Preferable illuminance under LED lighting for migraineurs aiming to relax

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This study aims to reveal the preferable illuminance for migraineurs aiming to relax in a room. We conducted an experiment of subjective evaluation on preferable brightness using a 1/4 scale model of a living room whose space consisted of a gray floor and a white wall. The room equipped two kinds of LED lamps: RGB LED lamps and white LED lamps on the ceiling. We set up ten lighting conditions which differed in CCT and SPD. Subjects controlled the illuminance in the room so as to be their preferable brightness under each lighting conditions. The results showed that migraineurs preferred lower illuminance as compared with non-migraineurs under all lighting conditions.

Practitioner Summary: For migraineurs who relax in a living room illuminated with LED lamps, the illuminance on the face should be about 50 lx lower than the non-migraineurs’ preferred illuminance.

Keywords: migraine, LED, spectral power distribution, subjective experiment

1. Introduction

A room designed for relaxation consists of some physical components, such as light, air, sound and heat. In particular, lighting is an important factor when configuring relaxation room. The atmosphere in the room depends on the light source, brightness and correlated color temperature (CCT). In previous studies, the experimental results using RGB fluorescent lamps showed that low illuminance and low CCT were preferred for relaxation (Oi, N. et al. 2007) and that preferable illuminance of RGB fluorescent lamps is almost similar to that of RGB LED lamps (Oi, N. et al. 2009).

Preferable lighting conditions depend on physiological characteristics such as gender, age, chronic disease and so on. About 20% of women ranging from twenty to forty years old have migraine (Sakai, F. et al. 1997). The pain caused by migraine lasts 4 hours to 72 hours, and the migraine attacks occur at a frequency of twice a week from once to twice a month. Furthermore, sometimes the severe symptom of migraine triggers vomiting (Society, H.C.C.o.t.l.I.H. 2013). For these reasons, migraine sometimes prevents migraineurs from performing daily activities. In addition, about 40% of migraineurs have migraine headache triggered by light stimulation (Kelman, L. 2007). Therefore it is important to control the lighting conditions for migraineurs. It was reported that migraineurs are more sensitive to glare than non-migraineurs and to the light of 480nm which is the peak wavelength of intrinsically photosensitive retinal ganglion cell (ipRGC) (Tatsumoto, M. et al. 2013).

We have reported some experiments results on the preferable illuminance for migraineurs in a mock-up dining room (Kagimoto, A. et al. 2013), and on the preferable illuminance in a mock-up living room (Okuda, S. et al. 2014). However, in these studies, only two CCT conditions were examined. Therefore, this study aims to reveal the preferable illuminance for migraineurs to relax under some different lighting conditions in CCT and spectral power distributions.

2. Method

2.1 Experimental conditions

Figure 1 illustrates a plan and a section of the apparatus. We made a 1/4 scale model of a living room in which the space consisted of a gray floor (N7.0) and a white wall (N9.0). The model size was 700mm (width) x 1000mm (depth) x 730mm (height). It was furnished with a white table (N9.5), a black sofa (N2.0) and a white shelf (N9.5) as shown in Figure 2, and five RGB LED lightings [iColor Cove MX Powercore, Philips
Color Kinetics] and five white LED lightings [iW Cove MX Powercore, Philips Color Kinetics] with three kinds of LED chips with different correlated color temperature on the ceiling. We set up ten patterns of the lighting conditions from 2100K to 11000K in CCT as shown in Table 1. Figure 3 shows the spectral power distribution of the ten lighting conditions measured from the vertical illuminance condition on the face of the participant at 600lx, and Figure 4 shows the chromaticity values of the lighting conditions. In this experiment, we set three different spectral power distribution conditions in which chromaticity values were close to 4000K, and two different spectral power distribution conditions in which chromaticity values were close to 5500K.

<table>
<thead>
<tr>
<th>Lighting conditions</th>
<th>2100K</th>
<th>2700K</th>
<th>3700K</th>
<th>3900K</th>
<th>4000K (1)</th>
<th>4000K (2)</th>
<th>4000K (3)</th>
<th>5500K (1)</th>
<th>5500K (2)</th>
<th>11000</th>
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<tbody>
<tr>
<td>u'</td>
<td>0.296</td>
<td>0.260</td>
<td>0.239</td>
<td>0.225</td>
<td>0.224</td>
<td>0.225</td>
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<td>0.192</td>
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<td>v'</td>
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<td>0.487</td>
<td>0.508</td>
<td>0.501</td>
<td>0.504</td>
<td>0.504</td>
<td>0.496</td>
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<tr>
<td>Δuv</td>
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<td>-0.001</td>
<td>-0.016</td>
<td>0.003</td>
<td>0.000</td>
<td>0.001</td>
<td>0.004</td>
<td>0.019</td>
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<td>3890</td>
<td>4042</td>
<td>3977</td>
<td>4054</td>
<td>5577</td>
<td>5437</td>
<td>11482</td>
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<tr>
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<td>80</td>
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<td>84</td>
</tr>
</tbody>
</table>

Figure 1. Experimental space

Figure 2. Actual views of the scale model in the lighting conditions of 2700K and 5500K (1)
2. Procedure

Subjects adjusted the illuminance by using ascending and descending methods so as to set the preferable level. Each subject repeated 3 times each ascending series and descending series under 10 kinds of lighting conditions. The initial condition of ascending series was 10 lx, and that of descending series was 600 lx on vertical illuminance at subject’s face.

2.3 Subjects

Subjects were classified into two groups, migraineurs and non-migraineurs, by medical screening on the basis of the International Classification of Headache Disorders (Society, H.C.C.o.t.I.H. 2013). They were 40 females in their twenties, half were migraineurs and the remaining half were non-migraineurs.
3. Results and Discussion

Figure 4 shows the average values of vertical illuminance on the face adjusted to preferable brightness by ascending and descending adjustments under each lighting condition. The average illuminances obtained by ascending adjustment for migraineurs were lower than that for non-migraineurs under all lighting conditions. There were significant differences of the preferred illuminance between migraineurs and non-migraineurs under the lighting conditions of 5500K (1) ($P<.05$) and 11000K ($P<.05$).

The average illuminance values of descending adjustment for migraineurs were lower than that for non-migraineurs under all lighting conditions. Especially, the preferable illuminance for migraineurs was lower than that for non-migraineurs under conditions of 2700K ($P<.05$), 3700K ($P<.05$) and 4000K (2) ($P<.05$).

Furthermore, the average values of the vertical illuminance on the face of ascending and descending adjustment for migraineurs were lower than that for non-migraineurs under all lighting conditions, and the difference of the preferred illuminance between migraineurs and non-migraineurs was about 50 lx. There

![Figure 4. Evaluation results of preferable illuminance on the face](image-url)
were significant differences of the preferred illuminance between migraineurs and non-migraineurs under the lighting conditions of 2100K ($P<.05$), 2700K ($P<.05$), 3700K ($P<.05$) and 5500K ($P<.05$), suggesting that migraineurs prefer low illuminance as compared with non-migraineurs especially under lighting with low color temperature. It was also shown that the difference of the preferable illuminance between the light colors was not large for both migraineurs and non-migraineurs. Migraineurs preferred the illuminance that range from 159 lx to 185 lx, non-migraineurs preferred the illuminance that range from 183 lx to 226 lx.

4. Conclusions
Migraineurs prefer low illuminance as compared with non-migraineurs under the conditions from 2100K to 11000K in CCT, particularly low color temperature. The difference of the preferred vertical illuminance on the face between migraineurs and non-migraineurs is about 50 lx.

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References