Measurement of light-mediated changes in pupil size under real-world conditions

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Introduction

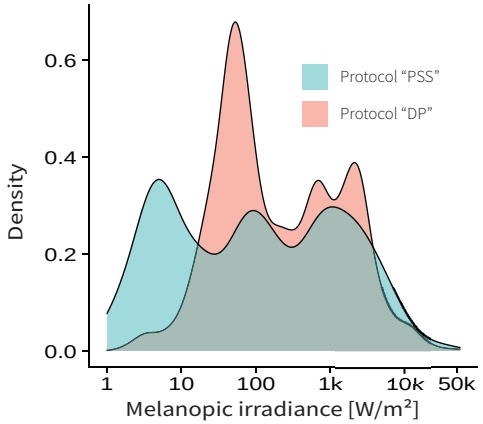
Pupil size is sensitive to a variety of higher-level processes including attentional shifts, target detection and cognitive load. At a lower level, pupil size is a non-invasive behavioural readout of visual and non-visual processing in humans, determined largely by the melanopsin-mediated stimulus on the retina.

Here, we demonstrate a method to assess the light inputs regulating pupil size under dynamic real-world conditions.

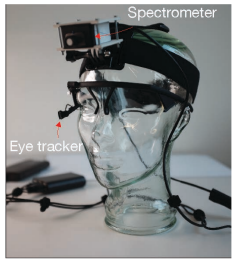
Methods

A wearable infrared video-based eye tracker (Pupil Labs GmbH) was integrated 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.



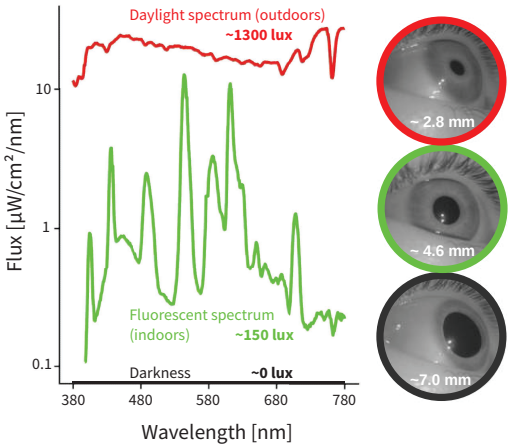
In both protocols healthy, young participants (n = 7, age: 20-30 years) moved in and between indoor and outdoor environments varying in light conditions and engaged in a range of everyday tasks.



We measured natural variation in pupil size across two protocols:

I. "Pilot series" ("PSS", n = 5), each 1× 50-min session in the institute.

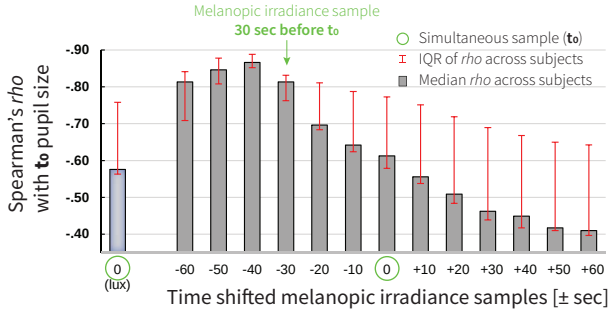
II. "Deep phenotyping" ("DP", n = 2), each 10× 70-min sessions in home environment.



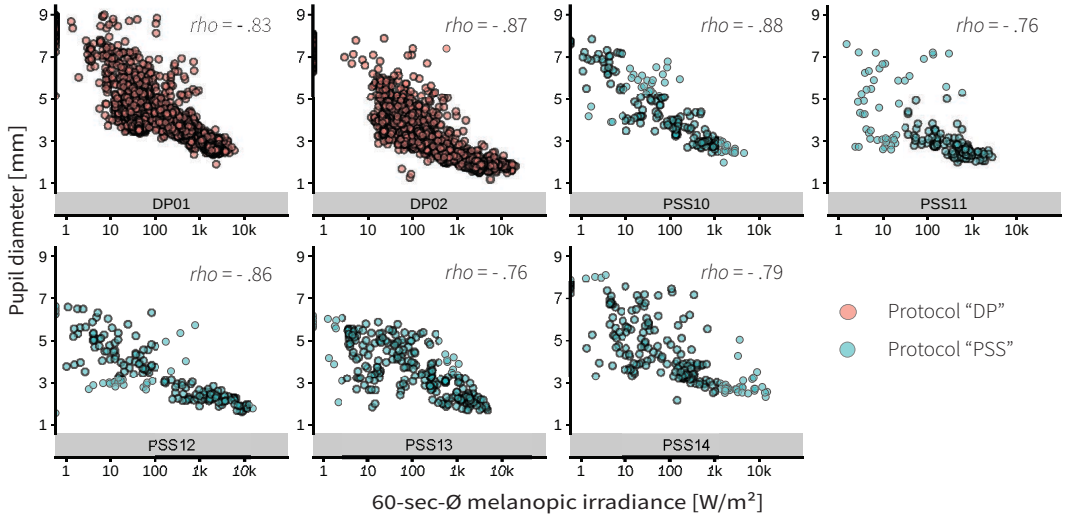
Results

We accurately predict 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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