Can light affect Brain Connectivity?

ELIF NAZ GECER (e.gecer@tue.nl) MSc.

Supervisors: PR.DR.IR. KARIN SMOLDERS[1], DR.IR. LUC SCHLANGEN[1], PR.DR.IR. YVONNE DE KORT[1]

EFFECTS OF LIGHT ON THE BRAIN

The discovery of a new retinal photoreceptor type called ipRGCs has stimulated interest in the study of the non-visual effects of light.[2] The ipRGCs exist in the inner retinal layer and they are the primary input for the non-image forming (NIF) pathway, which also originates in the eye but takes a different route than vision to influence perception reaching different parts in the brain that are strongly related to cognition, attention, alertness, arousal and sleep. **In this study we are investigating the effects of daytime light exposure on the brain by specifically targeting the ipRGCs with metameric light.**

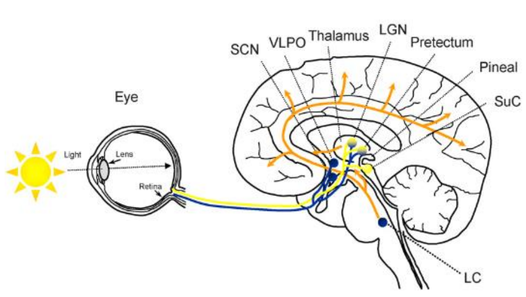

Figure 1. Pathways for light-induced activation of non-visual brain areas.[2]

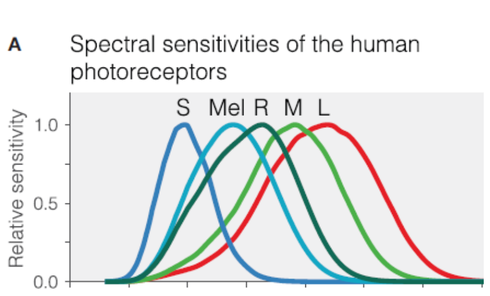

Figure 2. Spectral sensitivity curves of cones(S, M, L) , rod and ipRGCs.[3]

INPUT: METAMERIC LIGHT

In order to be able to target the ipRGCs specifically we are using two metameric light conditions that virtually look the same to a human observer but with different spectral characteristics.

For the calculation of the metameric light an optimization problem is formulated. A Constrained Nonlinear Programming algorithm is then used with the objective function set to maximize the melanopsin activation while keeping the activation of the cones at a constant level.

Figure 3. LightBox used in the experimental setup, contains 11 LEDs and forms a Ganzfeld-like Illumination

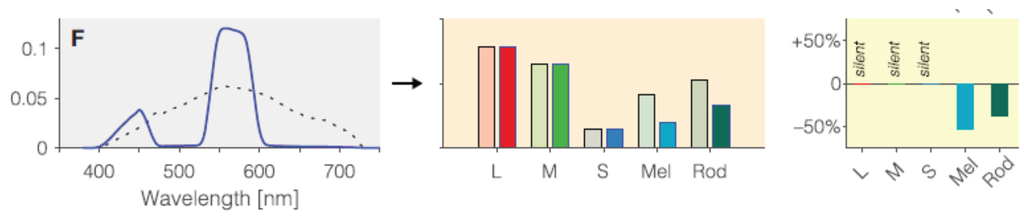

Figure 4. Silent Substitution Method is where the activation of the retinal photoreceptors are kept the same while creating a contrast for the desired photoreceptor group. In the above example only the levels of ipRGCs (melanopsin) and Rod activations are nonzero when the lighting condition is compared to the background condition.

EXPERIMENTAL DESIGN

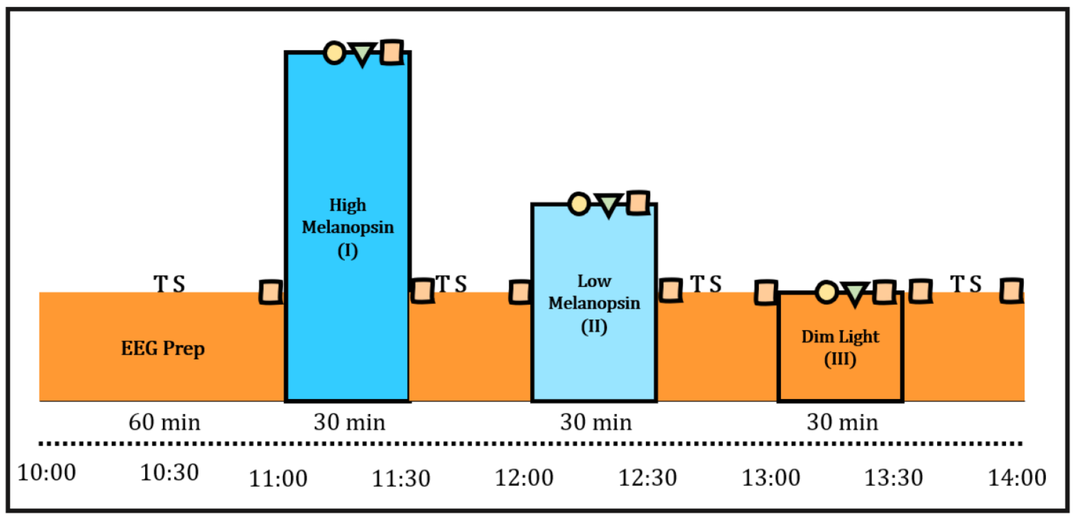

Figure 5. Visualization of the experimental light conditions (High Melanopsin, Low Melanopsin and Dim Light sessions of 30 minutes). The shapes indicate the timing of the tasks. The order of the conditions are counterbalanced across subjects

The main outcome measure of this experiment is the EEG derived metrics, the secondary outcome measures are performance metrics, and subjective assesments.

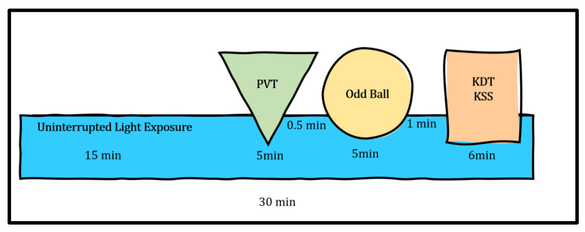

Figure 6. During the experimental conditions participants are asked to perform short tasks (PVT, Oddball) and complete subjective assessments.

OUTPUT: NEUROIMAGING DATA

To quantify the NIF effects of light we used EEG, a noninvasive neuroimaging method, to continuously monitor the brain activity of the participants as they go through different lighting conditions.

It is possible to derive different metrics from the EEG data. The main focus of this study will be to compare the EEG Connectivity Measures across the lighting conditions but other metrics such as EEG Power Spectral Measures and ERP measures will also be investigated.

We expect to find higher overall brain connectivity in the highest melanopsin condition in comparison to low melanopsin and dim light conditions.

Figure 7. TMSi SAGA 64+ EEG used in the experiment

This project is a part of the ETN LIGHTCAP, under the Marie Skłodowska-Curie actions framework. You can get more information about the project and the research team at this link:

[1] Eindhoven University of Technology, IEIS

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[4] Spitschan, M., & Woelders, T. (2018). The method of silent substitution for examining melanopsin contributions to pupil control. Frontiers in neurology, 9, 941.

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