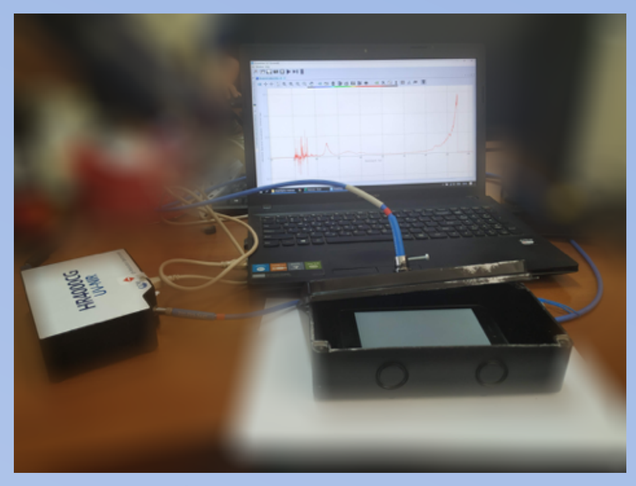
Blue light reducing software applications for mobile phone screens: measurement of spectral characteristics and biological parameters.

S. Mitropoulos[1], V. Tsiantos[2], A. Amerikanos[3], I. Sianoudis[3] A. Skouroliakou[1]
[1]Department of Biomedical Engineering, University of West Attica, Athens, Greece
[2]Department of Physics, International Hellenic University, Thessaloniki, Greece
3Department of Biomedical Sciences, University of West Attica, Athens, Greece

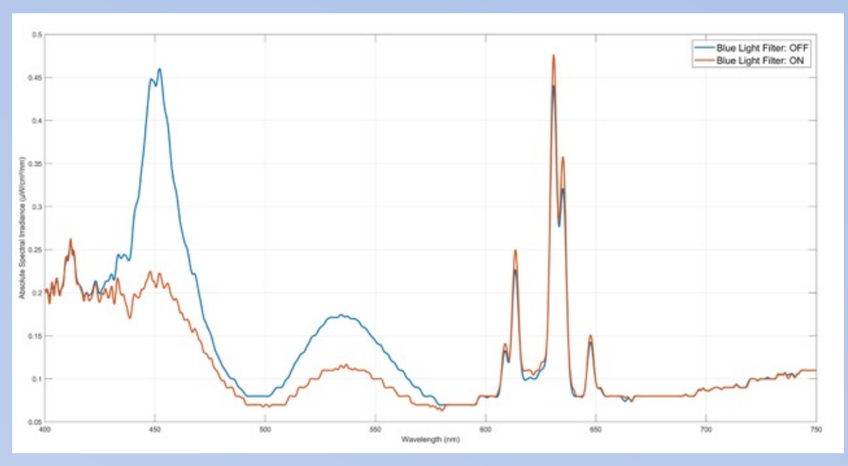


Spectral measurement setup

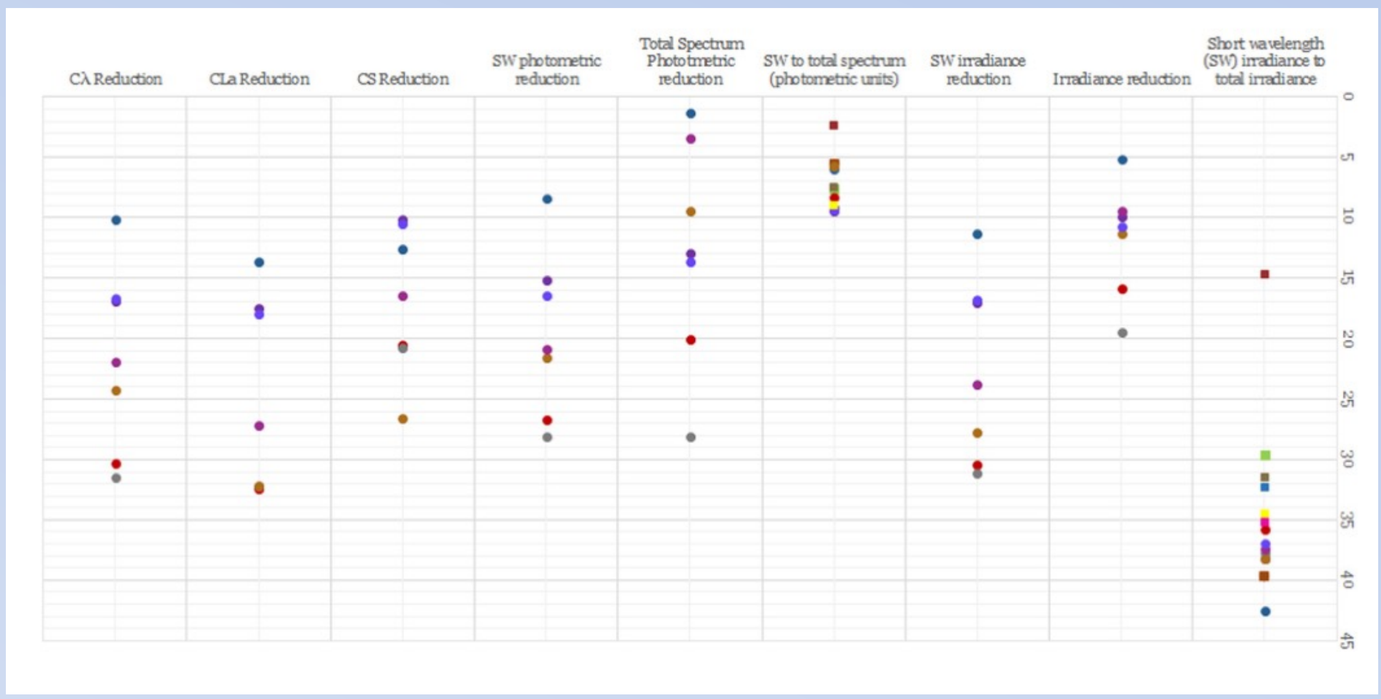
Introduction: The visible light spectrum emitted by smartphone screens is mainly determined by screen technology. Apart from the visionary system light is also a significant input for the circadian regulation system that organizes the timing of all daily biological functions. The human visual and circadian systems are characterized by different mechanisms of light processing thus presenting different sensitivities and responses to retinal light exposure. A number of indices have been proposed to characterize light interaction with the human circadian system. These indices are calculated from a measurable quantity, usually spectral irradiance E(λ). Research on the implementation of a comprehensive quantitative model of the interaction between light and the human circadian system is ongoing, nevertheless two broad suggestions from the scientific community are the reduction of unnecessary high levels of light at night and attenuation of the short wavelength spectrum components.

To that end a number of smartphone software applications reduce the light emitted in the blue region of the spectrum by controlling the relative weight of the signal emitted by each color sub pixel, whilst maintaining optimal illuminant quality.

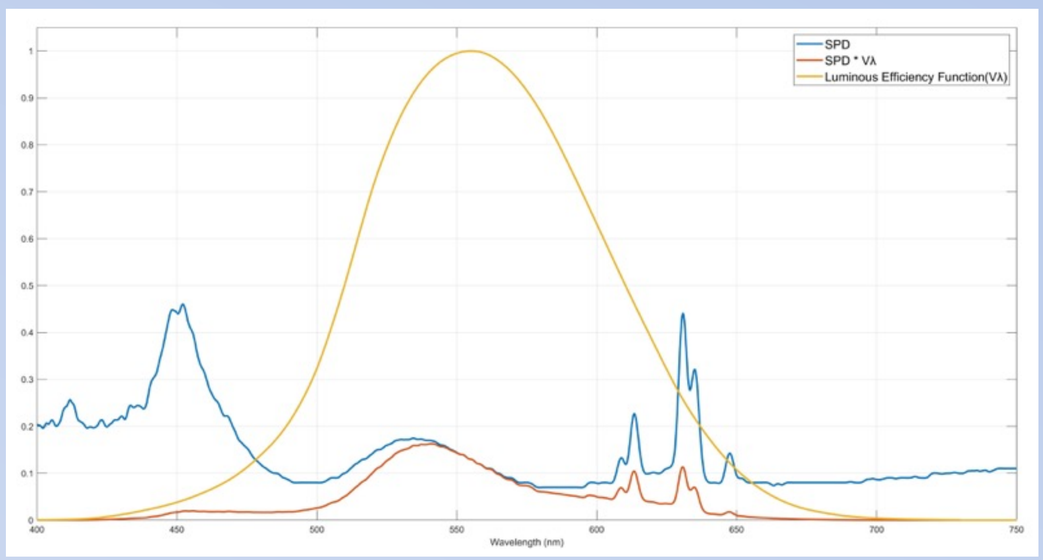
Materials - Methods: The Spectral Power Distribution (SPD) of the light emitted from smartphone screens was assessed for a range of smartphones, without and with the blue light filtering application. Total spectrum and shortwave (SW) spectrum (420nm-500nm) power were calculated in radiometric and photometric units. Illuminance, Circadian Stimulus (CS) and Circadian Light (CLa) as well as percentile reduction for all parameter values after the application of the blue light reduction filter was calculated.



Spectral Power Distributions of a smartphone screen with the blue light filtering application off (blue line) and on (red line)



Percentile reduction in radiometric, photometric and circadian parameters (different colors correspond to different smartphone models)



SPD in radiometric units, Vλ (photopic luminous efficiency function) and their product (spectral distribution in photometric units).

Results: Applications have proven effective in reducing the short wavelength spectral components. Their performance however does depend on smartphone make and model. As expected reduction in total spectrum power is higher in illuminance than in irradiance terms, whilst circadian indices variations correspond better with the SPD in radiometric terms.

Variations in the values of SPDs as well as photo biologically relevant parameters are high according to operating system and smartphone model.

Conclusions: As the blue light component seems to be affecting circadian rhythm, it is advisable to adjust screen illumination characteristics according to the time of day. Built in applications in most cases prove very effective on selectively reducing shortwave visible electromagnetic radiation, no matter which metric is used, up to 30%. The spectral power distribution in radiometric terms seems more relevant in photobiologic calculations and should be measured in relevant experiments. Research on the exact quantitative interaction characteristics of human circadian system and light is ongoing. However smartphone users can effectively reduce their exposure to blue light whilst maintaining good illuminating conditions by utilising the available software applications.

REFERENCES
- Rea, M.S., Figueiro, M.G., Bierman, A., Bullough, J.D., “Circadian light”. Journal of Circadian Rhythms vol. 8, no. 2, 2010, DOI: 10.1586/14737159.1.2.211.
- SCHEER “Opinion on Potential risks to human health of Light Emitting Diodes (LEDs)”, 2018. Retrieved from: https://ec.europa.eu/health/
- Duffy J.F. and Czeisler C.A. “Effect of Light on Human Circadian Physiology”, Sleep Med Clin. vol. 4, no. 2, pp. 165-177, 2009.
- Glickman G., Levin R., and Brainard G.C.,“Ocular input for human melatonin regulation: relevance to breast cancer”, Neuro Endocrinol Lett, vol. 23 Suppl 2: pp. 17-22, 2002.
- Brainard GC, Hanifin JP, Greeson JM, Byrne B, Glickman G, et al., “Action spectrum for melatonin regulation in humans: Evidence for a novel circadian photoreceptor”, J Neurosci vol. 21, no. 16, pp. 6405-6412, 2001.
- Thapan K, Arendt J, Skene DJ, “An action spectrum for melatonin suppression: Evidence for a novel non-rod, non-cone photoreceptor system in humans”, J Physiol, vol. 535, no. 1, pp. 261–267, 2001.
- M. Aubé, J. Roby, M. Kocifaj, “Evaluating Potential Spectral Impacts of Various Artificial Lights on Melatonin Suppression, Photosynthesis, and Star Visibility”. PloS one. vol. 8. e67798, 2013, DOI: 10.1371/journal.pone.0067798.
- Falchi F, Cinzano P, Elvidge CD, Keith DM, Haim A, “Limiting the impact of light pollution on human health, environment and stellar visibility”, J Environ Manage, vol. 92, pp. 2714-2722, 2011.