Regulation of Pupil Size Under Real-World Conditions

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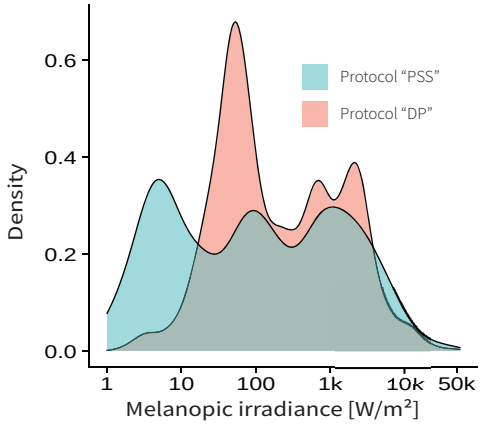
Introduction

Pupil diameter is a non-invasive biomarker for the clinical assessment of retinal and neurological conditions. Steady-state pupil size is primarily determined by the activity of the intrinsically photosensitive retinal ganglion cells (ipRGCs), expressing the photopigment melanopsin. From controlled laboratory studies we know that melanopic radiance drives pupil size, but there is a lack of data in real-world light exposure. **Here, we demonstrate a novel method to assess the light inputs regulating pupil size under dynamic real-world conditions.**

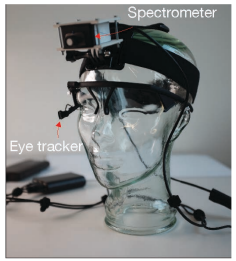
Methods

We integrated a wearable infrared video-based eye tracker (Pupil Labs GmbH) with a small-scale spectroradiometer (Ocean Insight Inc.) and attached to a bespoke 3D-printed adjustable head mount.

Both devices were connected to a miniature, battery-driven control computer (Raspberry Pi), enabling simultaneous sampling of pupil size and spectral irradiance at 10-sec intervals.

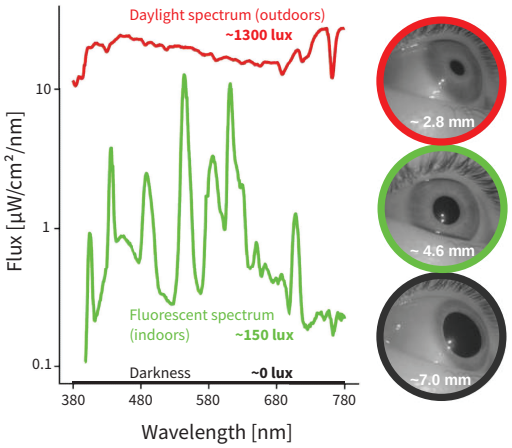


In both protocols healthy, young participants (n = 7, age: 20-30 years) moved in and between indoor and outdoor environments varying in light conditions and engaged in a range of everyday tasks.



We measured natural variation in pupil size across two protocols:

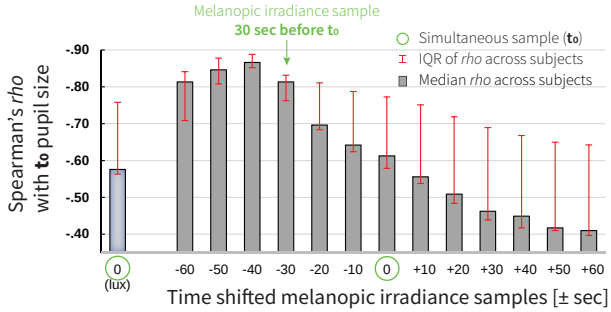
I. "Pilot series" ("PSS", n = 5), each 1× 50-min session in the institute.
II. "Deep phenotyping" ("DP", n = 2), each 10× 70-min sessions in home environment.



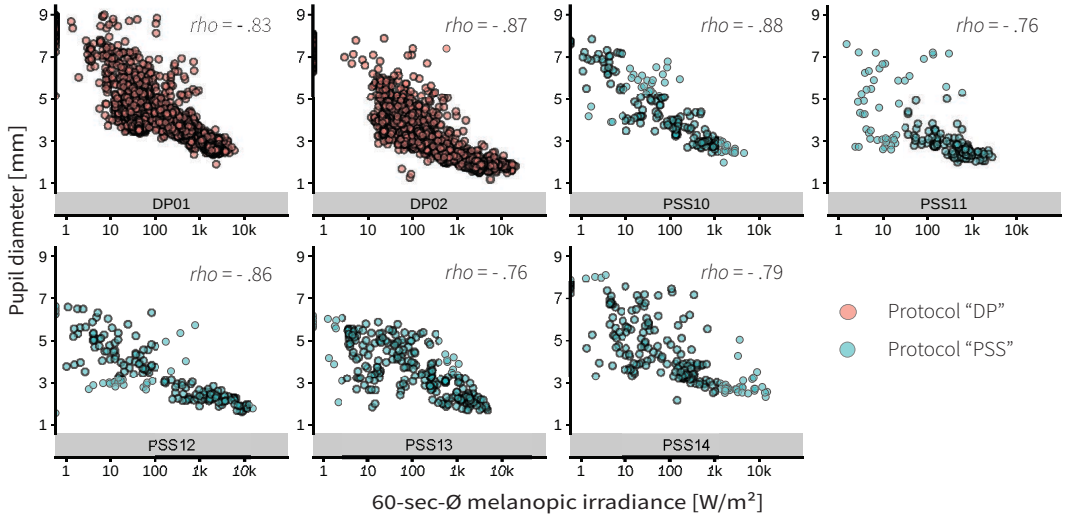
Results

We succesfully measure variation in pupil size as a function of near-corneal melanopic irradiance in the real world, yielding distinct dose-response curves for each participant.

Under these uncontrolled conditions, data retention was reasonably high (~65% data retained).



In line with slow melanopsin signalling, pupil size was more accurately predicted by integrating preceding melanopic irradiance values (60-sec window) than the simultaneous samples.



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Key References

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