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**Experiment Title:** Replication of published reports of pupil constriction to illusory glare

**Research Project:** Glare illusion pupil constriction: perception, pupillometry

## **Purpose and Approach**

The size of the pupil adjusts automatically when the eye is exposed to different intensities of light. The glare illusion is an annular stimulus that induces a percept of central brightness. A greater pupil constriction to this stimulus has been reported as compared to various control stimuli (Tamura 2016), although it is not clear in these studies if the control stimuli match the glare stimulus in integrated luminance. The purpose of this project is attempt to replicate the claimed greater pupil constriction to illusory glare in normally sighted control subjects, making use of appropriate control stimuli.

## **Subjects**

We will collect a complete dataset from 15 headache-free control subjects. Our manner of screening subjects and declaring them as headache-free will follow our prior pre-registration ([https://github.com/gkaguirrelab/preregistrations/tree/master/squint\\_2018](https://github.com/gkaguirrelab/preregistrations/tree/master/squint_2018)). Some of the subjects we study will be drawn from the population of headache-free controls that were studied in this prior project.

## **Subject Preparation**

At the start of a data collection session, subjects will be acclimated to the experimental room. The operator will then review the experimental procedure with the subject and adjust the apparatus for subject comfort. The IR video camera will be adjusted to view the left eye of the subject.

## **Apparatus**

Stimuli are presented on the Metropsis display and controlled using the Metropsis software running on a Mac connected to the display. Subjects will observe the stimuli binocularly, while seated on a chair facing the display with their head secured on a chin rest to keep a constant distance from the display. Subjects wore a headset with an IR video recording camera pointed at the left eye.

## **Stimulus**

We used 3 profiles of radial stimuli with a center and a surround, placed on a background. The surround can contain a gradient that changes in contrast linearly from the inner ring of the surround annulus to the outer ring. We used a MATLAB script to calculate the average contrast

across the surround given the contrast value selected for the center and background. Contrast is specified in the range of -1 to 1, with the half-on state of the display at zero, and the max and min primary settings corresponding to -1 and 1, respectively. This contrast convention is what is used by the Metropsis / Psykinematix system used to create the stimuli. The values defined for the inner and outer radii of the surround for these stimuli created equal integrated contrast across all three stimuli types.

Subjects are presented with one stimulus at a time, with diameters of the outer and inner stimulus boundary at 9 degrees and 3.4 degrees of visual angle, respectively. The background was uniform, with a black fixation dot in the center appearing whenever a stimulus was not present on the screen. The 3 profiles presented were Glow, Halo, and Uniform. All three stimuli had a center contrast value of 1. Glow had a linear profile, which modulated from a contrast value of -0.5 on the outer boundary of the surround region to a value of 1 on the inner boundary. Halo had a similar profile as Glow but the direction of the gradient was reversed. Uniform had a uniform contrast value of 0.137 in the surround region. These stimuli all had nominally equivalent integrated luminance across the display.

## **Trial Design**

Each trial in the experiment begins with a 100ms tone that sends out a TTL pulse upon onset. This pulse is sent to another Mac laptop which is set to record using MATLAB. When it receives the pulse as a 't' button press there is a variable delay of 0-500ms, after which the camera begins recording for that trial and the stimulus is presented after a 1000ms delay. The camera records for 4s and then processes the trial video. There is a 1.25s window between the recording ending and the next trial start to allow time for MATLAB to save the previous video and be ready to receive the next TTL pulse. The only other luminous object in the room is the Mac monitor running the Metropsis software, which is set to the lowest possible brightness. Stimuli are presented in randomized order between the three possible profiles, Glow, Halo, and Uniform. Subjects will sit for 42 trial blocks (14 trials per profile) and then be allowed a brief break before starting the next block. Each session will consist of four of these blocks and subjects will participate for a total of one session each.

## **Pupillometry**

We will measure pupillary light reflex from the subject's left eye as they observe the stimuli as described above. The pupil response will be measured using an infrared camera (Pupil Labs EyeTracker). This video output will be processed using open source code (<https://github.com/gkaguirrelab/mtrpGlarePupil>) to extract pupil size as a function of time over each trial.

## **Exclusion Criteria**

We will exclude subjects on the basis of poor quality pupil data. Data from a single block will be discarded if 25% of data frames are deemed "bad" by the tracking algorithm. If for a given

session, 75% of all trials within a given stimulus type are discarded (Halo, Glow, Uniform), or 50% of total trials across all stimulus types are discarded, all data from this session will be excluded.

If a session is excluded due to poor quality pupil data, the subject may be rescheduled for additional sessions; this decision will be made on a subject-by-subject basis after consideration of the factors that contributed to poor data quality.

## **References**

Tamura, Hideki, Shigeki Nakauchi, and Kowa Koida. "Robust brightness enhancement across a luminance range of the glare illusion." *Journal of vision* 16.1 (2016): 10-10.