Real time pupil size detection as a live marker of arousal state and perceptual sensitivity

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#2545

Introduction

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

Main Goal

Use pupil size as a reliable and effective indicator for changes in arousal state and perceptual sensitivity in real-time.

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Participants

5 healthy adult participants (mean age: 23.75 years); Target N = 35 with MEG

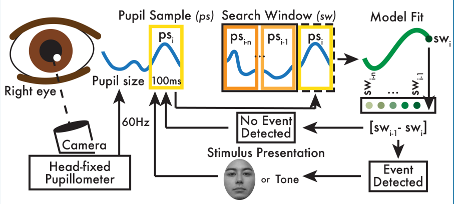
Method & Materials

Particpants completed a visual perception task while concurrently recording pupillometry and eye-tracking with the EyeLink 1000 Plus (1000Hz, SR Research, Inc.) sampling from the right eye.

Real-Time Pupil Modeling

A novel, real-time algorithm tracked pupil diameter and detected one of five pupil phase conditions: (1) peak, (2) trough, (3) falling, (4) rising, and (5) random times. The model first records pupil diameter and stores it. Then appends it to a collection of prevvious stored pupil size segments. A fit is done on these segments and the last point of the fit, indicating the direction of pupil size is stored. These points are then compared to determine if one of the conditions is met.

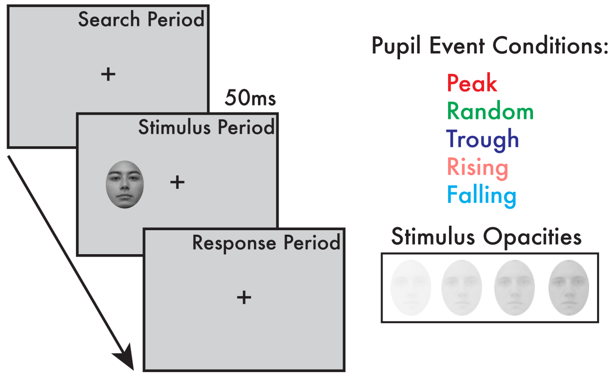
An overview of the model is presented below:



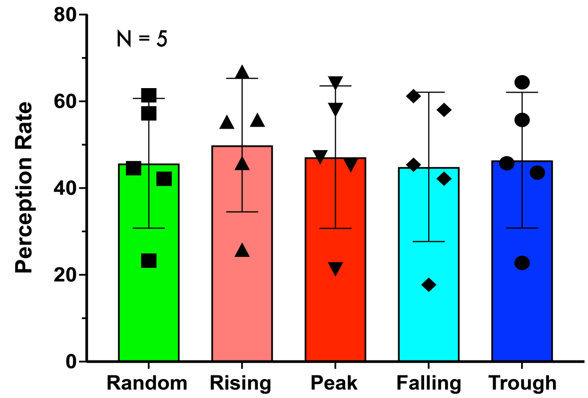
Behavioral Paradigm

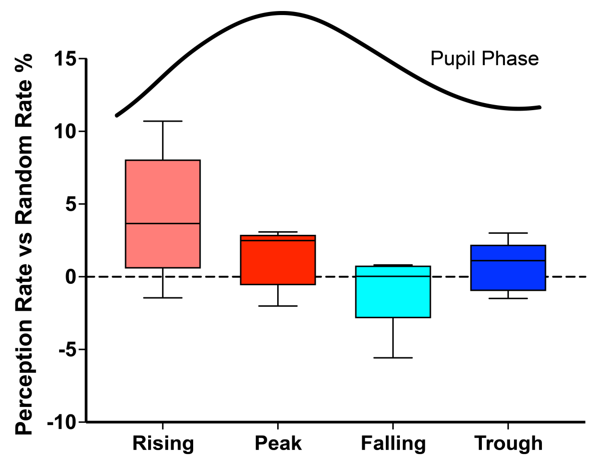
The behavioral task consisted of a main task phase, that was split up into 10-minute blocks across the entirety of the experiemental session. Participants responded with a button press to the same facial stimulus but presented at varying opacities ranging from 5% to 30% in steps of 1.5%. Perceived responses were confirmed stimulus location and response latency from the onset of the stimulus (<2s).

An overview of the behavioral paradigm is presented below:

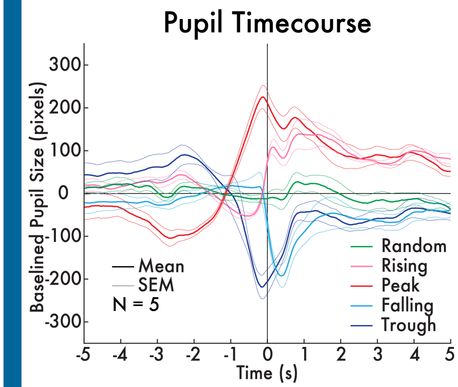


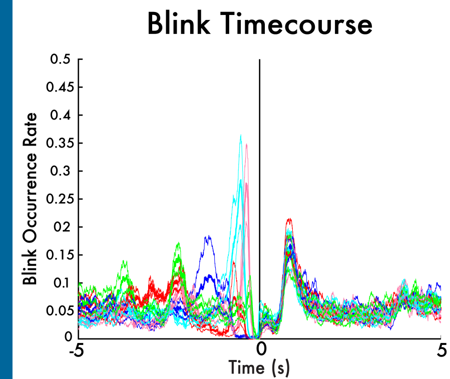
Behavioral Results





Pupil Results





Conclusions

(1) Pupil size phases can reliably be captured in real-time.
(2) Perception rate increases during pupil transitional phases (falling and rising).
(3) Similar perception-evoked pupil response found across all pupil phase conditions.

Future Directions

We intend to use this paradigm in conjunction with MEG collection to investigate the concurrent brain electrophysiology associated with pupil phase and changes in perceptual sensitivity state. An fMRI analysis with concurrent pupillometry will offer insight on the subcortical involvement.

References

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