Light, Entrainment and Alertness: A Case Study in Offices

Scant attention has been given to testing the effects of light on building occupants' non-visual responses and, consequently, lighting specifiers have been offered little guidance on the design and application of lighting for non-visual effects. This study addressed that gap by field-testing a novel luminaire (Figure 1) designed to promote circadian entrainment and alertness in actual office environments.

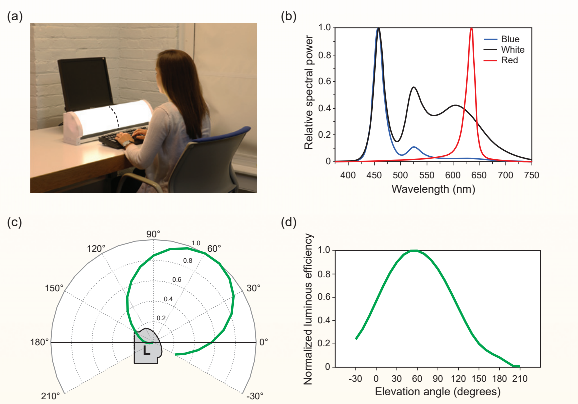

Figure 1. The desktop luminaire used in the study. (a) The luminaire's position relative to the desktop and the participant, and the location of the photometric cut (dotted line) used for the light distribution calculations. (b) The relative spectral power distributions of the three lighting interventions. (c) Polar plot of the luminaire's (L) light distribution (represented by the heavy green line) recorded at the photometric cut. (d) Cartesian plot of the luminaire's light distribution, by elevation angle, recorded at the photometric cut.

Methods

Nineteen participants from 3 United States Department of State office buildings in Washington, DC, completed the 3-week study protocol (Figure 2). The LRC developed and built 20 luminaires for mounting on desktops near participants' computer monitors (see Figure 1). Three lighting interventions were designed to promote circadian entrainment and alertness by delivering: (1) morning saturated blue light (06:00–12:00, λ_{max} = 455 nm, CS ≥ 0.4), (2) midday polychromatic white light (12:00–13:30, 6500 K, CS ≥ 0.3), and (3) afternoon saturated red light (13:30–17:00, λ_{max} = 634 nm, CS = 0). Objective and subjective measures of rest–activity, sleep, vitality, and alertness were used to evaluate the lighting interventions.

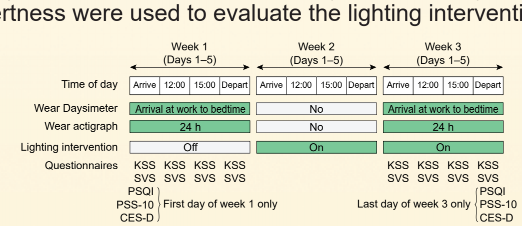

Figure 2. The study protocol.

Results

The rest–activity results showed that interdaily stability was significantly greater and sleep end time was significantly earlier during the intervention (Figure 3). Participants felt significantly less sleepy at the post-lunch dip (Figure 4) during the intervention.

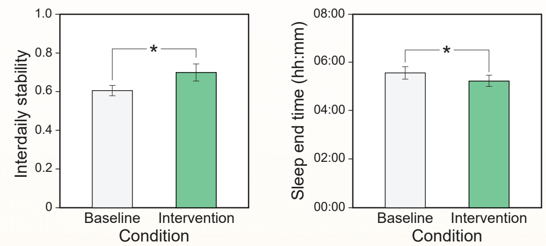

Figure 3. Participants exhibited more consolidated rest–activity patterns (i.e., greater interdaily stability [left]) woke up earlier (i.e., earlier sleep end time [left]) during the intervention compared to baseline, indicating better circadian entrainment. The error bars represent standard error of the mean and the asterisk denotes statistical significance (*p* <0.05).

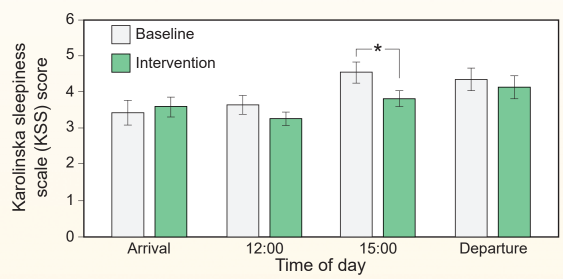

Figure 4. Participants reported feeling less sleepy around the time of the post-lunch dip (≈ 15:00) during the intervention compared to baseline. The error bars represent standard error of the mean and the asterisk denotes statistical significance (*p* <0.05).

Conclusion

The data support the inference that light exposures, when properly applied, can promote circadian entrainment and increase alertness.

Publication

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