PERCEIVED AND YET NOT SEEN: NON-VISUAL EFFECTS IN DAYLIT SPACES

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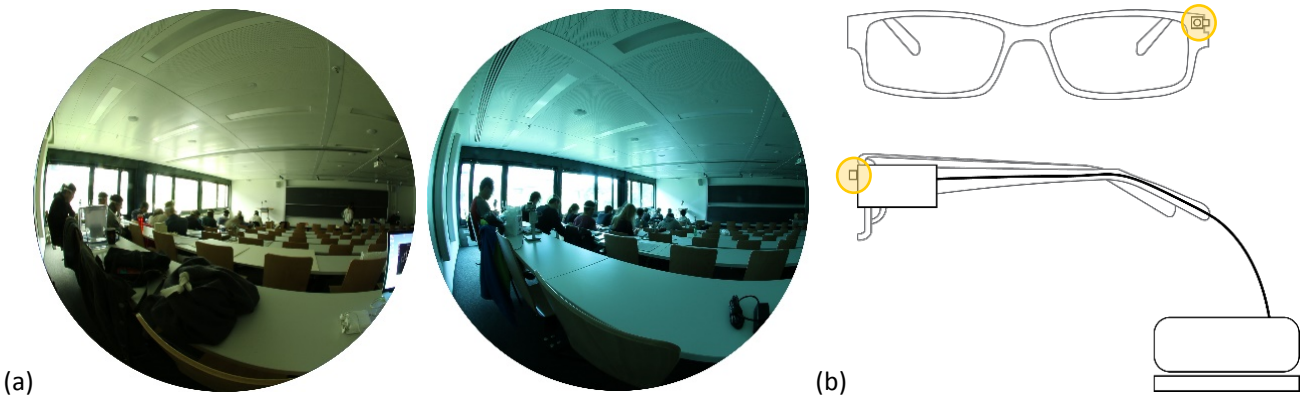
1. ABSTRACT

Findings from neuroscience are increasingly interwoven with architectural research (1,2). Understanding physiological responses to environmental stimuli in the built environment is critical when evaluating occupant health and wellbeing. Research in the field of photobiology has shown that lighting conditions can significantly alter our circadian rhythms through the non-visual system (3,4). This might result in acute changes regarding fatigue, vigilance or cognitive performance during our daily routines (6). Among the variety of architectural parameters of relevance to lighting design (e.g. orientation, material choice, environmental conditions…), the challenge is to determine which specific features, if any, have a significant influence on the physical properties of light initiating a neurobehavioral process.

Until recently, most of the studies on the non-visual system were done at night with controlled light exposure. In order to test if realistic daylight exposure during working hours triggers physiological and behavioural responses, we designed a field experiment at the EPFL (Switzerland) to monitor different lighting conditions. The experimental conditions were created using an adaptive façade glazing technology called electrochromic. Participants were recruited and asked to work for 6 hours per day in either a classroom with the glazing turned on (which makes the light bluer), or turned off (neutral lighting condition) (fig.1). We know from photobiology that the intrinsically photosensitive retinal ganglion cells (ipRGCs) responsible for converting light into a neurological signal, are most sensitive to wavelengths around 480nm (blue light). By exposing participants to blue and neutral light we can test if the spectral sensitivity of the non-visual system produces noticeable changes on alertness, fatigue or cognitive functioning, but also, on heart rate variability or skin temperature. Each of these markers was assessed qualitatively and quantitatively with hourly app-based self-rated questionnaires and performance tests, and with continuous physiological measurements. Circadian rhythmicity was also monitored outside the experimental setup using skin temperature sensors and app-based sleep-activity diaries. Vertical illuminance and irradiance was continuously recorded at the eye level with a customized wearable device (fig. 2), and used as an input for a predictive computational model (7) to assess the potential of lighting for non-visual responses.

Tracking light exposure over time under “real life” conditions is essential to evaluate the role of adaptive architectural strategies, such as glazing, on improving behaviour and mitigating negative effects on wellbeing in classrooms. The protocol developed for this study allows us to monitor, for the first time and with limited intrusion, effects of different daylighting conditions on circadian rhythmicity, physiology and subjective behaviour.



(a) (b)

Figure 1. (a) Experimental design. Control group experienced daylight neutral conditions (left) and intervention group experienced red-impoverished daylight (right). (b) SMEAS, customized wearable device to measure vertical illuminance and irradiance.

2. REFERENCES

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is a PhD Candidate at the LIPID laboratory at EPFL and holds a diploma in architecture from ETSA Sevilla (Spain). Before joining EPFL, she was Research and Honorary Assistant at the University of Sevilla, from 2011 until 2015. She completed an MA in Technology and Design, and an MSc in Sustainable Environmental Design (Architectural Association School of Architecture, London UK). Her doctoral research focuses on the interaction between architectural design, daylight and acute non-visual effects in occupants, for working environments.

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heads the Laboratory of Integrated Performance in Design (LIPID) at EPFL, whose research activities focus on building performance and decision support in the architectural context, especially as it pertains to human comfort, perception and health and on the use and optimization of daylight in buildings. She is Full Professor of Sustainable Construction Technologies and Dean of EPFL's School of Architecture, Civil and Environmental Engineering (ENAC). Before joining EPFL as a faculty member in 2010, she was Assistant then Associate Professor tenure-track at MIT, where she founded the MIT Daylighting Lab in 2004. She holds an MSc in Physics and a PhD in Building Physics from EPFL, and has been a Visiting Scholar at the Lawrence Berkeley National Laboratory in California, USA, in 2001-02 and 2009. She is the author of over 100 refereed scientific papers, recipient of several awards including the Daylight Research Award 2016. She was the leader and faculty advisor of the Swiss Team, who won the U.S. Solar Decathlon 2017 competition. She is a member of the Board of the LafargeHolcim Foundation for Sustainable Construction and co-founder of the Sàrl OCULIGHT dynamics. She is also a member of the Editorial Board of the Elsevier Journal Building and Environment and of the Taylor and Francis Journal of the Illuminating Engineering Society (IES) LEUKOS.