Pupil size and phase as a real-time marker of perceptual sensitivity and whole brain activity

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Primary Aim: Track and map spontaneous neural fluctuations associated with pupil size/phase changes.

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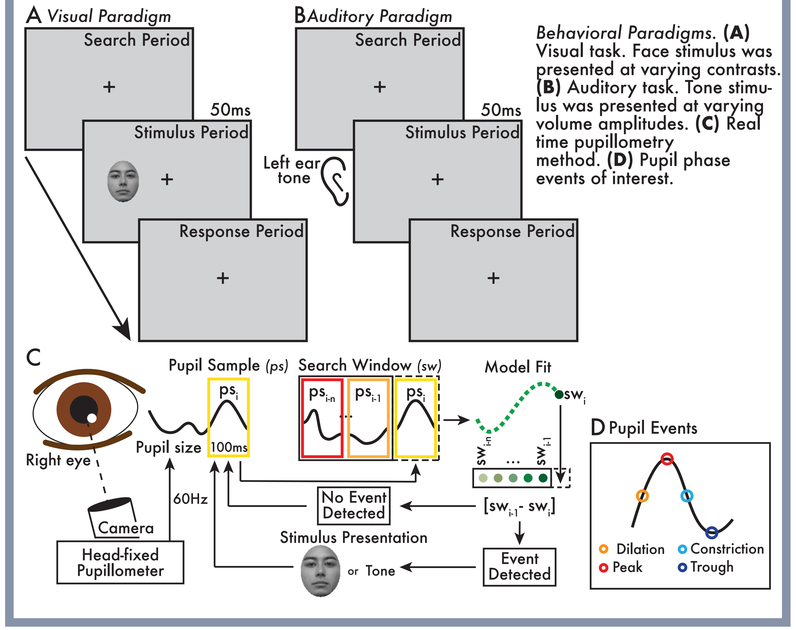
1. Motivation and Background

A primary driver of conscious state is arousal. Subcortical areas such as the thalamus and brainstem are linked to arousal state [1].
Changes in these regions have been historically difficult to measure using non-invasive methods. Pupil diameter subtly and spontaneously changes independently of environmental light [2]. These fluctuations have been shown to be associated with changes in arousal and evoked by perceptual events [3,4]. Therefore, pupil size may be a valid candidate for a real-time proxy for changes in arousal and perception state.

2. Participants & Methods

Behavioral: Eyelink 1000 Plus (SR Research, Inc.); 1000Hz, right eye
5 healthy adult participants (mean age: 23.75 years, males: 2).
MEG: CTF 275 MEG system (CTF Systems, Inc., Canada);
(600Hz; bandwidth (1-150Hz); 4 healthy adult participants (mean age: 25.25 years, males: 2); Target N = 35.
fMRI: HCP 7T resting state, BOLD, TR = 1000ms
83 healthy adult participants (mean age: 27.34 years, males: 43).

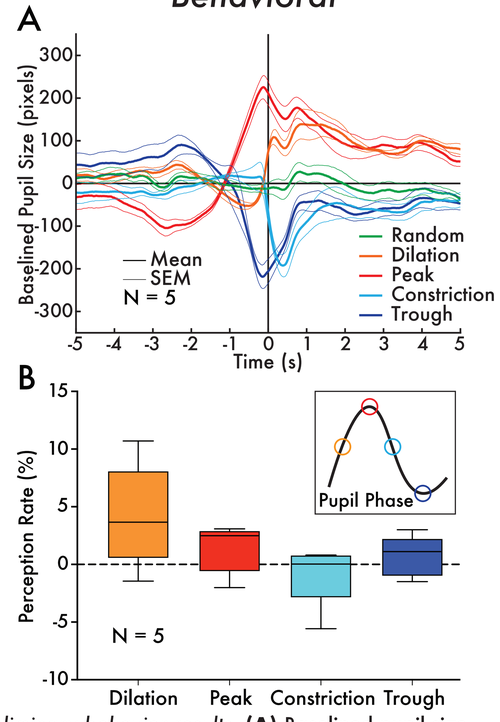
3. Behavioral Task



Behavioral Paradigms. **(A)** Visual task. Face stimulus was presented at varying contrasts. **(B)** Auditory task. Tone stimulus was presented at varying volume amplitudes. **(C)** Real time pupillometry method. **(D)** Pupil phase events of interest.

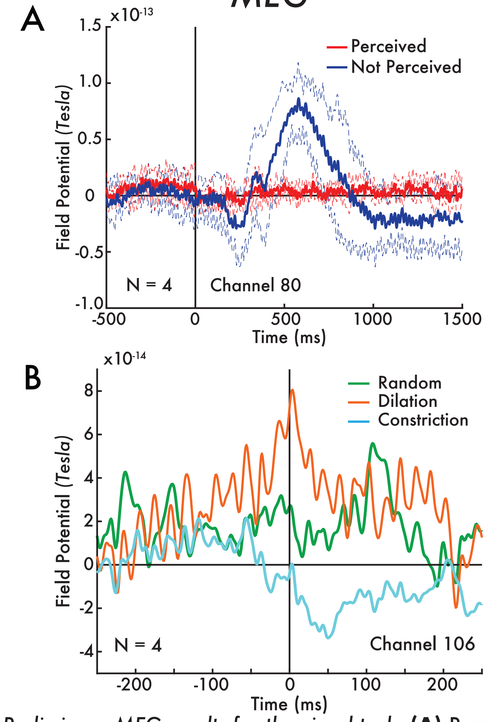
4. Results

Behavioral



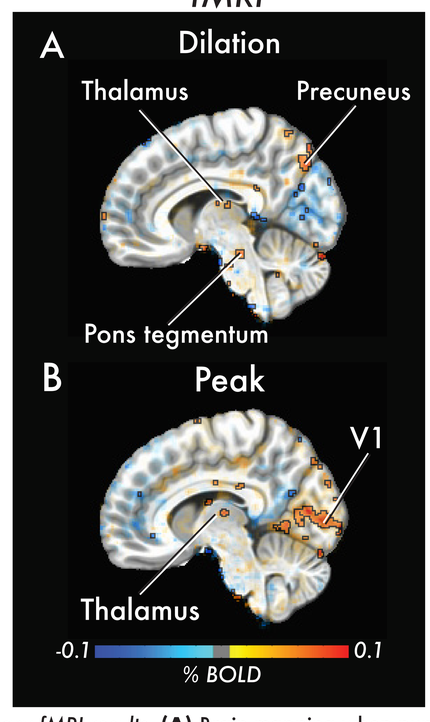
Preliminary behavior results. **(A)** Baselined pupil size timecourse for the five conditions. **(B)** Perception rate subtracted from the random rate.

MEG



Preliminary MEG results for the visual task. **(A)** Perceived and not perceived field potential timecourse. **(B)** Field potential timecourse of random, dilation and constriction.

fMRI



Preliminary fMRI results. **(A)** Brain mapping when pupil size is in a dilation phase. **(B)** Mapping when pupil size is at a peak phase. Percent change BOLD (% BOLD).

5. Conclusions

Behavioral
- Our real-time algorithm demonstrates that pupil size changes can be detected reliably and effectively in real-time.
- Perception rates increase during dilation pupil phases and decrease during constriction pupil phase. No change in peak and trough phases.

MEG
- Perceived and not perceived face stimuli show diverging reponses.
- Dilation phase shows an in increase in potential, while the constriction phase shows decreases in potential.

fMRI
- Dilation and peak pupil phase events show BOLD changes in thalamus, pons tegmentum, precuneus, and V1.

6. Future Directions

- Complete MEG data collection (35 participants).
- Conduct detailed analysis of the MEG data, including examining the differences between the auditory and visual task.
- Complete analysis on fMRI data for each of the pupil phase conditions to understand how these fluctuations may change throughout time

References

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Special thanks to our SFIM and LBC lab members for feedback and suggestions and to our participants!