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Procedure to estimate lighting at mesopic/scopic levels in epidemiological studies

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Introduction

It is well known that exposure to artificial light at night (ALAN) may cause negative health effects. It is a topic of interest in epidemiological studies to investigate the health effects of the low residual light that remains in a bedroom when it is dark and can interact with people suffering from lagophthalmia and even can overstep the eyelids. This residual light can be due to exterior light that seeps through windows and doors, small clock screens, indicator lights, etc...

Light sensors that can be purchased at a competitive price have an absolute threshold at 0.01 lux so that, they are unable to measure the lower levels in a dark bedroom at night. Nowadays this low light level is qualitatively estimated through questions as "How many fingers do you see?" or "Can you detect the hand movement?" being the uncertainty of the estimation very high.

In this work we present a subjective procedure for estimating low level light values comprised between 10^{-2} lx and 10^{-3} lx. The method is based on visual detection of the minimum contrast letter, in a letter contrast sensitivity chart, for different levels of light.

Methods

1. A green LED point source with a very faint light emission has been placed at the extreme of an optical bench and a GOSSEN MAVOLUX 5032C USB lucimeter has measured the illumination at seven different distances from the source (Figure 1). A linear fitted expression, based on inverse square law, has been obtained from the logarithmically transformed variables (Figure 2). This expression allows us to derive, by extrapolation, the illumination level at further distances, where the light levels are below of the lucimeter absolute threshold of 0.01 lux.

2. A letter contrast sensitivity chart, with twelve Sloan letters of 42 mm size in decreasing values of modulation, displayed in 4 rows and 3 columns, has been printed in a DIN A-4 white card stock sheet (Figure 3). The contrast of the letters decreased in a geometrical progression with common ratio $\sqrt{2}$ from the maximum contrast (0,913) in the first letter to the minimum (0,020) in the last.

The light levels analyzed varies from low mesopic to high scotopic and range measurement is from 0,01 lx to 0,001 lx. Therefore, eccentric fixation was needed to guess the letters as the distance increased, due to so dimming light.

A group of thirty visually healthy people (9 men and 21 women) aged between 18 and 50 has been recruited in order to relate the position of the letter with minimum contrast discerned and the light level (lx) in the place (Figure 4).

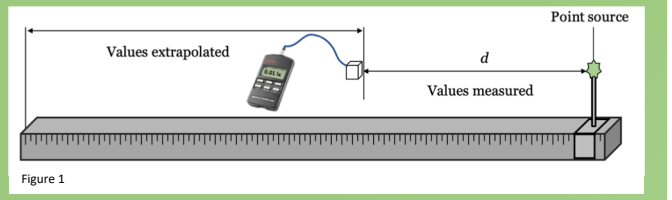

Figure 1

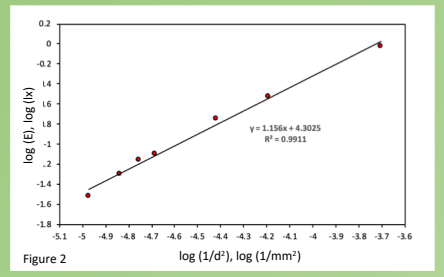

Figure 2

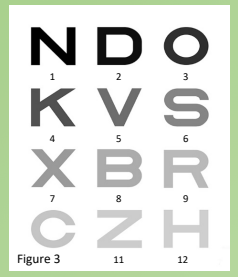

Figure 3

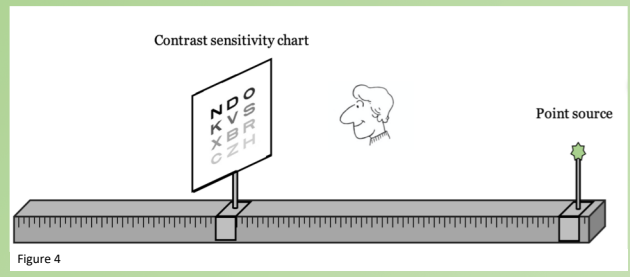

Figure 4

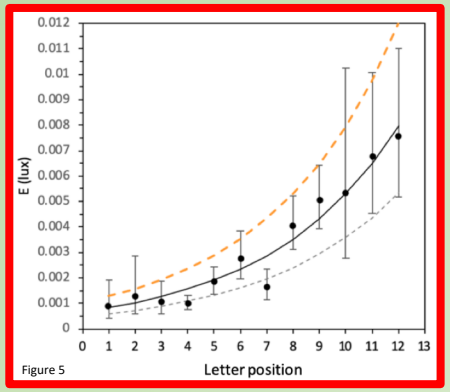

Figure 5

Results

Figure 5 displays results obtained with its corresponding uncertainty ranges. The letter with highest contrast (letter 1) may be discerned at approximately 0,001 lx while observers needs a mean illumination of 0,007 to discern the letter with lowest contrast (letter 12). As expected, the uncertainty increases as the position of the letters increases, that is, as the contrast of the letters decreases.

The high variability in the results obtained recommends to assign a range of illumination to each value instead of a single value.

Results obtained are redundant because uncertainty ranges overlap between them but overlapping aids to obtain more precision in this type of measurements.

Conclusions

A subjective method to measure low light levels has been presented. It allows estimating light measurements that ranges between 10^{-2} lx and 10^{-3} lx.

This method is not expensive and with a little training it can be applied to estimate low light levels in dark rooms.