International Commission on Illumination
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Descriptor: Lighting. Illuminating engineering
Descriptor: Photometry

THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organization devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organizations concerned with matters related to the science, technology, standardization and art in the fields of light and lighting.

The work of the CIE is carried out by Technical Committees, organized in seven Divisions. This work covers subjects ranging from fundamental matters to all types of lighting applications. The standards and technical reports developed by these international Divisions of the CIE are accepted throughout the world.
A plenary session is held every four years at which the work of the Divisions and Technical Committees is reported and reviewed, and plans are made for the future. The CIE is recognized as the authority on all aspects of light and lighting. As such it occupies an important position among international organizations.

LA COMMISSION INTERNATIONALE DE L'ECLAIRAGE

La Commission Internationale de l'Eclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science, de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par Comités Techniques, organisés en sept Divisions. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.
Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

DIE INTERNATIONALE BELEUCHTUNGSKOMMISSION

Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedsländern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in rund 40 Ländern.

Die Ziele der CIE sind:

1. Ein internationales Forum für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Meßtechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird durch Technische Komitees geleistet, die in sieben Divisionen organisiert sind. Diese Arbeit betrifft Gebiete mit grundlegendem Inhalt bis zu allen Arten der Lichtanwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind auf der ganzen Welt anerkannt.
Alle vier Jahre findet eine Session statt, in der die Arbeiten der Divisionen berichtet und überprüft werden, sowie neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

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The following table provides an overview of the oral presentations, presented posters and posters presented at the conference. The papers are published in the proceedings in consecutive order of presentation. Papers that have not been submitted are marked as such ("n.s.").

The papers have not been peer-reviewed by CIE.

CAN A DYNAMIC LIGHTING HELP PEOPLE FAST SLEEP?

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Abstract

The high-pressure environment in the fiercely competitive society nowadays has increased the number of sleepless people who are influenced the physical and mental conditions because of inadequate rest time. A lot of people therefore seek for medication; however, it would cause bad side effects. It is expected to propose a method with less stimulation but being able to help people fall asleep faster, have sufficient sleep, and effective improve the quality of life. To enhance the quality of sleep, a dynamic lighting system which could assist people in fast falling asleep is proposed in this study. The dynamic lighting source would periodically change the colour with time. According to the experimental results, the use of dynamic lighting could more easily have the participants fall asleep.

Keywords: dynamic lighting, sleepless, fall asleep faster

1 Introduction

Insomnia is a common problem that takes a toll on your energy, mood, health, and ability to function during the day. Chronic insomnia can even contribute to serious health problems. According to guidelines from a physician group, insomnia is difficulty falling asleep or staying asleep, even when a person has the chance to do so. People with insomnia can feel dissatisfied with their sleep and usually experience one or more of the following symptoms: fatigue, low energy, difficulty concentrating, mood disturbances, and decreased performance in work or at school. A lot of people therefore seek for medication; however, it would cause bad side effects.

For improving the problem of insomnia, the way to help people have good sleep quality is the important. Therefore, for help people fall sleep faster during the night working, a varied-colour lighting system is proposed in this study, expecting to enhance users' spirit after sleeping. This assistive lighting system is non-invasive and useful for helping people to have healthy working environment.

2 Methods

To enhance the quality of sleep, a dynamic lighting system which could assist people in fast falling asleep is proposed in this study. The dynamic lighting source would periodically change the colour with time. Total 30 participants join in the experiment for 3 sets of experiment. The full experiment lasts for 1 hour, a questionnaire is preceded before and after the experiment, and the brainwave and electrocardiography are measured in the full experiment. The questionnaire is used for the subjective evaluation, and brainwave and the analysis of heart rate variability is regarded as the non-subjective evaluation.

2.1 Experimental lighting source

The lighting environment for each experiment contains dynamic lighting (with 30-minutes colour change of red, yellow, and purple), low-colour temperature flat lighting (with illumination 9.1 lx and colour temperature 2800 K), and complete darkroom.

Figure 1 – Experimental environment

2.2 Experimental procedure

We propose the varied-colour lighting system, expecting to help users fall sleep faster and improve the users' sleep quality. The auxiliary luminaire could change with time to provide the users with different illumination and spectra. The changes of illumination and spectra are shown in Figure 2. The measuring distance between the lighting system and the measuring instrument is 1 m.

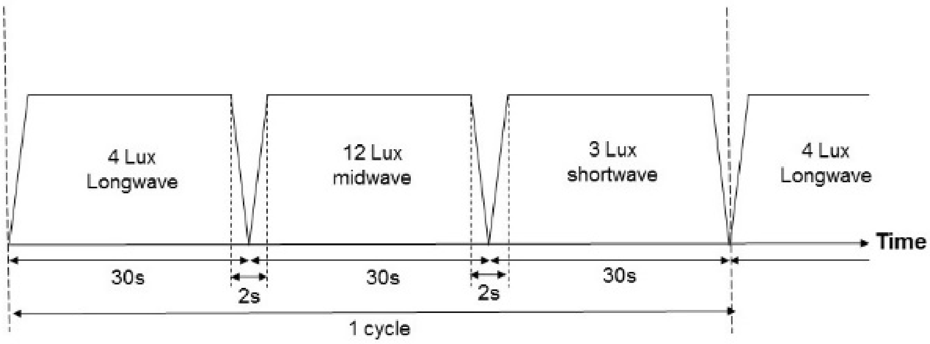

Figure 2 – The proposed lighting

2.3 Physiological detection

The EEG signals at Temporal lobe (T_7, T_8) and Occipital lobe (O_1, O_2) are extracted for the analyses. The δ wave (0.3-4Hz) energy change is regarded as the objective the sleep quality of a short rest assessment index in this dissertation (Hese,2011). HRV analysis is also used as the objective quality assessment index in this experiment, with normalized low frequency power (nLFP) and normalized high frequency power (nHFP) as the evaluation parameters (Malik, 1996).

2.4 Psychological Questionnaire

A 6-point questionnaire is applied to inquire the subjects' perception after the experiment, Table 1. The higher score stands for the higher perception of the person at the time.

Table 1 – The questionnaire in this study

Items	Scores					
You feel comfortable after the experiment	1	2	3	4	5	6
You have good rest quality after the experiment	1	2	3	4	5	6
You are full of energy after the experiment	1	2	3	4	5	6
You would like to keep taking breaks after the experiment	1	2	3	4	5	6

3 Results and Discussion

According to the δ wave analysis result, the δ wave energy percentage at T_7, T_8, O_1 and O_2 with the varied-colour lighting system is higher than it without the luminary and with low CCT light, and the lowest δ wave energy percentage appears on the sleep with low CCT light. The results of δ wave on different points are shown as Figure 3.

The nHFP values of the group without light and the other group with the varied-colour lighting system are higher than the group with low CCT light. Besides, the groups with the varied-colour lighting system and low colour-temperature luminary present better statistical significance at 25 min ~ 35 min. According to the nLFP analysis result, where there is no statistical difference at different time intervals. The result is shown as Figure 4.

Regarding the comfort, the three groups do not appear statistical differences. The group with low CCT light has lower quality of sleep, with statistical significance. The subjects with the varied-colour lighting system perceive better spiritual energy after the experiment, with statistical significance. The result is shown as Figure 5.

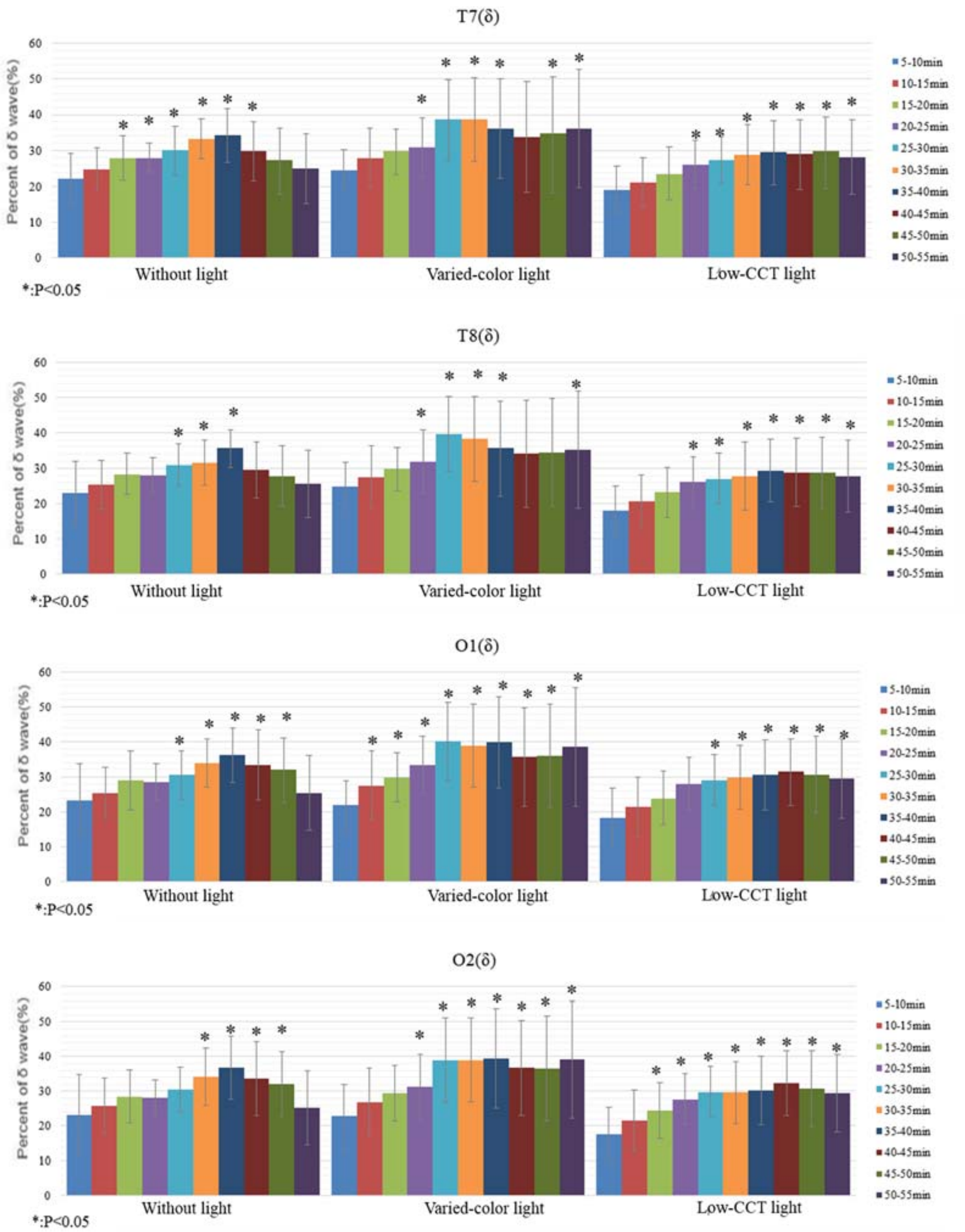

Figure 3 – Variation of the delta wave

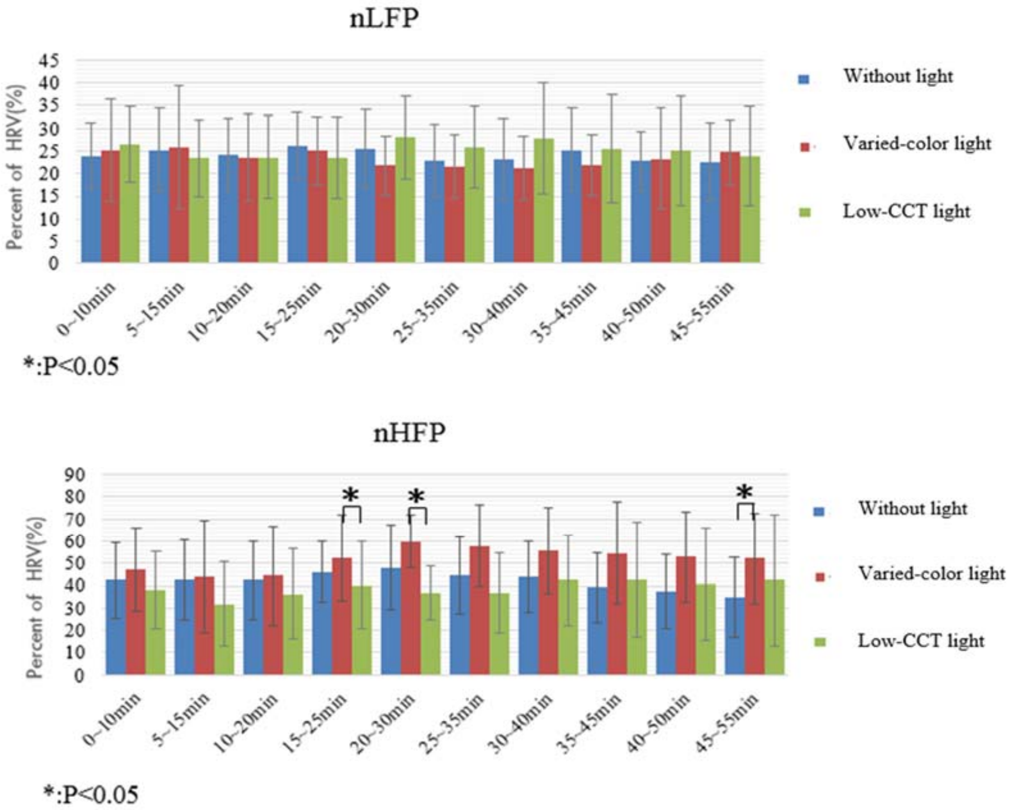

Figure 4 – The results of HRV analysis

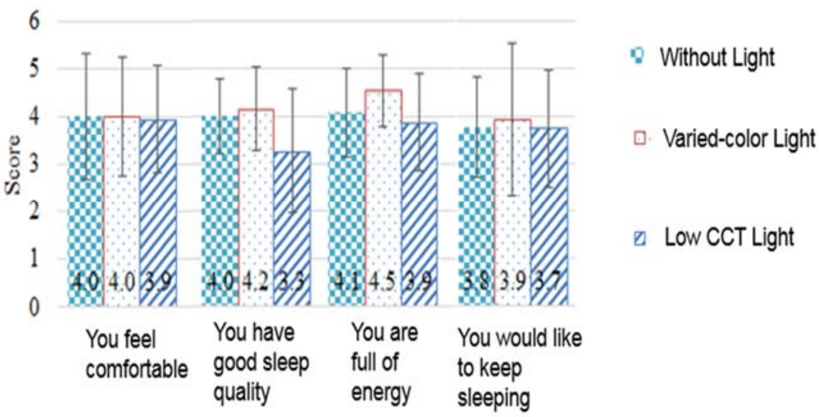

Figure 5 – The results of 6-points questionnaire

The results of all indexes for our verification. Both the δ wave and nHFP of HRV were increased significantly with using the varied-colour lighting. It means subjects are in sleep stage 2 or 3 when resting in our proposed varied-colour lighting environment (Trinder, 2001). The results of our designed questionnaire show that people have better sleep quality when they having a short break in the varied-colour lighting environment. To sum up, all results show that the use of our proposed varied-colour light could enhance the rest quality, or speed up to enter the deep sleep stage, and both the results of objective assessment and subjective assessment present consistency.

It is considered that the varied-colour light could enhance the quality of sleep because the brain induces the evoked events, when the environment illumination instantly decreases and then increases caused by the change of light source generating the illumination change for 2sec, to enhance the electroencephalography energy at 0.5 Hz, which is in the frequency threshold of δ wave. In this case, the δ wave energy percentage obviously increases during the dynamic sleep-aid luminary irradiation to further enhance the quality of sleep.

4 Conclusion

A varied-colour light which could help sleep fast is proposed in this dissertation, and both subjective assessment and objective assessment are utilized for the verification. The objective assessment result shows that the use of the varied-colour light could enhance the δ wave power and the parasympathetic activity. The subjective assessment also reveals that the use of the varied-colour light could promote the users' rest quality. The objective assessment result is consistent with the subjective assessment result. It is expected that the varied-colour lighting could be applied to clinical verification to actually assist people who need to improve the quality of sleep in the future.

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INFLUENCE OF CIRCADIAN STIMULUS AND COLOUR TEMPERATURE ON CHILDREN'S STUDY PERFORMANCE AND FATIGUE

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Abstract

An experiment was carried out to study the effects of lighting on children's work performance and eye fatigue in an office room. The lighting source was a 11-chanel LED lighting system. There were 5 different lighting conditions. For CCTs, 3000 K, 4000 K, 5000 K were adopted, they were the most commonly used CCT in Chinese indoor lighting. There were two CS levels, a higher range of 0.107~0.140 and a lower range of 0.033~0.045 at cornea level. Twelve junior school students participated the experiment. Work performance task including d2 test, reading, copying textbooks and finding. Eye fatigue was measured by CFF and NPA. The results show that children have higher alertness level under high CS lighting conditions. Higher CS lighting also make children get more eye fatigue. 4000 K can improve children's work performance.

Keywords: Work performance, Fatigue, Circadian stimulus, CCT

Introduction

Over the years, researchers have strived to find the relationship between the lighting parameters and human biological and psycho-physiological responses. More intensive studies have been carried out after the finding of intrinsically photosensitive retinal ganglion cells (ipRGCs) which contains the photopigment melanopsin. The mechanism behind lighting and human biological performance is now becoming more clearly. Since children's lens have a higher transmittance than adults' and also serum melatonin concentration varies with ages. It is important to investigate how lighting affect children's performance.

One early study by Küller and Lindsten investigated the impact of daylight on both behavioral and physiological parameters amongst children in classrooms. Their results showed that children studied in classrooms without window displayed a different annual variation of the chronobiologic marker cortisol in comparison to those who studied in classrooms with window. Other studies reported that higher CCT and dynamic lighting systems seems to provide better work performance and higher alertness level.

Since Berson et al. found a third type of photoreceptor in the retina called intrinsically photosensitive retinal ganglion cells (ipRGCs). This cell provides a connection describing the mechanism of human biological effect controlled by light. These cells have their 'own' nerve connections to, amongst others, locations in the brain called the suprachiasmatic nucleus (SNC), which is the biological clock of the brain, and the pineal gland. So it forms one important biological factor that lighting can affect is hormone secretion, which includes cortisol ('stress hormone') and melatonin ('sleep hormone'), playing an important role in governing alertness and sleep.

Higuchi et al found that the percentage of melatonin suppression by light in children at night was almost twice than that in adults, suggesting that melatonin is more sensitive to light in children than in adults. They explained that children have larger pupils and higher transmission rate of crystal lens. These ophthal-mological characteristics imply high sensitivity of melatonin to light in children. So, children should be more sensitive to different CS level lighting. A filed study by Figueiro et al was conducted with eight-grade children. There were two groups: one group wearing orange glasses to minimize the short-wavelength light exposure needed for circadian system stimulation and the other group did not wear the orange glasses. However, they found that performance scores on a brief, standardized psychomotor vigilance test and self-reports of well-being, did not show significantly difference between the two groups.

The aim of this study is to explore how lights with different CS values affect school children's study performance. High and low CS lightings were designed under different CCTs. Attention and eye fatigue were the two main tests to evaluate performance here.

Lighting conditions

The experiment was performed in a typical office room at the university. The windows were covered with heavy curtain so daylight was cut off from the room and the only light source was an 11-channel spectrum tuneable LED lighting system on the celling. In this study, the spectral power distributions of lightings were specially designed by optimising CS and CCT using a spectrum tuneable LED system. Five different lighting conditions were investigated in this study according to three CCTs (3000 K, 4000 K and 5000 K) and two CS levels (0.2 and 0.4). They were designated as 3000K0.2CS, 3000K0.4CS, 4000K0.2CS, 4000K0.4CS and 5000K0.4CS, at 500 lx at desk level. Here 5000K0.2CS cannot be calculated out at 500 lx. The melanopsin illuminance at desk level of each lighting source were 29, 34, 37, 53 and 65 respectively. Table 1 summarises the lighting conditions for each experimental condition.

Table 1 – Detail of lighting parameters

Phase	1	2	3	4	5
CCT	2995 K	4033 K	4996 K	2944 K	3982 K
Illuminance from desk Illuminance from cornea	492 lx 74 lx	494 lx 74 lx	509 lx 76 lx	509 lx 76 lx	496 lx 75 lx
CS （desk）	0.42	0.42	0.47	0.21	0.26
CS（cornea）	0.110	0.107	0.140	0.033	0.045
S cone	13.93	27.34	33.39	18.92	19.67
Melanopsin	34.29	52.54	65.40	29.36	36.96
Rod	47.74	62.78	74.68	44.40	52.25
M cone	67.96	75.37	82.47	65.57	70.72

Methods

Twelve junior school students including 6 girls and 6 boys having a mean age of 9.3 years old took part in the experiment. There were 5 different lighting conditions so that each participant came to the lab at 5 different days at the same time period of each day. Each participant was instructed to keep a regular sleeping schedule during the experiment.

Comprehensive methods were used in the experiment including cognitive tasks, fatigue test and mood & sleepiness questionnaire. For cognitive performance, d2 test was used to measure the attention and concentration level. Reading novels, painting colour and copying textbooks were adopted as the mental load tasks, which were similar to the routine work at school. For the visual fatigue assessment, ophthalmological parameters critical flicker frequency (CFF) (Blehm et al., 2005) and near point accommodation (NPA)(Lee et al., 2011) were used. Physiological signal SpO2 was also measured (Wang et al., 2016). They have been commonly used in different fields to estimate the visual fatigue. Visual performance was measured by the Landolt rings with different size and orientations of gap generated by a computer software. Subjective feelings were also measured by three questionnaires: mood (sad, happy, angry, fun, laughing (exciting)), sleepiness (shown by 5 different pictures) and eye fatigue (eye uncomfortable, blurred vision, body pain). Figure 1 shows the apparatus used in some tests.

Figure 1 – The apparatus used in this experiment

The procedure was as following. Before the real experiment, a 10-minutes training session was conducted to familiarize the testing methods. Participants then had a 5-minutes adaptation. In the real experiment, the questionnaire and four fatigue tests were conducted to establish the base line result. Subsequently, they did the d2 test and three mental loads tasks, taking about 65 minutes. Finally, eye fatigue and questionnaire were repeated. Each session lasted about 120 minutes. In total, 38 hours were spent and the whole experiment lasted about 1 week.

Results

All the data were analysed with SPSS 22.0 software. Since some data were heterogeneity of variance and not normal distributed, Mann-Whitney U test and Kruskal-Wallis test (95 % CI) were adopted to perform the significant test. The task performance results showed that CS had a significant effect on two tasks (d2 and reading speed), i.e. participants had a higher d2 score under higher CS lighting (p=0.024, M-U test) and also faster reading speed under high CS lighting (p=0.029, M-U test) on both 3000 K and 4000 K. This implies that a higher CS lighting help to improve concentration and alertness which may cause a better study performance. Figure 2 shows the task results of different lightings.

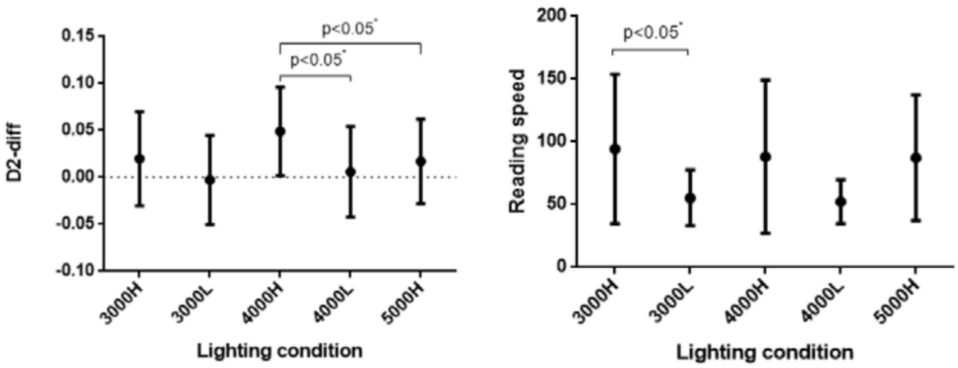

Figure 2 – Result of D2 test and reading speed

Figure 2 results showed that CCT also produced great effect on d2 test because 4000 K lighting to have the highest score among all the CCTs especially comparing to 5000 K (p=0.011, M-U test). This indicates that 4000 K is a suitable CCT for children to raise attention.

For eye fatigue tests, CFF and NPA represent the difference between the post- and the pro-measurement. The lower the CFF and NPA difference values are, the heavier eye fatigue participants will feel after the tasks. Both CFF and NPA results showed the trend that a higher CS lighting would cause more eye fatigue than that of a low CS lighting, see Figure 3. The effect on CFF was much stronger than that of NPA.

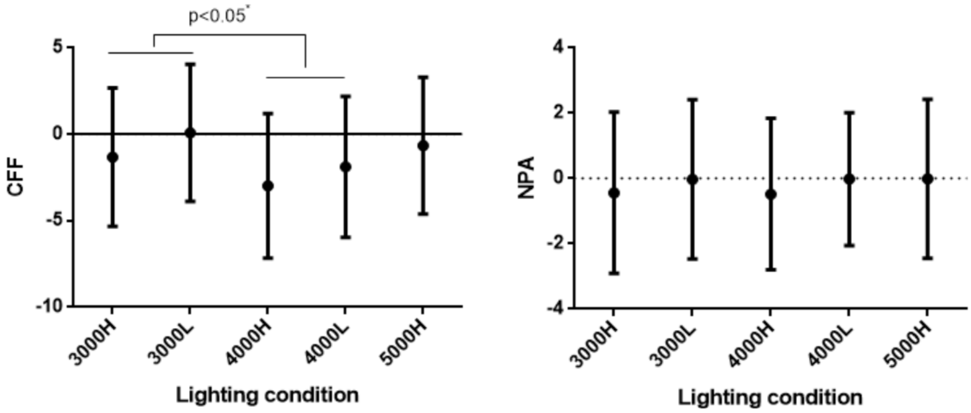

Figure 3 – Result of CFF and NPA

CFF showed that different CCT levels have influence on it (p=0.086, K-S test) and there was significant difference between 3000 K and 4000 K (p=0.044, M-U test), i.e. 4000 K to have the highest CFF value (the highest eye fatigue) amongst all the lightings.

The results from the Mood questionnaire seems to be not so precise to describe the participants feelings. The only indictor which had significant difference among different lightings is "laughing". A high CS lighting makes participants feel more excited comparing to low CS lighting (p=0.031, M-U test). Higher CCT can also makes participant to be more excited.

Comparing the result of work performance and fatigue, the results clearly showed that the lighting condition that improve work performance always cause more fatigue. An additional analysis was conducted to find the relationship between concentration and fatigue. The result of d2 test and CFF were chosen to represent concentration level and fatigue level, respectively. It was found that concentration (d2 test) and eye fatigue (CFF) had significant relationship (Pearson Correlation Coefficient = -0.308, p=0.04). The higher attention level devoted into the work, the higher eye fatigue will be expected. It seems to be difficult to find a light to produce high study performance and low eye fatigue.

Conclusions

- Children tend to have higher concentration level and more excited under higher CS lighting conditions, but also higher CS lightings may lead to more fatigue.
- Children's cognitive performance may not improve at higher CCT level. They had the highest attention level at 4000 K lighting condition.
- Among all the CCTs, 5000 K caused lower eye fatigue on children.
- Among all the methods in this experiment, d2 test was the most effective test to evaluate the cognitive performance, CFF was the most effective test for measuring eye fatigue.
- Both subjects' attention level and eye fatigue had a significant weak negative correlation.

Acknowledgment

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EFFECTIVENESS OF BRIGHT LIGHT THERAPY IN THE TREATMENT FOR MOOD DISORDER

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Abstract

This paper laid out two cases of treatment, each carried out with different bright light therapy conditions, based on the condition of effective bright light therapy for seasonal affective disorder. The purpose of this paper is to assess the evidence base for the effect of bright light therapy on non-seasonal depression and depression oriented people. Bright light therapy used had significant positive effect on emotion, leading to significant drop of heart rate and blood pressure. We found that physiological parameters and psychological scales were independent factors in featuring the improvement of mood disorder. In this study, we obtained an optimum bright light therapy condition: LED light at 4400 K of 4000 lx conducted in the evening tend to have good effect on non-seasonal depression and depress oriented people.

Keywords: Depression, light therapy, PANAS, heart rate

1 Introduction

Depression is a common mental illness that affects about 350 million people worldwide. Symptoms including feeling depressed, low self-esteem, difficult to concentrate, seriously affect the quality of life. At the same time, about 60 % of people who committed suicide suffered from depression. Depression can be divided into two types, seasonal affective disorder (SAD) and non-seasonal depression. Seasonal affective disorder occurs at specific time annually, following seasonal pattern. On the contrast, people with non-seasonal depression are possible to feel depressed at any time of the year.

Currently, drug is effective for 50 % to 60 % patients, and only 35 % to 40 % of them showed revive of symptoms during 8 weeks intake of medication. At the same time, there are serious side effect when using drug, including vomit, diarrhoea, tremor, insomnia, anxiety and sexual dysfunction. Long-term intake of drug causes damage to human body. Thus, alternative or adjunctive intervention is needed to improve the treatment of depression.

Bright light therapy has biological effect. By observing the intra-circadian rhythm phase of patients with seasonal depression relative to the external clock delay, such as the sleep-wake cycle, it has been found that bright light therapy through the clock phase advance can produce antidepressant effects. Study found that in areas with little sunshine, the incidence of depression is higher. Large quantity of experiments, comparison and researches have proved that bright light therapy have certain therapeutic effect on seasonal affective disorder. Bright light therapy has become an effective treatment for preliminary treatment of seasonal affective disorder. However, the effect of light therapy, including bright light therapy, on non-seasonal depression needs to be further studied on.

Meanwhile, light with different colorimetric parameters can lead to different biological effect. According to former studies, we found that there were experiments conducted in different time in the day. Despite of studies which had insignificant treatment effect, former experiments still showed space to be further studied on, including experiments with small number of participants which could cause randomness, like Lewy's (1987), Terman's (1989) and Yerevanian's (1987) experiments, or unsuitable time of experiment which could cause side effect, like Terman's (1987), Yerevanian's (1987) and Wirz-Justice's experiment. These could not be ignored.