


LATVIJAS UNIVERSITĀTE
 ANNO 1919
INSTITUTE OF SOLID STATE PHYSICS UNIVERSITY OF LATVIA


ESF
 EIROPAS SOCIĀLAIS FONDS
 EIROPAS SAVIENĪBA
 IEGULDĪJUMS TAVĀ NĀKOTNĒ

System for melanopsin related pupillometry

S.Fomins, B. Zutere, G.Krūmiņa
 UL ISSP
 Biology Faculty UL
 Optometry and Vision Science Department UL
 Riga, April 10th, 2015

ESF projekts Nr.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001
 "Redzes pārslodzes fizioloģijas pētījumi un redzes stresa diagnostikas metodikas izstrāde"

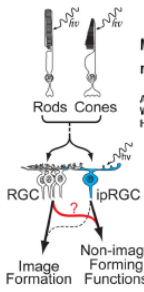

DEVELOPMENTS in Optics and communications 2015

Presentation plan

- What is melanopsin?
- Pupillometry.
- What and why we do.

Melanopsin

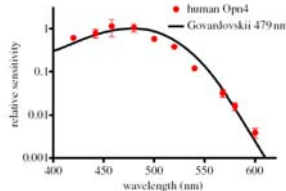
Nature, 2008 May 1, 453(7191): 102–105. doi:10.1038/nature06820



Melanopsin cells are the principal conduits for rod/cone input to non-image forming vision

Ali D. Güler^{1,*}, Jennifer L. Ecker^{1,*}, Gurpreet S. Lal^{2,†}, Shafiqul Haq³, Cara M. Altimus¹, Hsi-Wen Liao³, Alun R. Barnard², Hugh Cahill³, Tudor C. Badea⁴, Haiqing Zhao¹, Mark W. Hankins⁵, David M. Berson⁶, Robert J. Lucas^{2,†}, King-Wai Yau³, and Samer Hattar^{1,†}

“Photodian” luminous efficiency function C_λ



Rea MS, Figueiro MG, Bullough JD, Bierman A (2005) A model of phototransduction by the human circadian system. *Brain Res Rev*, 50:213–28.

Gall, D Bieske, K (2004) **Definition and measurement of circadian radiometric quantities.** *Proceedings of the CIE Symposium '04 on Light and Health*. Vienna: Commission Internationale de l'Éclairage, pp. 129–32.

*Bailes HJ, Lucas RJ. (2013) Human melanopsin forms a pigment maximally sensitive to blue light (Imax 479 nm) supporting activation of Gq/11 and Gi/o signalling cascades. *Proc R Soc B* 280: 20122987.

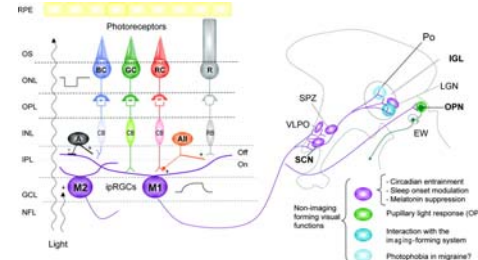
Robert J Lucas et al. (2014) Measuring and using light in melanopsin age. *Trends in Neurosciences*, 37(1), p.1-9.

Melanopsin and pupil

- Melanopsin is found in ~ 2.5% of the total rat retinal ganglion cells (RGCs).
- Melanopsin containing cells project to suprachiasmatic nuclei (SCN).
- Melanopsin expressing axons directly target the SCN suggesting that melanopsin is important in entrainment through the retinohypothalamic tract (RHT).

Hattar S, Liao HW, Takao M, Berson DM, Yau KW (Feb 2002). "Melanopsin-containing retinal ganglion cells: architecture, projections, and intrinsic photosensitivity". *Science* **295** (5557): 1065–70.

Melanopsin and pupil



SCN-suprachiasmatic nuclei
 OPN-olivary pretectal nuclei
 EW – Edinger-Westhal nuclei

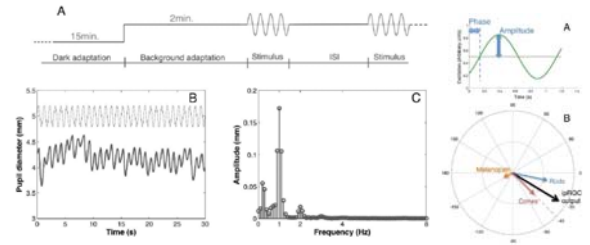
<http://www.neurology.org/content/76/16/1422/F1.expansion.html>

Pupillometry

- Pupillometry is about 50 years old technique.
- Mental and neural activity indicator.
- Non-invasive.
- Pupil reaction occur in the absence of voluntary, conscious processes.

Laeng B., Sirois S., Gredeback G. (2012) Pupillometry; A window to the preconscious? Perspectives on psychological science 7(1), p.18-27.

Proposed analysis



Barrionuevo PA, Nicandro N, McAnany JJ, Zele AJ, Gamlin P, Cao D. Assessing rod, cone, and melanopsin contributions to human pupil flicker responses. Invest Ophthalmol Vis Sci. 2014;55:719–727.

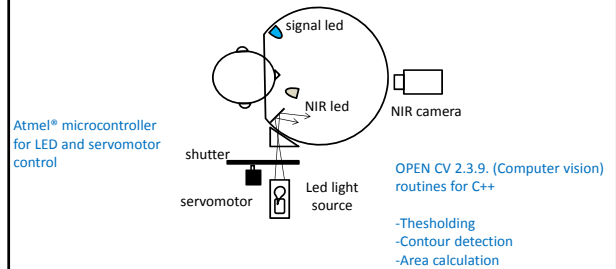
Our approach

- **Aim1:** to relate the pupil reaction through the daytime to mental/visual fatigue
- **Aim2:** evaluate the illumination impact on melanopsin signal

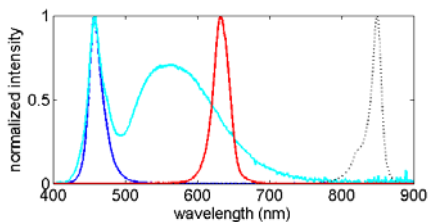
- 15 inch sphere as Ganzfeld
- NIR filtered high frame rate CCD
- Almost monochromatic light



System overview

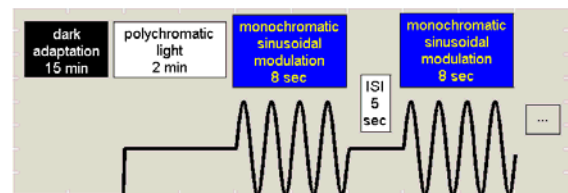


Spectral characteristics of light stimulation

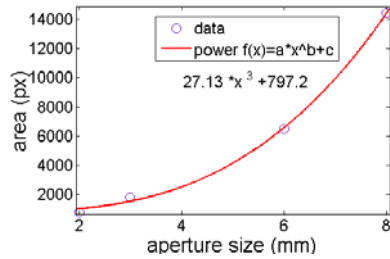


Peak (nm)
 Blue - 457
 Red - 630
 NIR - 850
 Cool white 6000K

Measurement protocol

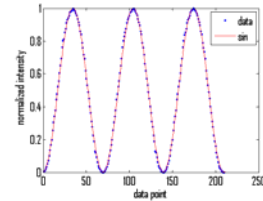


Area to pupil size

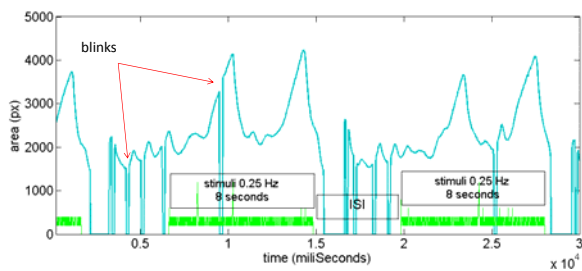


Sinusoidal light modulation

- Easy to achieve with LED and pulse width modulation (500Hz).
- Not so easy with real illumination. However, circular aperture provide excellent sinusoidal light modulation.



Raw measurement data



Conclusions

- High frame rate (180Hz) system for pupil size tracking is developed.
- Light modulation: LED or any other source/monochromator.
- Equipped with necessary triggers and measurement protocols.

Future work

- FFT application to distinguish the cone signals from melanopsin signal.



Thank you!

Work is supported by

ESF project No.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001



IEGULDĪJUMS TAVĀ NĀKOTNĒ