The role of pre-stimulus alpha rhythms in non-retinotopic feature integration

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1. Introduction

Visual detection is modulated by pre-stimulus alpha oscillations (8–12 Hz)[1].

The effect of pre-stimulus activity in other tasks, beyond detection, remains unknown.

We investigated the role of ongoing EEG rhythms during spatio-temporal feature integration using the SQM paradigm[2,3].

3. Method

Part 1 - EEG decoding

- Linear discriminant analysis (LDA) was used to decode the reported offset direction from evoked EEG scalp topographies and to identify EEG patterns of non-retinotopic integration.
- Activation patterns were derived from the LDA decoder to select electrodes sensitive to the difference between reports in VAV condition (1st vernier vs 2nd vernier reported).

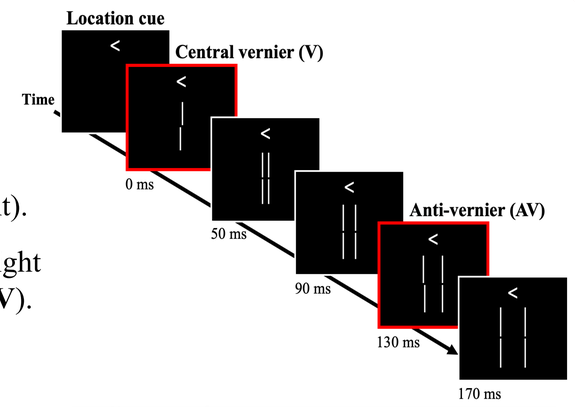
Part 2 - Pre-stimulus analysis

- Single-trial EEG signal at the LDA-informative electrodes was used to investigate whether pre-stimulus oscillatory activity modulates the percept of the integrated offset in VAV condition.

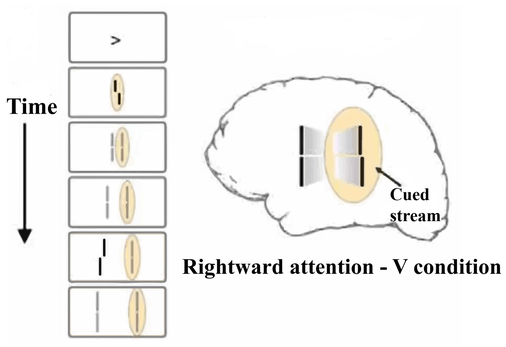
2. Paradigm

The sequential metacontrast paradigm (SQM)

- Attend to the cued stream.
- Report the perceived offset direction (left or right).
- The attended stream contains one line with a slight offset (**V**) or two lines with opposite offsets (**VAV**).

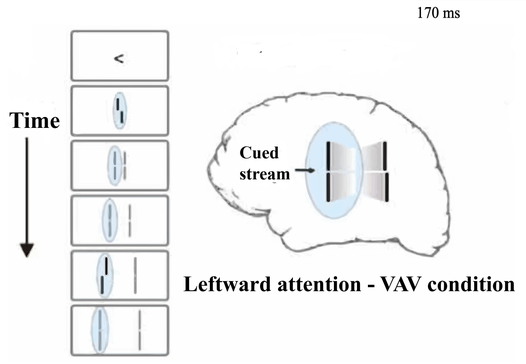


Non-retinotopic feature integration in the SQM



A single offset in the stream is transmitted to the flanking lines.

- Report of central vernier is above chance level.

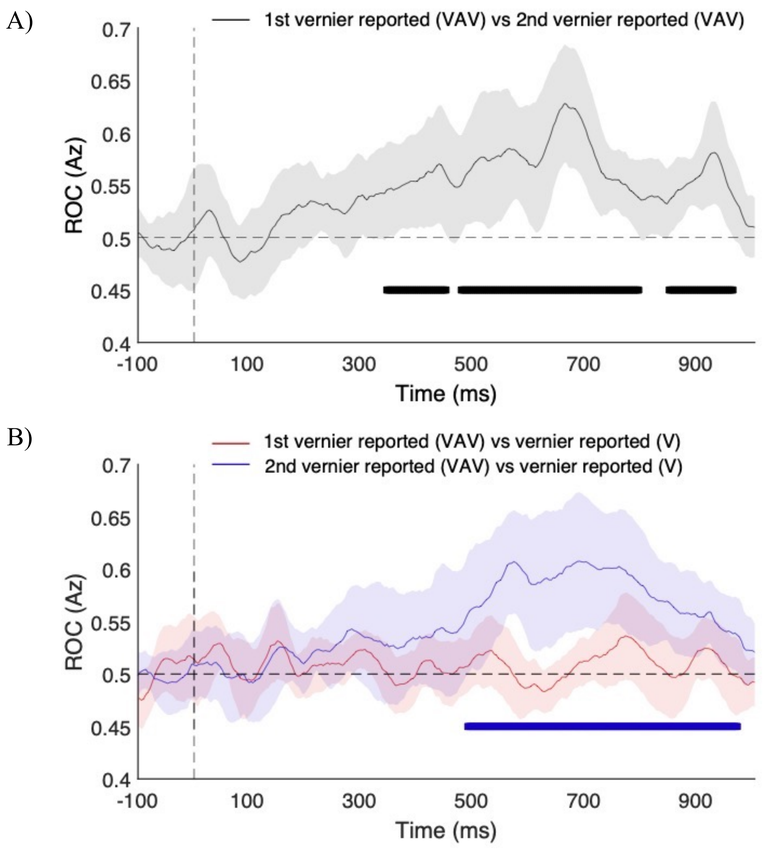


Two offsets in the same stream cancel each other.

- Report of central vernier is at chance level.

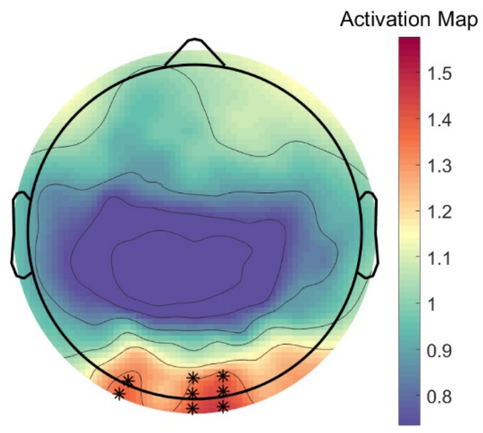
4. Results – EEG decoding

1. Brain signal decoding (LDA)



The classifier performance discriminating **A)** 1st vernier reported vs 2nd vernier reported in VAV trials, and **B)** 1st or 2nd vernier reported in VAV trials vs vernier reported in V trials (mean and 95% CI). Significant time windows are highlighted (cluster-based permutation test, $p < 0.05$).

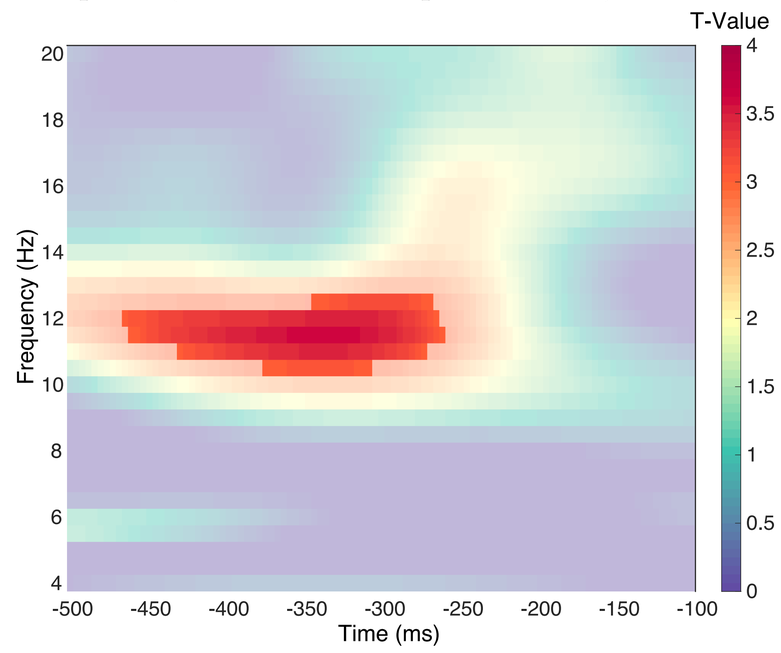
2. Scalp topography from discriminant signal (1st vs 2nd vernier reported in VAV)



LDA-derived scalp activation patterns across the entire significant decoder in Figure 1A. Asterisks show selected electrodes whose absolute activation signal was above the 95th quantile.

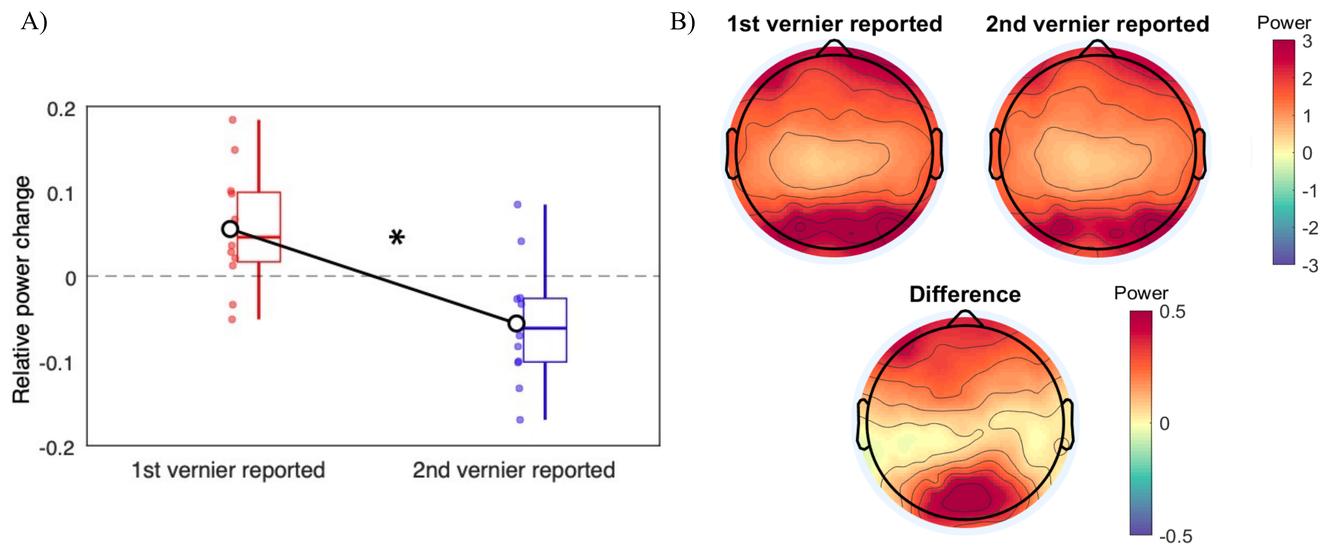
5. Results – Pre-stimulus analysis

3. Pre-stimulus spectral power (1st vs 2nd vernier reported in VAV)



A multilevel linear regression was performed on the time-frequency representation of the instantaneous power to investigate the relationship between pre-stimulus activity and reported offset in the VAV condition. A separate mixed-model analysis was run for each time-frequency tile in a window from -500 to -100 ms. Significant cluster is highlighted (FDR-adjusted p-values).

4. Power difference within the significant cluster (10.5 to 12.5Hz, -465 to -260ms)



A) Relative power change in pre-stimulus cluster, taking the mean power in all VAV trials as a baseline. Asterik highlights the significant difference (p-value = 0.01, Cohen's d = 0.84). **B)** Power comparison in topographical plots confirms that the largest difference occurs in the occipital area.

6. Conclusion

Our results showed that:

- While an integrated offset is perceived when two opposite verniers are presented, the dominance of one vernier over the other can be decoded from post-stimulus activity using LDA analysis.
- Activity at occipital electrodes was most informative of which vernier was reported throughout the significant window.
- Higher pre-stimulus alpha power in these electrodes coincided with more reports of the 1st vernier, whereas no effect of alpha phase was found.

Together, our findings indicate that pre-stimulus alpha power can also modulate the perception of longer stimuli that need to be integrated across space and time. Spontaneous alpha rhythms might therefore affect the relative weighting of visual features embedded in a continuous stream.

Reference

1. Busch, N. A., Dubois, J., & VanRullen, R. (2009). The phase of ongoing EEG oscillation predicts visual perception. Journal of Neuroscience, 29(24), 7869–7876.
2. Drissi-Daoudi, L., Doerig, A., & Herzog, M. H. (2019). Feature integration within discrete time windows. Nature Communications, 10(1), 1–8.
3. Plomp, G., Mercier, M. R., Otto, T. U., Blanke, O., & Herzog, M. H. (2009). Non-retinotopic feature integration decreases response-locked brain activity as revealed by electrical neuroimaging. *Neuroimage*, *48*(2), 405-414.

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