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Contrast-Induced Variability in Gamma Oscillations and Eye Movements: A Pilot Study

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It is generally assumed that brain rhythms reflect the neural processes required to perform the cognitive operations demanded by the task. This assumption has led to theories assigning a specific role of gamma oscillations (30 – 90 Hz) involved in information binding[1], thereby enabling higher-order cognitive functions[2]. However, it remains unclear as to why gamma activity variation in the visual cortex primarily depends on stimuli properties[3].

It has been reported that **perception of gratings entails eye movements across the contrast border**[4]. Assuming the premise that oculomotor action control is a continuous process monitored by brain circuits, it appears relevant to consider to what extent eye movements and the control thereof bears some informative value of why and how **contrast and spatial frequency of the stimulus affects measures of gamma oscillations**. Here, the aim is to explore this by varying the contrast at constant spatial frequency.

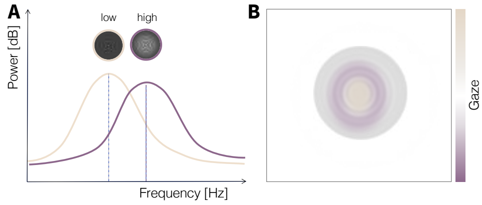

Fig. 1: Visualization of the hypotheses. (**A**) Increase of frequency of occipital gamma oscillations at peak power in the high contrast condition. (**B**) Differences in gaze metrics (gaze deviation, saccades, microsaccades) between low and high contrast conditions.

Methods

Sample

N = 10 pilot participants (M = 25.9, SD = 5.57, 40% f.)

Grating Task

- Concentric inward moving grating
- Conditions: low and high luminance contrasts
  - 100 trials low (50%) contrast
  - 100 trials high (100%) contrast
- Exclusion of grating presentation periods with button presses (25% of trials)

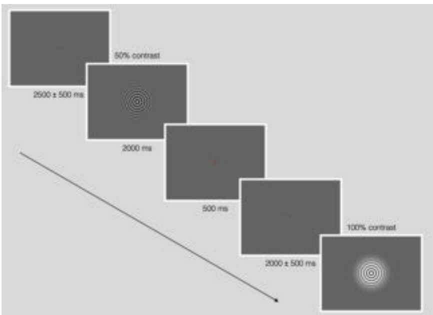

Fig. 2: Concentric grating task paradigm. Black fixation crosses and grating stimuli are shown alternatingly. Red fixation crosses prompt the participant to respond by button press. After a jittered interval of 2000 - 3000 ms of fixation cross presentation, a concentric grating stimulus with varying contrast intensity and orientation is presented for 2000 ms.

Eye-Tracking

- Contrast-dependent modulations in gaze deviation, microsaccades and saccades during stimulus presentation (300 ms – 2000 ms after onset)
- Eye tracker EyeLink 1000 Plus; sampling rate 500 Hz

EEG

- Contrast-dependent modulations of posterior gamma frequency and power during stimulus presentation (300 ms – 2000 ms after onset)
- 128-channel ANT Neuro EEG system, sampling rate 500 Hz
- Preprocessing with Automagic[5]: removal of noisy/outlier channels, high pass filter 0.1 Hz, ZapLine 50 Hz, artifact removal with ICLabel, ocular correction with OPTICAT

Results

Gaze

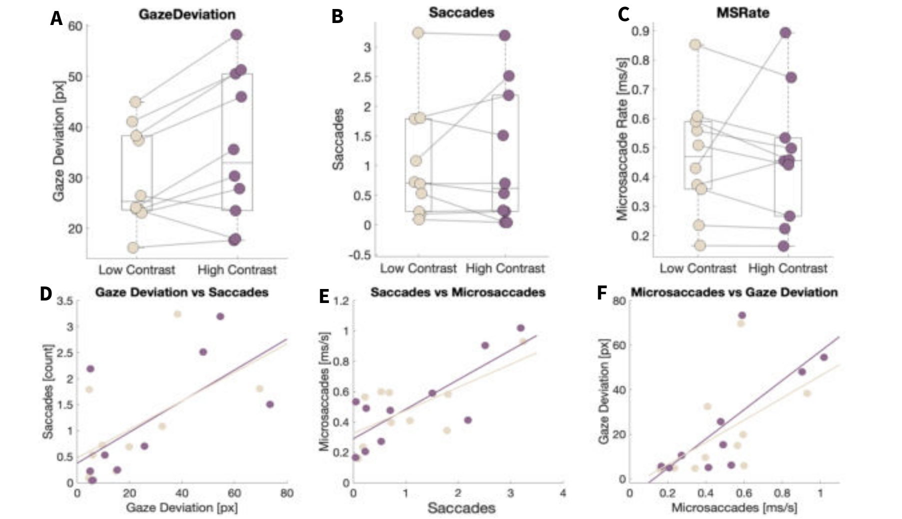

Fig. 3: Boxplots for eye-tracking metrics in the low and high contrast conditions, averaged over trials. Gaze deviation (**A**) as Euclidean distances from the center of the screen in pixels. Saccades (**B**) as the average numbers of saccades per trial. Microsaccade rate (**C**) as the average number of microsaccades per second per trial. Relations between eye-tracking metrics: Gaze deviation and saccades (**D**), saccades and microsaccades (**E**), and microsaccades and gaze deviation (**F**).

EEG

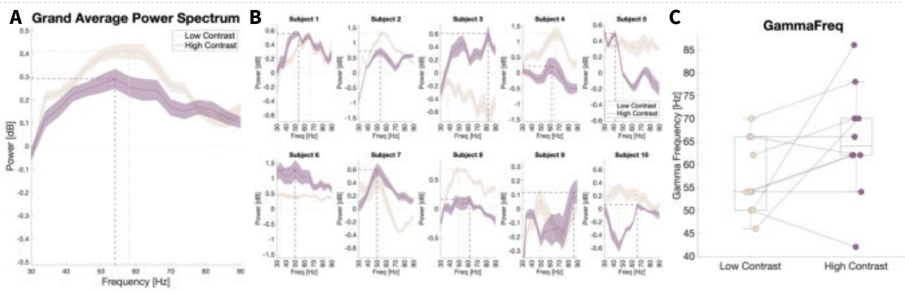

Fig. 4: Power spectral density of the grand average (**A**) and for individual participants (**B**) for baselined occipital gamma power in both conditions. Frequency in Hz is displayed on the x-axis with power in dB on the y-axis. Shaded areas around each line depict the standard error of the mean. Changes in gamma frequency between the conditions (**C**).

Association

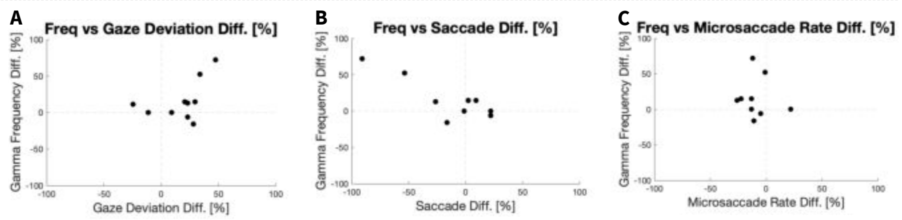

Fig. 5: Association for each subject between relative gamma frequency changes (y-axes) and gaze variability as percentage change in gaze deviation (**A**), saccades (**B**) and microsaccade rate (**C**; x-axes). Depicted changes are from the low to the high contrast condition, meaning that the values for the low contrast conditions were subtracted from the high contrast values.

References

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Conclusion

Preliminary results indicate potential trends in the relationship between eye movements and gamma oscillations, with variation observed across contrast conditions. These exploratory findings highlight a potential connection between gamma oscillations and oculomotor control, suggesting directions for future research to better understand the role of eye movements in modulating brain activity during cognitive tasks. However, due to insufficient statistical power, no definitive conclusions can be drawn regarding the relationship between gamma frequency and gaze variability. This study sets the stage for a future registered report with an adequately powered sample size.