Complete evaluation of daylight characteristics in working environments

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Abstract

Allowing an adequate entrance of daylight in working environments is extremely important to achieve energy savings and also to ensure users' wellbeing and health [1,2]. For example light is linked to the entrainment of the circadian system which regulates the timing of biological processes inside our body (circadian rhythms) [3]. To keep a 24h cycle, the human circadian system needs to be synchronized every day by an adequate exposure to light. The importance of keeping a 24h cycle lies in the link between circadian disruption, which happens when the circadian system's period is not 24 hours, and health diseases [4,5]. At the present time there is still much to discover about how the circadian system works, but it is known that its response to a light stimulus depends on light's intensity, SPD, and also on the duration and timing of exposure [6,7]. Therefore to evaluate the circadian impact of a light stimulus in indoor environments it is necessary to analyze its characteristics at users' eye level. This paper reports the results of measurements carried out in three offices, with different exposures, located in Naples (Italy) during different seasons (winter, spring, summer and autumn). Moreover the Irradiance Toolbox developed by Lucas et al. [8] was used to predict the photoactivation of the different photopigments in the human eye.

Method

Measurements were carried out in three offices, with different exposures, located in Naples (Italy) during winter, spring, summer and autumn. The equipment used to perform this study consisted in a CS 2000 spectroradiometer, a T10 illuminance meter and a CM 2600d spectrophotometer all manufactured by Konica Minolta. The offices will be referred to as Office 1 (OF1), Office 2 (OF2), Office 3 (OF3), their measured plans are reported in Figure 1.

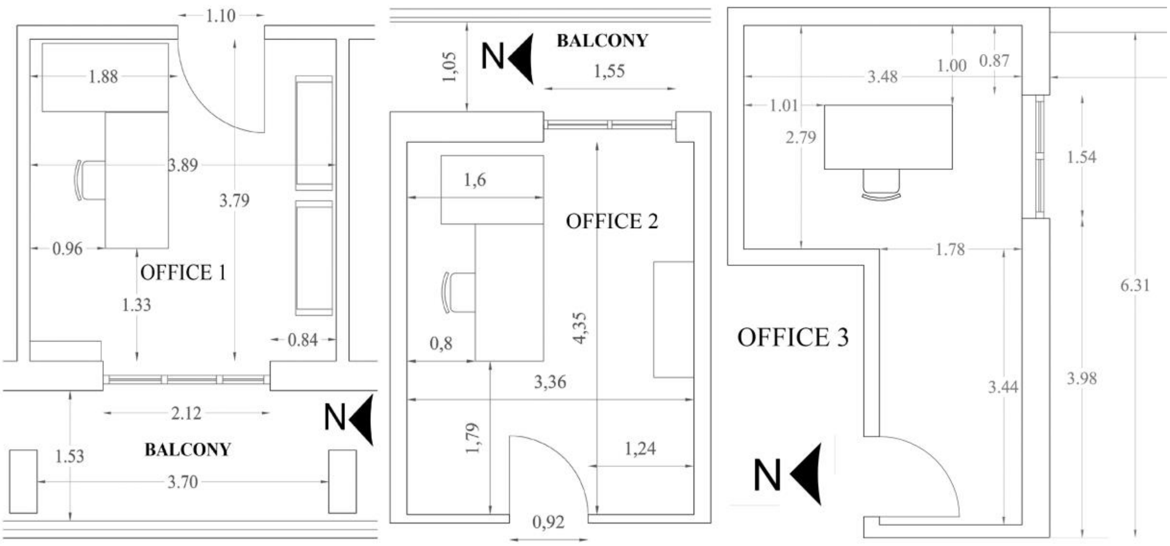

Figure 1. Office 1,2,3 measured plans

Measurements were carried out from 10:00 to 18:00 during different days for each season, during spring and winter measurements stopped at 17:00 because sunset occurs around that time. The following data were recorded for each day of measurement: global outdoor illuminances on a horizontal plane, sky CCTs, desk and eye level illuminances; eye level CCTs. Data related to days with the same sky condition were averaged to obtain for example eye level illuminances trends during a clear sky day for each office. In more detail, eye level irradiances were detected with different tilt angles of the spectroradiometer (0°,15° and 45° on the vertical plane and 45° right and left on the horizontal plane) which was placed at the same height of the head of a person seated at the desk (1.20 m). Irradiances measured in this way were averaged and used as input in the Irradiance Toolbox to calculate equivalent illuminances for the photopigments in the human eye. In this paper , for reasons of space , only the results of measurements carried out in OF1 during clear sky days in different seasons will be reported.

Results

Figure 2 reports data related to average clear sky days for OF1 during different seasons.

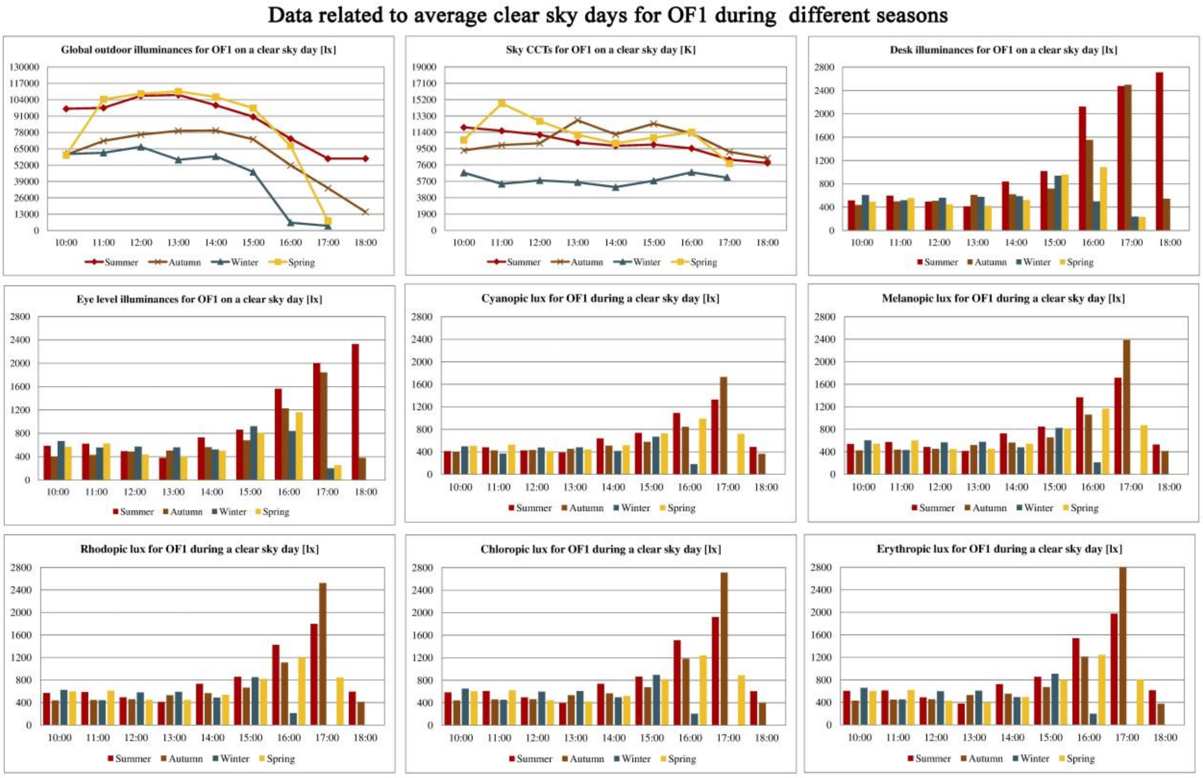

Figure 2. Data related to average clear sky days for OF1 during different seasons

It is interesting to observe that global outdoor illuminances for a clear sky day in spring and summer are similar and the lowest values are registered during winter. Sky CCTs during summer, autumn and spring are similar and winter values are again the lowest ones. As regards desk and eye level illuminances, the highest values are registered during the afternoon in each season, this is related to the westerly exposure of the office. In more detail, the maximum values were detected during summer and autumn. Cyanopic, melanopic, rhodopic, chloropic and erythropic lux trends are generally similar and they also tend to match eye level illuminances ones.

As regards the other two offices, desk and eye level illuminances show trends that are different from OF1's ones. In more detail for OF2 the highest values are reached during the first hours of the morning whereas for OF3 around noon. Moreover the maximum values were registered during summer and spring for OF2 and during winter for OF3.This findings are again related to the offices' exposure since OF2 is East oriented and OF3 is South oriented.

Discussion and conclusions

It is clear that to properly evaluate non visual effects of light it is fundamental to analyze light's characteristics at users' eye level. In order to introduce the analysis of such effects in the design practice, future researches should focus, on one hand, on fully understanding how non visual responses to light work, on the other hand there is also the need to carry out measurements like the ones performed in this study in different types of environments located around the world. This should led to the development of a database that will allow to understand if there are similarities in the characteristics of light received by users of different environments and also to investigate the possibility of developing simplified methods that allow to estimate non visual effects during the design phase.

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