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Impact of light incidence on acute alertness

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Non-image-forming (NIF) effects of light are elicited by numerous parameters, such as illumination level, spectral power distribution, spatial light distribution, duration and timing of the exposure and light history preceding the actual exposure. While the dependencies between most of these criteria and NIF effects have been elaborately studied, only a few studies investigated the effect of light incidence. These analysed the influence of the illuminated parts of the retina on melatonin suppression and phase shift under nighttime conditions. The results showed that density respectively sensitivity of the intrinsically photosensitive Retinal Ganglion Cells (ipRGCs) is highest at the lower (Lasko et al. 1999, Smith et al. 2002 and Glickman et al. 2003) and at the nasal part of the retina (Visser et al. 1999, RÃ¼ger et al. 2005). Beyond that, binocular illumination is more efficacious in melatonin suppression if compared to monocular illumination (Brainard et al. 1997 and Wang et al. 1999). Therefore, it is possible to preliminary define relevant areas within the field of view for ipRGC-influenced light (IIL) responses (see Figure 1).

Figure 2 shows four clearly different lighting scenes, which are for now assumed to be identical conditions in NIF studies, due to their comparable vertical illuminance and melanopic-weighted radiant incidence at the eye. This example points out that the illuminance or irradiance might not be the adequate measure to quantify the stimulus for IIL responses and NIF effects correctly, if retinal sensitivity plays a role. Since they are spatial integral measures. For comparison and to evaluate how the incident angle affects these effects, the accurate spatial description of the applied lighting condition is of utmost importance.

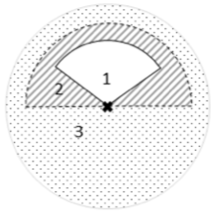

Figure 1: Suggested regions in the observed hemisphere which are critical in terms of IIL responses. region 1: very important, region 2 less important, region 3 is said to have no effect

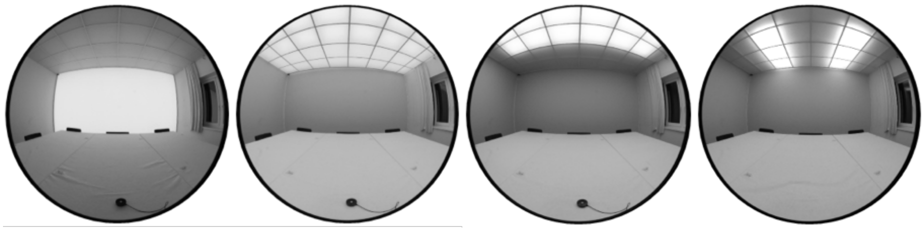

Figure 2: Four different lighting scenes which are comparable in terms of vertical illuminance and melanopic-weighted radiant incidence at the eye

The proposed study will investigate the impact of luminance distributions in day- and night-time condition on acute alertness in two different experimental setups. Acute alertness as a measure of NIF-effects is chosen due the possibility to be assessed in both, subjective and objective ways and in day- and night-time condition. It will be evaluated in a test block by performing reaction time tests, e.g. Psychomotor Vigilance Task (PVT) and Stroop test, and self-assessment questionnaires, e.g. Karolinska Sleepiness Scale (KSS). The first setup consists of one half of an integrating sphere which provides a homogeneously illuminated hemisphere and is set to a constant vertical illuminance and melanopic-weighted radiant incidence at the eye. Two conditions will be evaluated, a supposed effective condition (light predominantly coming from region 1 and 2) and a no or less effective condition (light predominantly coming from region 3) both in night and day time. Specially adapted glasses will be used to restrict the observer's field of view (FOV) accordingly. This setup is intended to demonstrate the applicability of acute alertness instead of melatonin suppression as a measure of NIF-effects in night time and its transferability in day time.

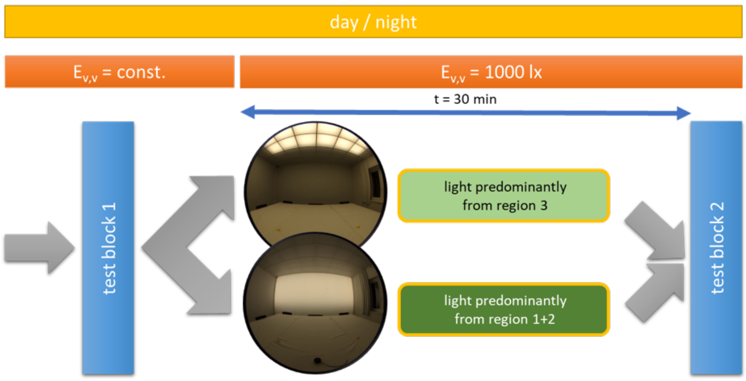

Figure 3: Schematic of lighting scenes and conditions

The second setup is a more realistic office-like test room with the possibility to freely adjust the luminance distributions at walls and ceiling. They will be set according to the two above mentioned conditions. Here this setup is intended to demonstrate the transferability in office-like workplaces and will therefore only be used in day time. A constant spectrum will be used throughout conditions and setups. In both experiments, conditions are presented in randomized order and before exposure begins a test block will be performed to define the baseline values and after 30 minutes of exposure it will be conducted again. While exposure subjects are required to maintain a fixed gazing direction, which will be recorded by eye tracking as well as pupil diameter. Room parameters like ambient air carbon dioxide content and temperature will be recorded, too.

Differences between the baseline and after exposure values will be used as measure for the impact on acute alertness and as indicator for NIF-effects. Before starting the experiment, subjects will be checked for vision disorders and parameters like age, chrono type, light history, caffeine consumption and other performance influencing substances, health status, sleeping hours and time of waking up will be recorded and checked for influence. Each subject will conduct all conditions (at least per setup) to minimize interindividual differences in light incidence sensitivity.

I expect the summer school to provide a very useful insight into the variety of psychological experimental designs. My aim for the focus group is to evaluate and optimize my experimental design and the choice of the psychological tests especially from a psychological point of view.