OP21

## USER CONTROL AND SATISFACTION WITH DIFFERENT ILLUMINANCE RANGES

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**Objective:**

User-control means that the occupants of a space have control over the amount of light provided by electric lighting, i.e. illuminance adjustment or dimming.
In past studies, the results of tests allowing illuminance adjustment have been used to suggest that recommended illuminance levels are not correct in some situations because the mean illuminance is either above or below the recommended value. This has now been shown to be an incorrect interpretation of the results. Stimulus range bias means that the range of illuminances available through the dimming control affects the mean setting: a range with a high maximum illuminance leads to a higher mean setting. Analysis of the results however shows that people tend to be consistent in their settings, for example always setting an illuminance above the group mean, and this suggests some consistency in preference.

A possible strategy for reducing lighting energy consumption is to provide user-control but with a carefully chosen stimulus range. Consider for example a range of 0 lx to 500 lx, this upper limit being a widely used target for office lighting. Results of past research suggests preferences will lie across a wide part of the available range, with a result that many people will select an illuminance lower than 500 lx, and this means, assuming suitable technology, that energy consumption is reduced. In addition to energy, occupant satisfaction with the visual environment is critical because people who are satisfied with the lighting will also be in a more pleasant mood, be more satisfied with the work environment and more engaged in their work.

What is not yet known is an appropriate maximum illuminance, sufficiently high to accommodate a wide range of preferences, and sufficiently low to target energy reduction. A study was carried out to investigate satisfaction with user controlled lighting with two ranges of illuminance, 0 lx - 500 lx and 0 lx - 700 lx.

**Methods:**

The test environment comprised a space approximately 2,1 m high and 2,4 m in length and width. When seated inside this space, test participants were instructed to set their preferred amount of light using a rotary control dial and the resulting desktop illuminance was recorded. This task was repeated 8 times in random order, for both ranges, starting from low and high initial illuminances (anchors), with each combination repeated twice.

Satisfaction with the amount of light was reported using a 5-point scale, ranging from 1 (I would prefer a lot less light), and 3 (I am satisfied with this level of light) to 5 (I would prefer a lot more light). Satisfaction was recorded after trials using low range with low anchor and the high range





with a low anchor, and also for an illuminance set by the experimenter matching that rated by the participant with the low range.

40 participants were used, of whom 53 % were female and the age range was 18-64 years old.

**Results:**

Table 1 shows results of the adjustment task. It can be seen that within each range trials using the low anchor lead to lower illuminances than did the high anchor, and that the high range lead to higher illuminances than did the low range: these differences are significant ($p < 0,001$). Subsequent analysis of each anchor *x* range combination suggested significant differences in all cases ($p < 0,008$).

Figure 1 shows mean illuminances set using the two ranges and this suggests consistency in relative settings between ranges: a person who sets a low illuminance in the range did so for both ranges. Spearman's test suggests significant correlation ($r = 0,91$, $p < 0,001$).

Of the 320 settings of preferred illuminance gained in this study, 28 (9 %) were set to the maximum available illuminance, with no apparent trend with illuminance range or anchor (Table 1). Of these, two participants are responsible for 15 settings, the remainder distributed between 9 others.

Table 2 shows the results of the satisfaction ratings. Analysis using Friedman's test suggests significant differences ($p < 0,001$). Subsequent analysis using the Wilcoxon test does not suggest a difference between the ratings following the low-range trial and the high-range trial, but that these satisfaction ratings were significantly different ($p < 0,001$) to the satisfaction rating made following the illuminance set by experimenter.

For those illuminances set directly by test participants, the satisfaction ratings indicate they were satisfied with the amount of light with a small tendency to prefer slightly more light – a common but surprising finding since Table 1 indicates that higher light levels could have been set in the majority of trials. A lower satisfaction with the amount of light was found for the illuminance set by the experimenter, this being the same illuminance as was set and rated by the test participant using the low range and low anchor.

**Conclusions:**

One potential strategy for reducing energy consumption in office lighting is to provide user control over light levels. The results presented in this article suggest that people tend to set different illuminances when presented with different illuminances ranges and anchors, but that this difference in illuminance does not lead to a significant change in satisfaction with the amount of light.

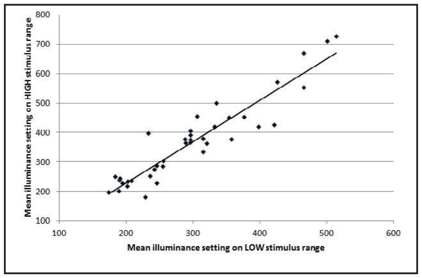


**Figure 1 – Comparison of illuminances set on the low (0 lx - 500 lx) and high (0 lx - 700 lx) ranges**

**Table 1 – Preferred illuminances set in the illuminance adjustment task**

| . | Low range (0 – 500 lx) | | High range (0 – 700 lx) | |
|---|---|---|---|---|
| . | Low anchor (86 lx) | High anchor (454 lx) | Low anchor (86 lx) | High anchor (634 lx) |
| Median preferred illuminance | 184 | 391 | 194 | 491 |
| Mean preferred illuminance | 218 | 385 | 250 | 488 |
| std dev | 116 | 89 | 168 | 133 |
| n | 40 | 40 | 40 | 40 |
| Frequency of setting the maximum illuminance | 6 | 11 | 4 | 7 |

**Table 2 – Ratings of satisfaction with the amount of light**

| . | Low range, low anchor | High range, low anchor | Low range, low anchor - set by experimenter |
|---|---|---|---|
| Mean rating of satisfaction | 3.25 | 3.18 | 3.70 |
| std dev | 0.44 | 0.39 | 0.52 |
| n | 40 | 40 | 40 |



Abstracts

**OP22**

## EXPERIMENTAL EXAMINATION AND SIMULATION OF A LED INTERIOR LIGHTING SPACE

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**Objective:**

Measurement by an imaging luminance measurement device (ILMD) or simulation by a software are two approaches for the studies of interior lighting space. The comparison and revision of these two methods is required for the improvement and acceleration of lighting designs and their verifications. In this work, the studies on a controllable LED interior lighting space by the above two methods were systematically performed. Relevant parameters such as luminance distribution of lighting and environments, illuminance, UGR (unified glare rating) were measured or simulated.

**Methods:**

The experimental lighting space was built as a simple study, which contains a controllable LED ceiling light, a reading desk, ceiling, floor, and surrounding walls. For simulations, the luminous intensity distribution of the LED ceiling light was measured with a goniometer. The ILMD used in this work is based on a calibrated DSLR (digital single-lens reflex camera) with a fisheye lens. The luminance distribution as well as related parameters can be automatically calculated by this ILMD. A DIALux 4.9 software was used to simulate the luminance and illuminance distributions, and UGR of the lighting space. A SR3A spectroradiometer and a T-10 illuminance meter were used as standards for checking the experimental and simulated results. The reflectances of the desk, ceiling, floor and walls were estimated with luminances measured by the spectroradiometer and illuminances by the illuminance meter.

**Results:**

Luminances of various points on the walls or desk respectively obtained by the spectroradiometer, ILMD, and DIALux and are shown in Fig. 1, where the placements of the spectroradiometer and ILMD are at same position. It is observed that the luminances measured by the ILMD are close to those measured by the spectroradiometer with mean deviation less than -3 %. The luminances obtained from the simulation are less accurate than those from ILMD that may be caused from the incorrect assumption of Lambertian reflection of substances in the software. Additionally, the luminance distribution of the LED ceiling light measured by the ILMD is also well consistent with that by spectroradiometer. Figure 2 shows the comparison of UGR obtained by the ILMD measurements and the DIALux simulations. The symbols denote the measurements or simulations at various viewing positions and directions. The UGR by simulation is averagely larger than that by ILMD with amount of 0,4. The difference may be originated from the assumptions of the far-field source or Lambertian reflection of the simulation software, or algorithm for calculations of the ILMD.