Blumenfeld Lab EyeLink Dataset

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Brief Background:
Pupil diameter, blink, and eye gaze (e.g., saccades and microsaccades – involuntary, small eye movements) are predictors of cognitive and behavioral states **(1, 2, 3)**. For example, an increase in physiological arousal or locomotion may correspond with a dilating pupil. These measures may also predict conscious perception (i.e., if you noticed something in the environment) **(4)**.

References:

(1) McGinley, M. J., et al. (2015). "Waking State: Rapid Variations Modulate Neural and Behavioral Responses." Neuron 87(6): 1143-1161.
(2) Lee, A. M., et al. (2014). "Identification of a brainstem circuit regulating visual cortical state in parallel with locomotion." Neuron 83(2): 455-466.
(3) Einhauser, W., et al. (2010). "Pupil dilation betrays the timing of decisions." Frontiers in Human Neuroscience 4: 18.
(4) Einhauser, W., et al. (2008). "Pupil dilation reflects perceptual selection and predicts subsequent stability in perceptual rivalry." Proc Natl Acad Sci U S A 105(5): 1704-1709.

Primary Research Aim:
Can pupil, blink, microsaccade, or gaze data be used to predict conscious perception of target stimuli on a trial-by-trial basis? In other words, can these measures be used as a covert detector of conscious perception without overt report?

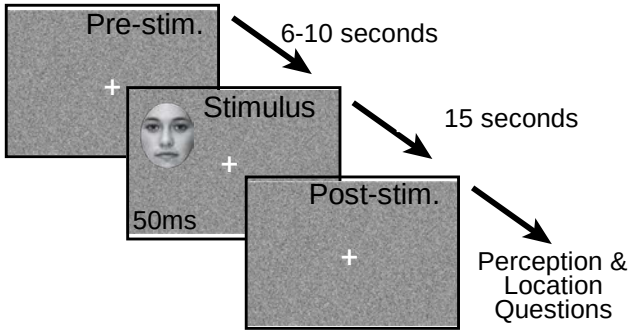
Visual Threshold Perception Paradigm:
Participants (n = 88, healthy adults, 19-43 years old) completed an at-threshold, visual perception task. This task consists of 4 main phases:

> **Phase 1 – Pre-stimulus:** participants fixate on a white cross overlaid over either a static noise background (as depicted below) or a narrated BBC fish documentary ("movie") background. This phase duration lasts 6-10 seconds.
>
> > **Note:** The purpose of the movie background is to stimulate a nearer to real-life sensory experience with competing visual and auditory stimuli.
>
> **Phase 2 – Stimulus:** the target stimulus, a face, appears in one of the four quadrants of the computer screen. The face appears for 50ms and the opacity of the face is set to the participants perceptual threshold (previous calibrated in a preceding task phase). This means, if the opacity is calibrated accurately and the participant is in the same relative brain-state as during the stimulus threshold calibration, the participants should only detect the stimulus 50% of the time.

Phase 3 – Post-Stimulus: following the stimulus presentation, the fixation cross and movie/noise backgrounds continue for 15 seconds.

Phase 4 – Questions: The trial is completed and participants are asked questions about whether or not they saw the stimulus and where it was located. These questions are used to confirm if they perceived the stimulus or not.

After responding to both questions, a new trial begins from the pre-stimulus phase. Participants typically completed ~128 trials broken up into four 32-trial study blocks. Participants are allowed to rest between blocks.



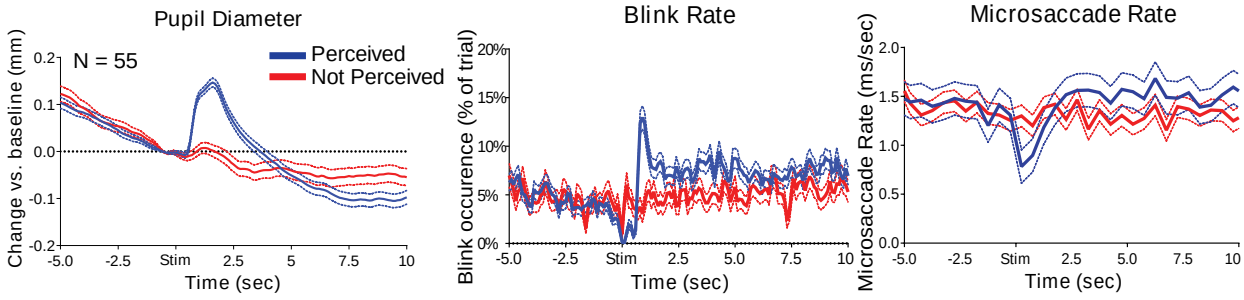
Two categories of trials for classification:

(1) **"Confirmed Perceived" (CP)**

(2) **"Confirmed Not Perceived" (CNP)**

Group Results:

Averaging over all trials there are transient changes in pupil diameter, blink, and microsaccade rates that are present for perceived (CP) and absent for not perceived (CNP) trials after the onset of the target stimulus (Stim).



Note: The actual single-trial data of course looks much noisier than the above plots!

GOAL: Correctly identify as many trials as CP as possible.

We are not interested (for now) in the correct classification of CNP trials.

Metrics for Success:

TP = number of true positive trials (i.e., trials classified as CP that were actually confirmed as perceived based on participant questions).

FP = number of false positive trials (i.e., trials classified as CP that were NOT confirmed perceived based on participant questions).

We require:

1. Positive predictive value or precision (TP/TP+FP) **≥ 0.90**

2. Total number of trails classified as CP (TP+FP) **should be maximized**

Dataset Technical Details

Pupillometry Recording Equipment:

System: EyeLink 1000 Plus
Sample rate: 1000 Hz
Recording mode: Binocular and head fixed (i.e., head is stabilized in a head/chin rest)

Overall Data Details:
Details of the dataset shared with you:

(1) All participants completed the visual perception paradigm described above.

(2) These data are aggregated across 4 studies (3 behavioral studies and 1 electroencephalography study). Some participants are repeated in the dataset because they volunteered in 2 or more of these studies (i.e., not all participants are equally represented in the dataset).

(3) Target stimulus (face) opacity is always set to the individual's perceptual threshold.

Note: The opacity value can be updated between task blocks and across study sessions within participants.

Data Types:

(1) Pupil Diameter – Left and right eye pupil diameter in millimeters.

(2) Eye Gaze – Left eye x-position and y-position; right eye x-position and y-position in pixels; position (0, 0) corresponds with the top left of the computer screen, and (1280, 768) corresponds with the bottom right of the computer screen.

Note: The values may exceed the bounds of the screen during blinks or pupillometry recording artifact events.

(3) Blink occurrence – Left and right eye blink events.

(4) Microsaccade occurrence – Binocular microsaccade events.

CSV Files:

General Notes: Each row of the csv files correspond to a single trial. There are 5822 trials (3700 CP trials and 2122 CNP trials). Some data types have left and right eye information. The data for the left and right eyes should largely overlap and utilizing data form a single eye may be sufficient for a high performing classifier. These data have already been excluded: trials when a blink has occurred during the stimulus onset and when blink occludes the majority of the data epoch.

(1) **trialtype.csv**
- **i. Column 1:** Study session type - “Report” or “No Report...”
- **ii. Column 2:** Screen background type - “Noise” or “Movie” (Noise = static noise background; Movie = BBC documentary movie background)

Note: Despite different study session types and screen background types, you are likely able to consider all these data together.

(2) **subject.csv**
- **i. Column 1:** Subject anonymous ID number.

(3) **quadrant.csv**
- **i. Column 1:** Screen quadrant in which the target stimulus (face) appeared (1 = top left corner; 2 = top right corner; 3 = bottom left corner; 4 = bottom right corner)

(4) **condition.csv**
- **i. Column 1:** True class of the trial (CP = confirmed perceived; CNP confirmed not perceived).

(5) **opacity.csv**
   i. **Column 1:** The opacity value for that particular trial. Opacities range from 0 (not visible) to 1 (fully opaque).

(6) **rawGazeRY.csv** (gaze position for the right eye in the y-position - pixels)
   i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 1-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(7) **rawGazeRX.csv** (gaze position for the right eye in the x-position - pixels)
   i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(8) **rawGazeLY.csv** (gaze position for the left eye in the y-position - pixels)
   i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(9) **rawGazeLX.csv** (gaze position for the left eye in the x-position - pixels)
   i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(10) **rawBlinkLogicalR.csv** (blink occurrence right eye; 0 = no blink; 1 = blink - 0s, 1s)
   i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(11) **rawBlinkLogicalL.csv** (blink occurrence left eye; 0 = no blink; 1 = blink - 0s, 1s)
   i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(12) **microsaccadeBinoc.csv** (microsaccade occurrence both eyes; 0 = no microsaccade; 1 = microsaccade - 0s, 1s)

i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

(13) **interpPupilL.csv** (pupil diameter left eye)

i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

ii. **Data preprocessing:** linear blink interpolation (i.e., blink events are cut from the pupil diameter data).

Note: The blink interpolation causes "edge effects" at the beginning and end of the pupil diameter data.

(14) **interPupilR.csv** (pupil diameter right eye)

i. **Columns:** Each column corresponds with a time point (1 ms interval; 1000 Hz sampling rate). Samples/Columns 0-6000 = pre-stimulus phase; Sample/Column 6001 = time of stimulus onset; Samples/Columns 6051-12000 = post-stimulus phase

ii. **Data preprocessing:** linear blink interpolation (i.e., blink events are cut from the pupil diameter data).

Note: The blink interpolation causes "edge effects" at the beginning and end of the pupil diameter data.

Some Clues:

Each trail includes data from 6 seconds before the stimulus till 6 seconds after the stimulus, and do not include earlier or later times as they are less likely to be useful. We only include data from "Phases 1, 2 and 3" above not "Phase 4" of the perception paradigm. In other words, we include Pre-stimulus, Stimulus and Post-stimulus data but do not include data from the Question and Answer period.

Sample/Column 6001 = time of stimulus onset. In our preliminary analyses we found the most useful information for classifying the data was in the ~3s after stimulus onset when the most obvious changes occur on average (see above average timecourse plots, but you may find something different!)

Good luck!