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Co-varying eye movements and power modulations of alpha oscillations during working memory: a pilot study

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1. Introduction

- There is an **inconsistency** in the literature regarding the **direction of the association between alpha power and WM load**. [1]
- The present proposal suggests that **different gaze patterns during commonly used WM tasks** (i.e., Sternberg and N-back) **predict variations in alpha power**.
- Differences in alpha power with WM varied with **variability in oculomotor action**: the higher the variability the stronger the decrease in alpha power and vice versa. [2]
- The variation of alpha power with WM load, or more generally, power modulations appear correlated with the cognitive task at hand, while in fact they evolved **primarily to support oculomotor control**.

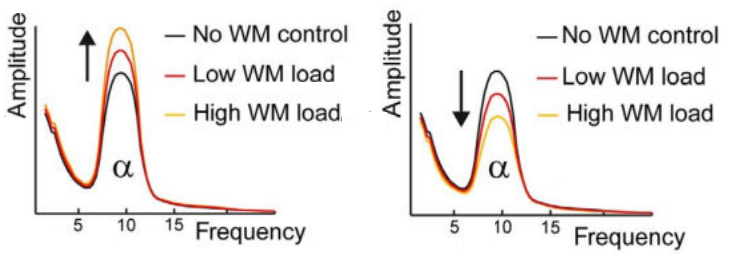

Fig. 1: Increases and decreases in alpha amplitude during working memory retention, depending on WM load and recruited sensory area. Adapted from van Ede, 2018.

2. Hypotheses

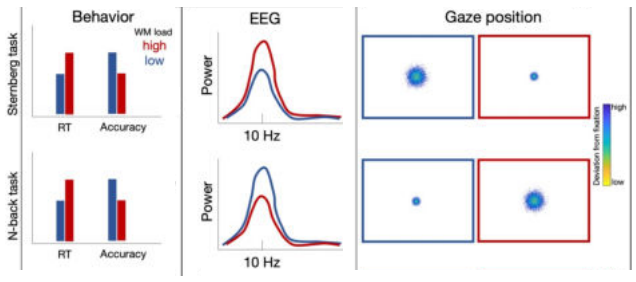

Fig. 2: Sternberg and N-back show similar behavioral data but the direction of the association between alpha power and WM load differs between the tasks. It is hypothesized that these differences are due to distinct variability of oculomotor action.

3. Methods

Dataset

- N = 10 pilot participants (mean age = 25.9, ± 2.13, 50% female)

Sternberg Task

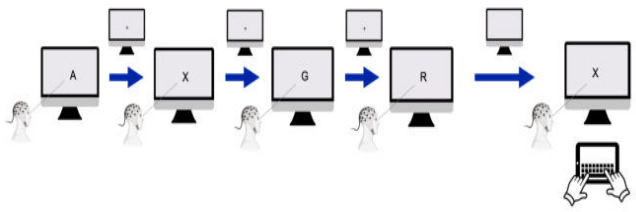

Fig. 3: Sternberg task. A trial consisted of a sequential presentation of 1, 4 or 7 letters (1.2 s each). The letters and the load were randomized. After a retention interval of 3 s another letter was presented. Participants were instructed to indicate by button press whether they thought it was a match or not.

N-back Task

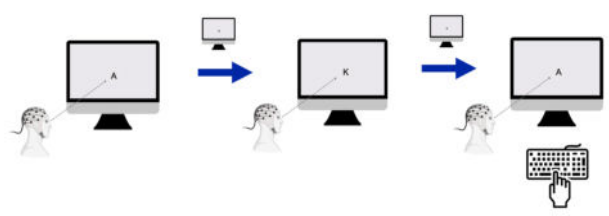

Fig. 4: N-back task. A block consisted of the sequential presentation of 100 letters (2 s each). Depending on the condition (1-back, 2-back and 3-back), participants were instructed to indicate by button press whether they thought the currently presented letter was a match to the letter N-back.

Psychophysiological Data

- 128-channel ANT Neuro EEG system, sampling rate 500 Hz
- Eye tracker EyeLink 1000 Plus
- Preprocessing: BP FIR filter 1-45 Hz

Behavioral Data

- Reaction time
- Accuracy

4. Results

Sternberg Reaction Times and Accuracy

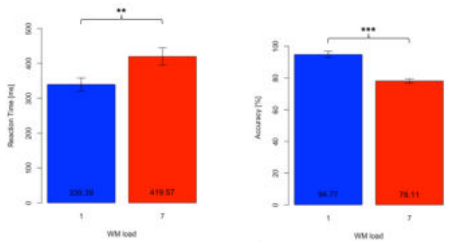

Fig. 5: Sternberg reaction time in ms and accuracy values in correct percentage for WM load conditions 1 and 7.

N-back Reaction Times and Accuracy

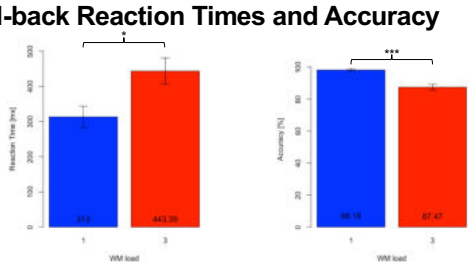

Fig. 6: N-back reaction time in ms and accuracy values in correct percentage for 1-back and 3-back conditions.

Sternberg Grand Average

Fig. 7: Grand average occipital power spectra and topographical alpha power distribution across WM load conditions 2 and 8.

N-back Grand Average

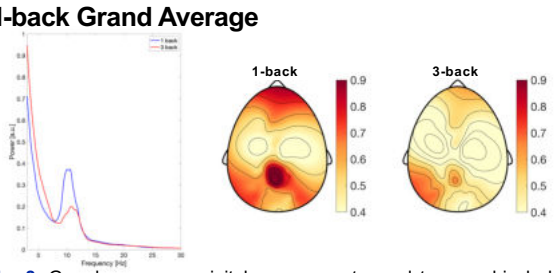

Fig. 8: Grand average occipital power spectra and topographical alpha power distribution across 1-back and 3-back conditions.

Sternberg Single Subjects

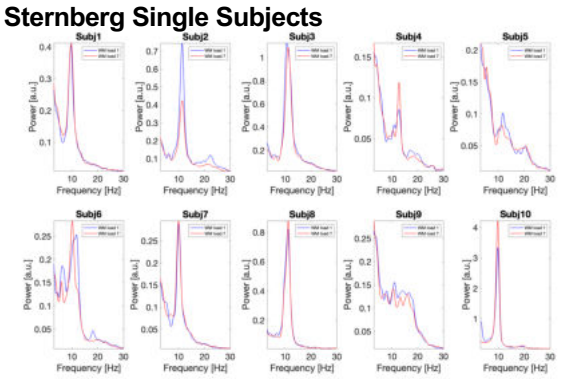

Fig. 9: Individual power spectra as function of WM load during the Sternberg task.

N-back Single Subjects

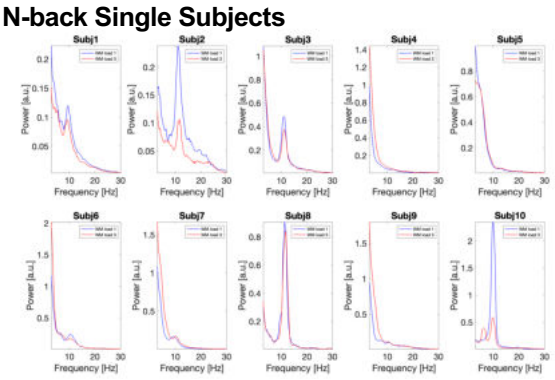

Fig. 10: Individual power spectra as function of WM load during the N-back task.

Gaze density during Sternberg task

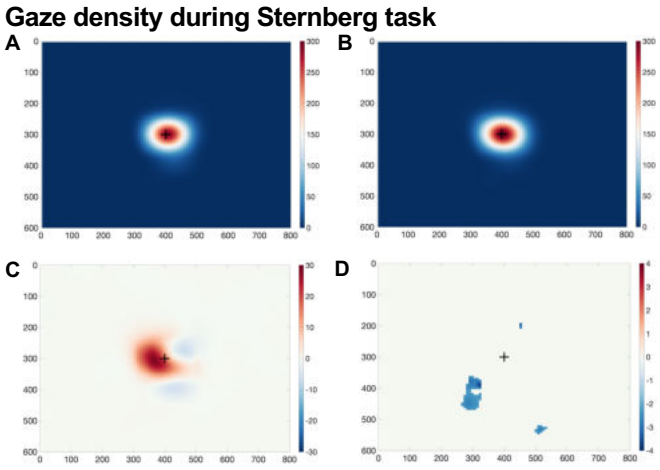

Fig. 11: **A** | Sternberg WM load 1 gaze density. **B** | Sternberg WM load 7 gaze density. **C** | Absolute gaze density difference from WM load 7 (B) – WM load 1 (A). **D** | T-values of gaze density difference from WM load 7 (B) – WM load 1 (A).

Gaze density during N-back task

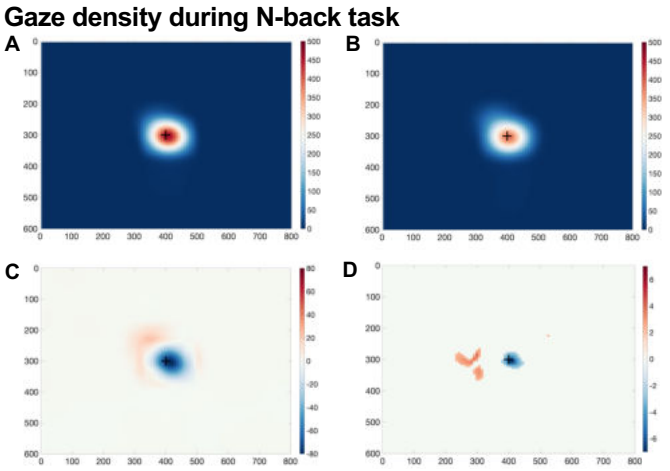

Fig. 12: **A** | 1-back gaze density. **B** | 3-back gaze density. **C** | Absolute gaze density difference from 3-back (B) – 1-back (A). **D** | T-values of gaze density difference from from 3-back (B) – 1-back (A).

References

1. 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. https://doi.org/10.1111/ejn.13759
2. 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 [Preprint]. Neuroscience. https://doi.org/10.1101/2021.09.24.461634

5. Conclusion (preliminary)

- Gaze and alpha power modulation during WM covary
- High WM load is associated with stronger alpha power reduction and higher gaze variability
- Strong inter-individual variability with modulation of posterior alpha power with WM load