Investigating Eye Metrics as an Indicator of Sensory Neural Processing, Behavior, and Conscious Perception

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1. Background

Brain states, including attention and arousal, spontaneously fluctuate during wakefulness, shaping behavior and conscious perception [2]. Pupil size, pupil size variance, blinking, and microsaccades track with arousal and attentional states because the brain regions regulating these eye metrics overlap with arousal and attention networks (e.g., brainstem and thalamus) [1].

We aim to **(1)** assess whether perception and behavior for visual and auditory stimuli correlate with eye metrics and **(2)** examine if brain activity linked to specific eye metrics modulates sensory-evoked brain activity and associated behaviors.

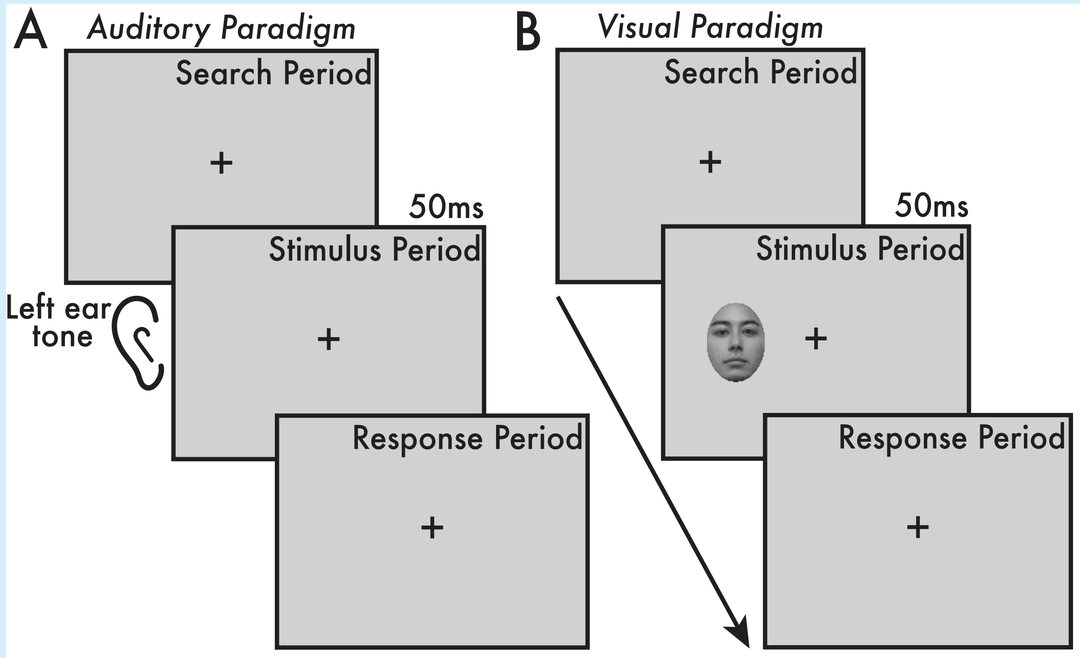
2. Methods

Participants: *Visual*: N = 34; female = 20; mean age = 29.06 years; mean education = 17.21 years. *Auditory*: N = 37; female = 22; mean age = 29.41 years; mean education = 17.08 years.

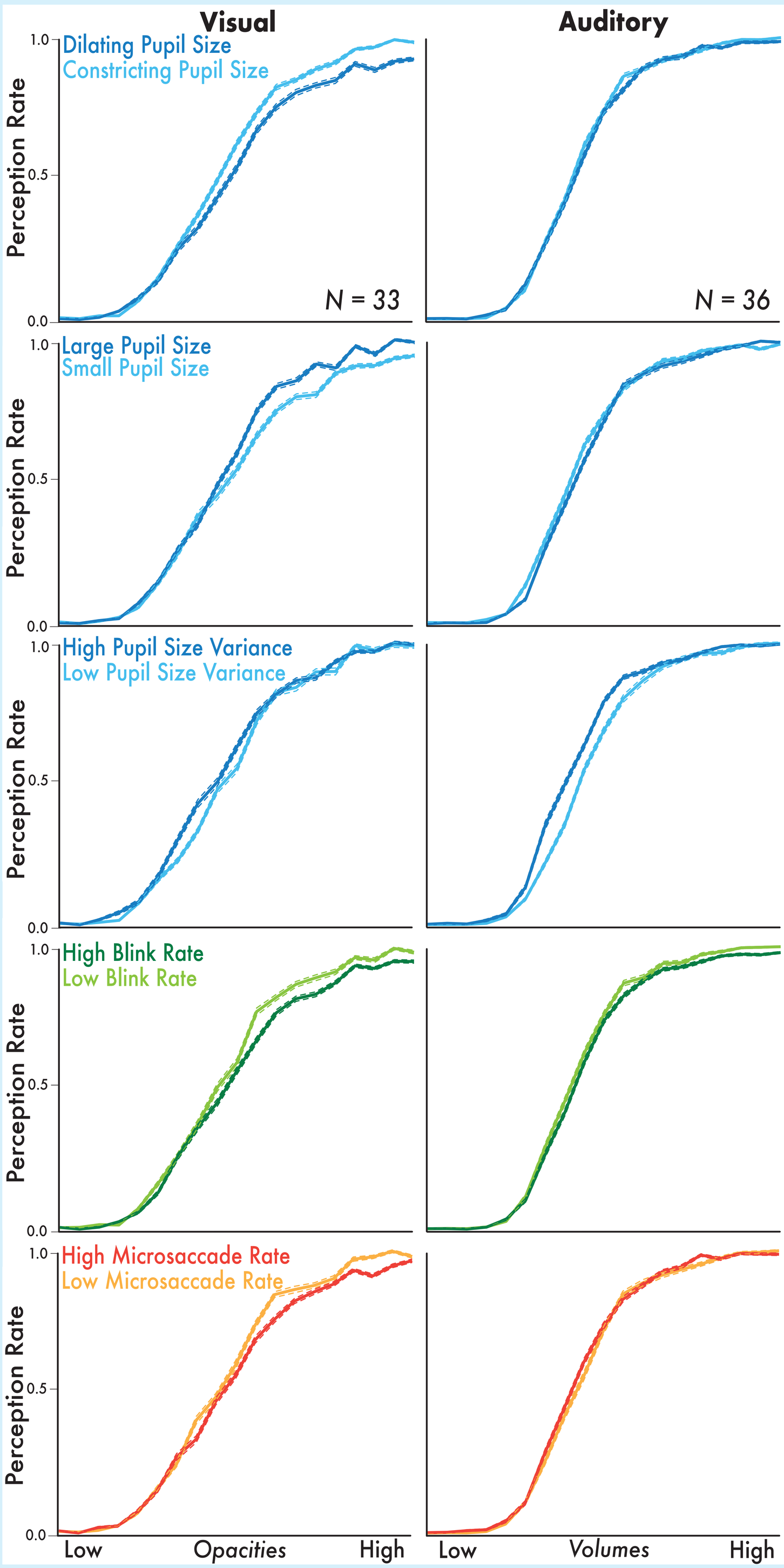
Eye Tracking: EyeLink 1000 Plus (1000 Hz; right eye; SR Res.)

MEG: CTF 275 MEG system (1200 Hz; CTF Systems, Inc.)

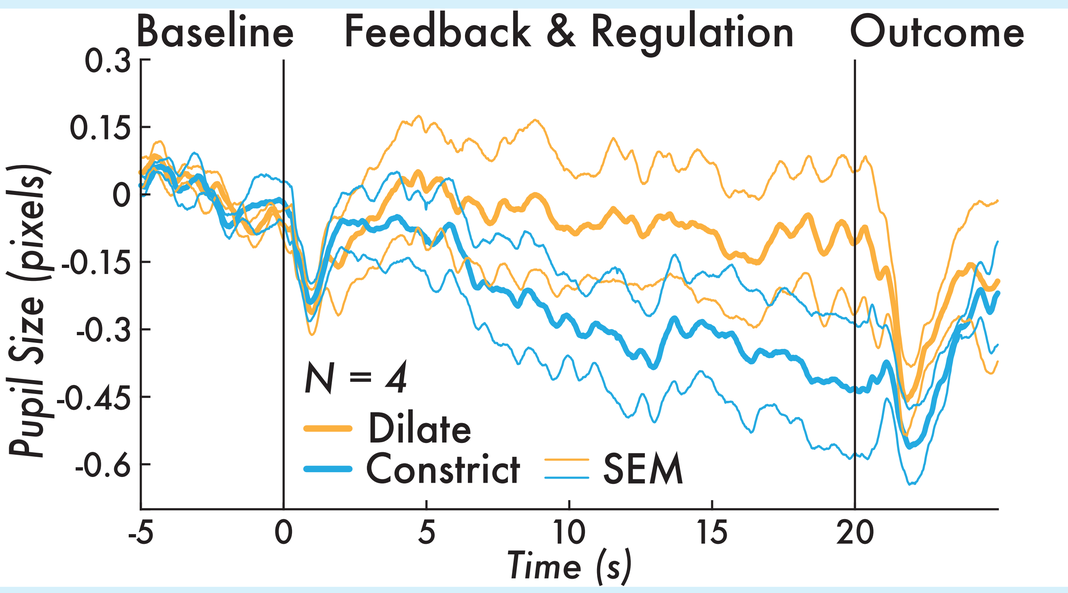
3. Behavioral Task



4. Behavioral Results



5. Biofeedback Results



6. Future Directions

- Analyze pupil phase by stimulus amplitude interactions in MEG and eye metric changes.
- Analyze visual vs auditory MEG response differences.
- Analyze the influence of directly modulating eye metrics in allowing casual modulation of brain state and behavior.

7. Conclusions

Behavioral: Pupil phase predicts changes in perception rate, not in reaction time.

Eye-tracking: *Visual:* Increased perception rate is associated with larger pupil size and pupil size variance, reduced blinking rate, and microsaccade rate. *Auditory:* Larger pupil size and pupil size variance are linked to increased perception rate. *Reaction time:* Decreased with stimulus strength across pupil size, pupil variance, blink rate, and microsaccade rate.

[1] Bradshaw, J. (1967) 'Pupil Size as a Measure of Arousal during Information Processing', Nature, vol. 216, pp. 515–516
[2] Kronemer, S.I., Bandettini, P.A. & Gonzalez-Castillo, J. Sleuthing subjectivity: a review of covert measures of consciousness. Nat. Rev. Neurosci. (2025). https://doi.org/10.1038/s41583-025-00934-1

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