Phase of pupillary unrest corresponds with perceptual sensitivity, MEG and whole brain fMRI signals

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#2468

Primary Aim: Track and map perceptual sensitivity and brain signals associated with pupil size changes in real-time.

1. Background

Perceptual sensitivity is closely linked to arousal/attention state regulated by neuromodulatory activity from the thalamus and brainstem [1]. These subcortical, arousal network foci are difficult to record. Therefore, an accessible, proxy measure of arousal would have numerous clinical and experimental benefits. One possible candidate is pupil size changes since it corresponds to widespread subcortical and cortical activity across species [2,3].

We aimed to: **(1)** examine how perceptual sensitivity changes are linked with the phase of pupil size and **(2)** track and map the brain activity associated with pupil phase.

2. Methods

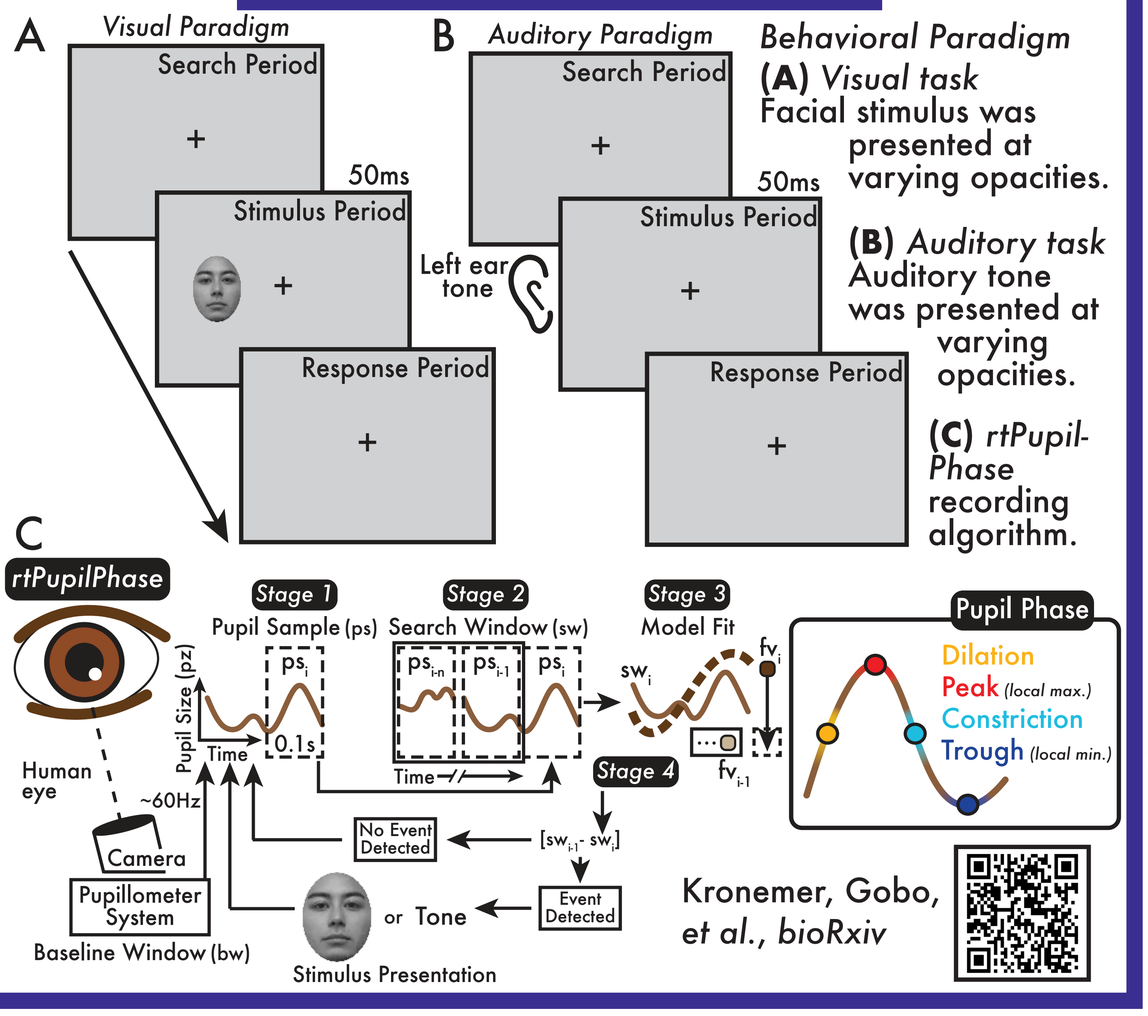
Participants: *Auditory task:* 33 adult participants; male = 13; mean age = 29.4 yrs; *Visual task:* 32 adult participants; male = 13; mean age = 29.8 yrs

Eye Tracking: EyeLink 1000 Plus (1000 Hz; right eye; SR Research, Inc.)

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

fMRI: 7T resting state with concurrent EyeLink (Human Connectome Project). 83 adult participants; male = 43; mean age = 27.34 yrs

3. Behavioral Task



Behavioral Paradigm

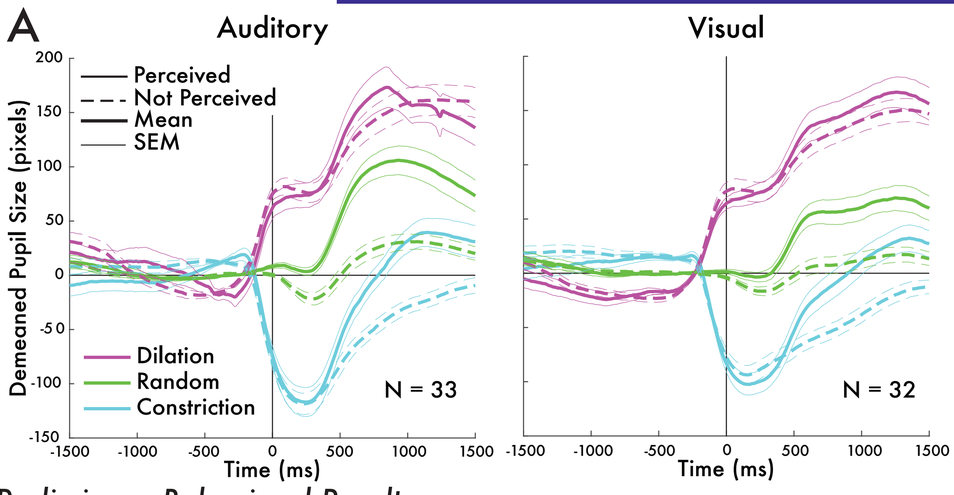
(A) *Visual task* Facial stimulus was presented at varying opacities.

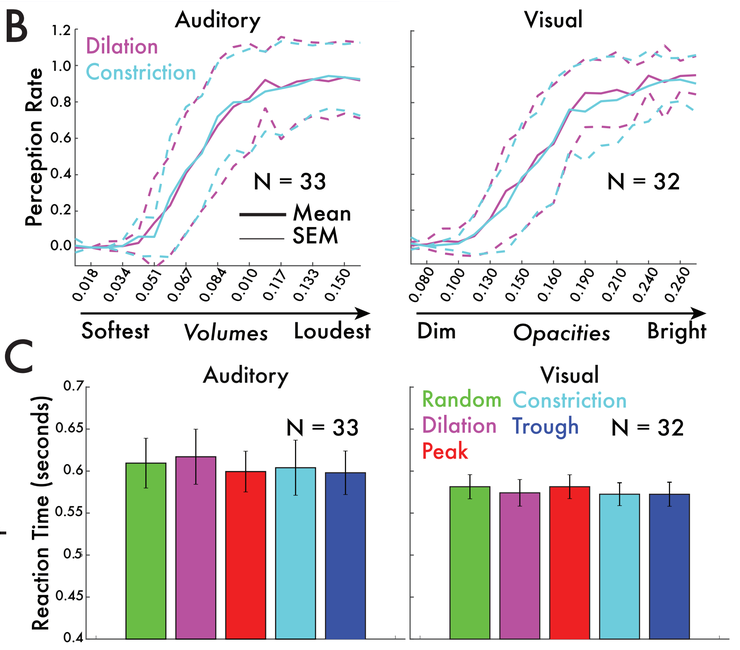
(B) *Auditory task* Auditory tone was presented at varying opacities.

(C) *rtPupilPhase* recording algorithm.

Kronemer, Gobo, *et al., bioRxiv*

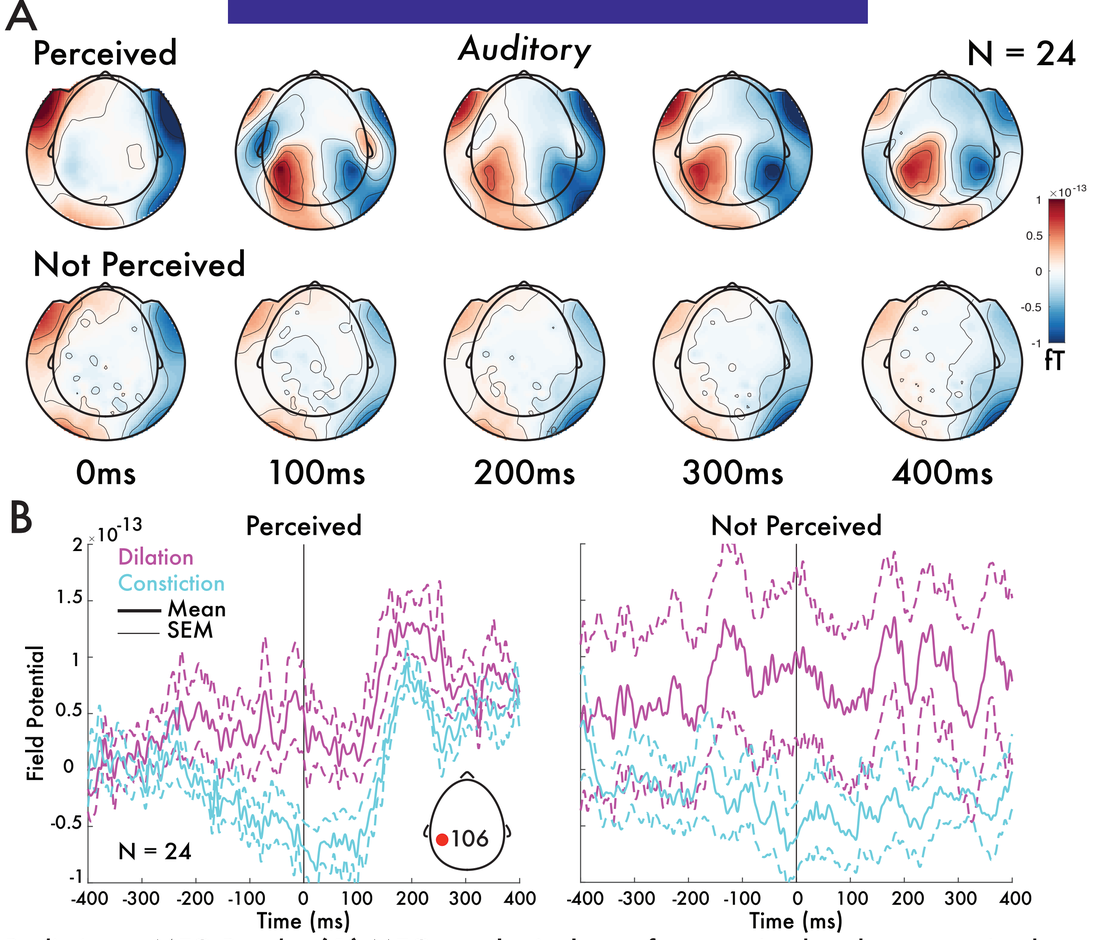
4. Behavioral/Eye Tracking Results





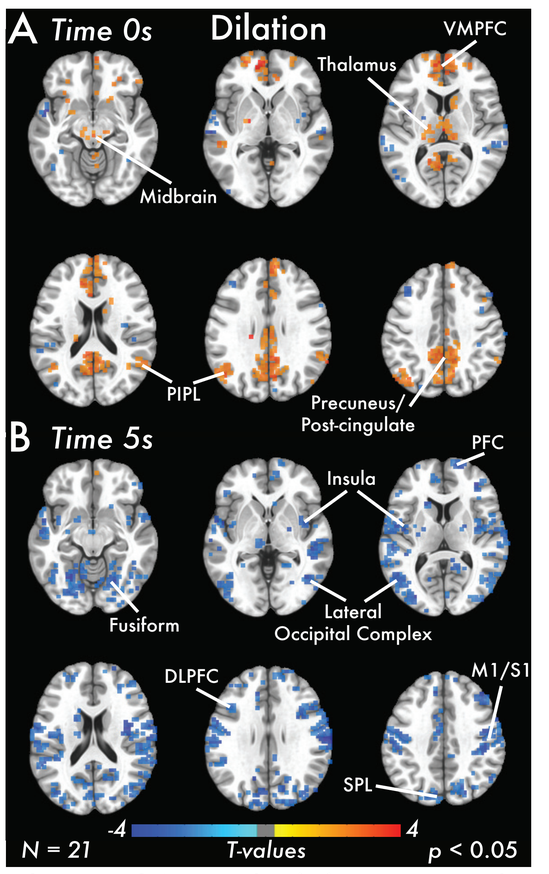
Preliminary Behavioral Results. **(A)** Perceived and not perceived pupil size changes before and following event detection for dilation,constriction and random events for auditory and visual tasks. **(B)** Psychometric curves for the auditory and visual tasks. **(C)** Reaction times for auditory/visual tasks.

5. MEG Results



Preliminary MEG Results. **(A)** MEG topological map for perceived and not perceived auditory stimuli. **(B)** Perceived and not perceived dilation and constriction timecourses before (-400ms) and after (+400ms) stimuluse onset (channel 106).

6. fMRI Results



Preliminary fMRI results. **(A)** Brain map when pupil size is in the beginning of a dilation. **(B)** Activity 5 seconds after dilation. Increases and decreases in T-values ($p < 0.05$).

7. Conclusions

Behavioral: Pupil phase does not predict changes in perception rate or reaction time.
Eye Tracking: Percieved/not perceived pupil size vary by pupil phase.
MEG: Perceived/not perceived events show differences in field potential. Pre-stimulus differences discriminate between dilation/constriction.
fMRI: Pupil dilation is linked to widespread brain fMRI signal changes.

8. Future Directions

- Analyze pupil phase by stimulus amplitude interactions in MEG and eye metric changes.
- Analyze visual versus auditory MEG responses differences.
- Analyze fMRI responses to other pupil phase events in the resting state data set.

[1] Setzer, B., Fultz, N.E., Gomez, D.E.P. et al. (2022), 'A temporal sequence of thalamic activity unfolds at transitions in behavioral arousal state.', Nature Communications vol. 13, 5442 (2022).
[2] Bradshaw, J. (1967) 'Pupil Size as a Measure of Arousal during Information Processing', Nature, vol. 216, pp. 515–516
[3] Kronemer, S.I., Aksen, M., Ding, J.Z. et al. (2022) 'Human visual consciousness involves large scale cortical and subcortical networks independent of task report and eye movement activity.' Nature Communications, vol. 13, 7342

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