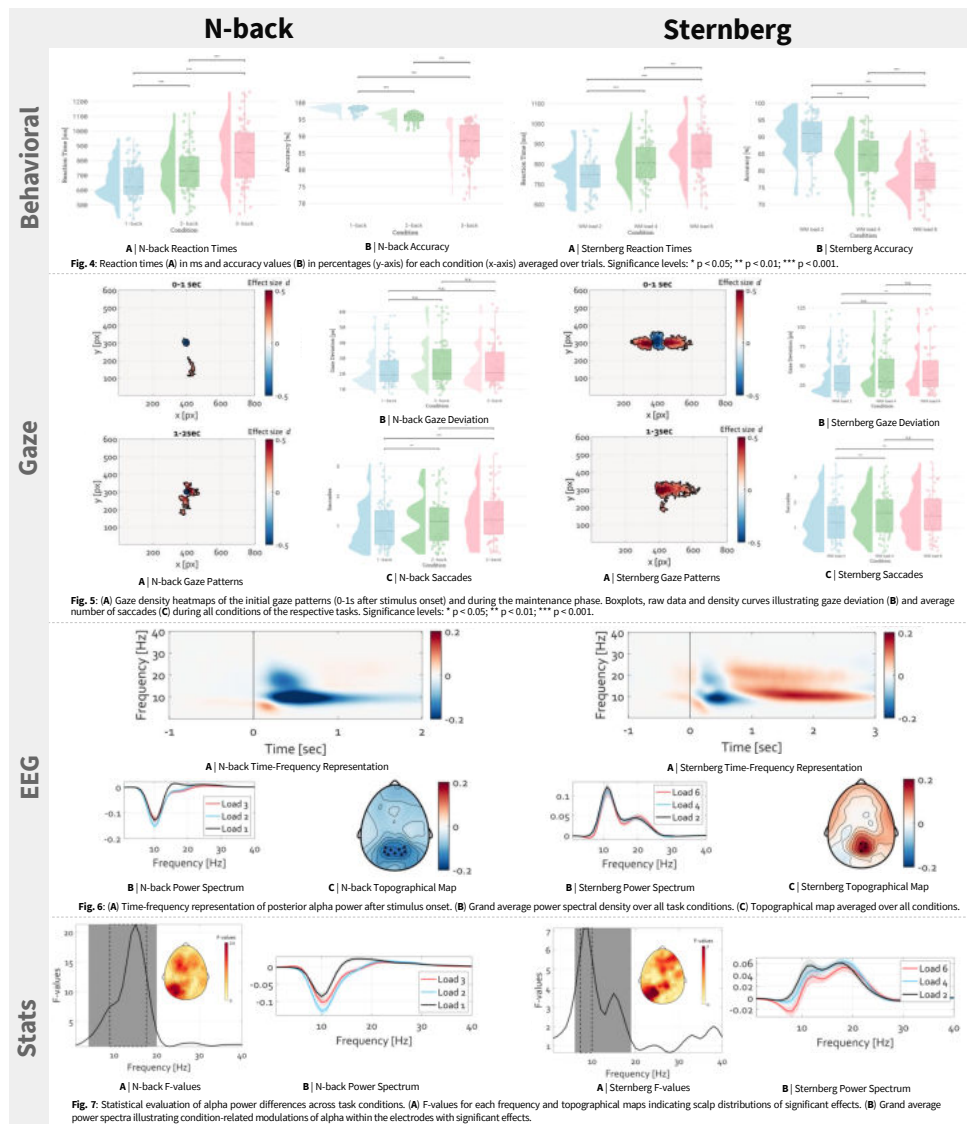
Eye Tracking

- Device: Eye tracker EyeLink 1000 Plus (sampling rate 500 Hz)
- Measure of interest: Load dependent changes in gaze variables (gaze density & saccades) during retention interval

EEG

- Device: 128-channel ANT Neuro EEG system (sampling rate 500 Hz)
- Preprocessing with Automagic^[3]: removal of noisy/outlier channels, high pass filter 0.1 Hz, ZapLine 50 Hz, artifact removal with ICLabel, ocular correction with OPTICAT
- Measure of interest: Load-dependent alpha power modulations in poster electrodes during retention interval

Results



References

- van Ede, F. (2018). Mnemonic and attentional roles for states of attenuated alpha oscillations in perceptual working memory: A review. *European Journal of Neuroscience*, 48(7), 2509–2515.
- Popov, T., Miller, G. A., Rockstroh, B., Jensen, O., & Langer, N. (2021). Alpha oscillations link action to cognition: An oculomotor account of the brain's dominant rhythm. *Neuroscience*.
- Pedroni, A., Bahreini, A., and Langer, N. (2019). Automagic: Standardized preprocessing of big EEG data. *NeuroImage*, 200-460–473.

Conclusion

This study was conducted as a Stage 1 Registered Report. In the preregistered analyses, we examined posterior alpha power modulations and gaze patterns across different WM tasks. In the N-back task, **higher WM load led to more gaze deviation and stronger alpha power reduction**. For the Sternberg task, **high WM load was linked to increased gaze variability**, whereas **no modulation of alpha power by WM load** was observed. Beyond these preregistered analyses, we conducted exploratory analyses, which revealed **distinct eye movement patterns** between the tasks, and **distinct neural activations** between encoding and maintenance processes.