LIGHT ENVIRONMENT EVALUATION UNDER DIFFERENT ORDERS AND SPEEDS OF ILLUMINANCE CHANGE

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ABSTRACT

For this study, the light environment and subjective impressions of observers are evaluated and compared as the illuminance level of an experimental room is changed between light and dark with different orders and speeds. Effects of mood states on the evaluation were also assessed. Results of statistical analyses indicated the following results. 1) In darkening experiments, deterioration of comfort, preference and sense of coziness are less by instantaneous change than by gradual change. 2) In brightening experiments, improvement of comfort, preference, sense of coziness and clearness are greater by instantaneous change than by gradual change. 3) When changed gradually, comfort and preference deteriorate after darkening. The sense of brightness decreases and the sense of glare increases after lightening for subjects of high vigour in mood states. 4) When changed instantaneously, a mood state does not affect the light environment evaluation.

Keywords: illuminance change, light environment evaluation, Profile of Mood States

1. INTRODUCTION

Greenhouse gas emissions of households and businesses have been increasing, although those in the other domains have tended to decrease in Japan. Urgent action must be taken. Lighting energy use in buildings accounts for about 20%; decreasing illumination levels are expected to save energy use and to limit greenhouse gas emissions. Kanazawa et al. (2011) clarified that electric energy use in office buildings was decreased by 26% if the illumination level was decreased by 25%. Kato (2012) inspected the effects of illumination change speeds on the occupants' brightness response, noting that gradual change can have a milder response.

Two illuminance levels were set for these experiments. Two types of experiments assessed effects of changing the order of lightening and darkening. Another two types of experiments examined effects of changing speed gradually and instantaneously. Subjects evaluated brightness, brightness for reading, glaring, uniformity, comfort, colour preference, flickering, comfort preference, and working performance of the light environment of each illuminance level. The impression about the room was also evaluated by subjects. Awareness of the illuminance change was asked in gradual change experiments. We introduce the profile of mood states test (POMS) to classify the subjects because comfort and preference might depend on personal physiological attributes. POMS tests are sometimes used in clinical medicine to measure patient mood states by the profile of six factors of tension, depression, anger, vigour, fatigue, and confusion.

2. EXPERIMENTAL METHOD

2.1 Facility Description

Four fluorescent lamps were installed on the experimental room ceiling. Lighting power was conditioned at two levels: 25% (Dark) and 100% (Light). The room temperature and humidity were maintained at 25°C and 50%. Curtains covered the four walls. Six subjects participated in the experiment simultaneously. The mean horizontal illuminance among six seats was 342 lx in the Dark condition and 2238 lx in the Light condition.

2.2 Experimental Procedure

Subjects entered the test chamber, sat around a table, and responded to questionnaires in the first lighting condition. The lighting level was changed; then the subjects answered questionnaires in the second lighting condition. There were two illumination change speeds: instantaneous change and gradual change in two minutes. Results of pre-experiments confirmed that change in

two minutes was less perceptible than change in one or four minutes. Both Dark-to-Light and Light-to-Dark experiments were conducted. Instantaneous change experiments continued for about 20 min. Gradual change experiments continued for about 25 min. The light environment evaluation was done in each lighting condition. Questionnaire items aside from the light environment evaluation were answered considering the subjects' adaptation to light conditions. Instantaneous change experiments examined 148 subjects. Gradual change experiments examined 172 subjects.

2.2 Evaluation Items

Impression of the room was evaluated by 32 semantic differential scales. Interfering, naturalness, and adaptability of the illuminance change were asked in gradual change experiments. 40 mood state scales were used to evaluate the POMS for a week prior.

3. RESULTS

3.1 Effects of change speed

3.1.1 Light environment evaluation in Light to Dark experiments

Fig. 1 presents light environment evaluations for Light to Dark experiments. The left panel shows instantaneous change data. The right panel shows gradual change data. Comfort evaluation differs between Light and Dark (p<0.01). No difference was found in preference evaluation between Light and Dark in instantaneous change experiments. However, both comfort and preference are lower (p<0.0001, 0.0001 respectively) in Dark than in Light in gradual change experiments.

Regarding impressions, the coziness sense does not differ for instantaneous change but it decreased for gradual change in Light to Dark experiments. The activity factor improves for instantaneous change, but it does not differ during gradual change.

3.1.2 Light environment evaluation in Dark to Light experiments

Fig. 2 shows the light environment evaluation in Dark to Light experiments. Comfort, preference, and performance evaluation differ between Light and Dark in instantaneous change experiments (p<0.01, 0.0001, 0.01 respectively). However, no differences are found between Light and Dark in gradual change experiments. Instantaneous change from dark to light improves comfort, preference and performance, but gradual change does not affect the evaluation of comfort, preference and performance.

Regarding the impression, coziness, and harmony sense improve by instantaneous change, but they do not differ by gradual change in Dark to Light experiments.

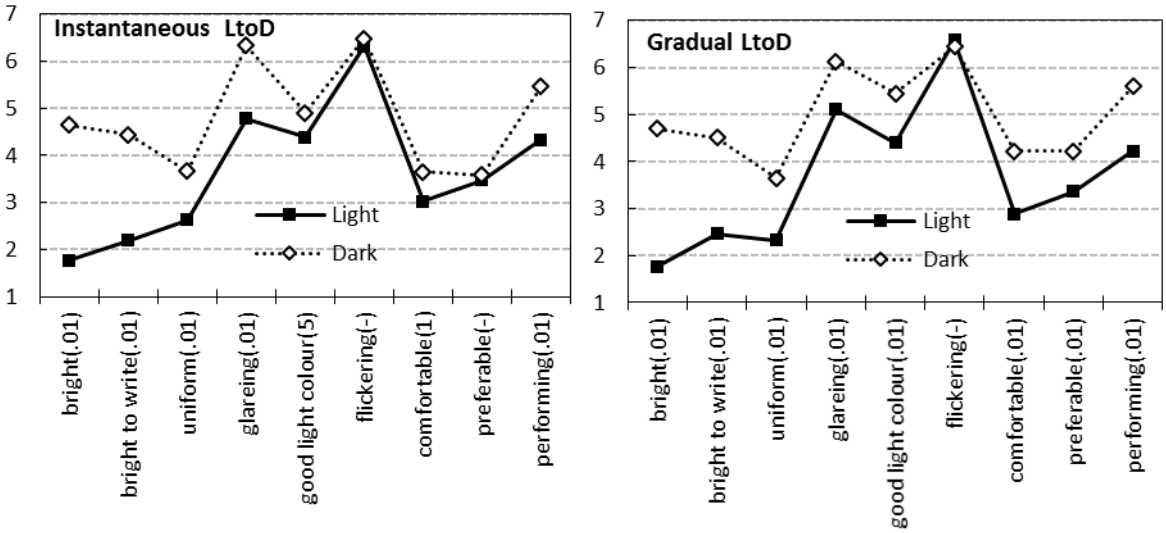

Fig. 1 Light environment evaluation (Darkening experiments: LtoD)

3.2 Effects of change awareness

Fig. 3 presents the difference by awareness of the change in gradual change experiments. The upper panels show data for Light to Dark experiments. The lower panels show data related to Dark to Light experiments. The vertical axis shows the difference of change from the first light condition minus the second light condition. In Light to Dark experiments, comfort, preference and performance decrease (p<0.01, 0.01, 0.01) if subjects feel the light change to be interfering and unadaptable. In Dark to Light experiments, comfort, preference and performance do not increase whether subjects have interference or an unnatural feeling related to the light change or not.

3.3 Profile of Mood States and light environment evaluation

Profiles of Mood States of the subjects were classified into four clusters as Fig. 4 shows. High vigour cluster-1 and low vigour cluster-2 are compared.

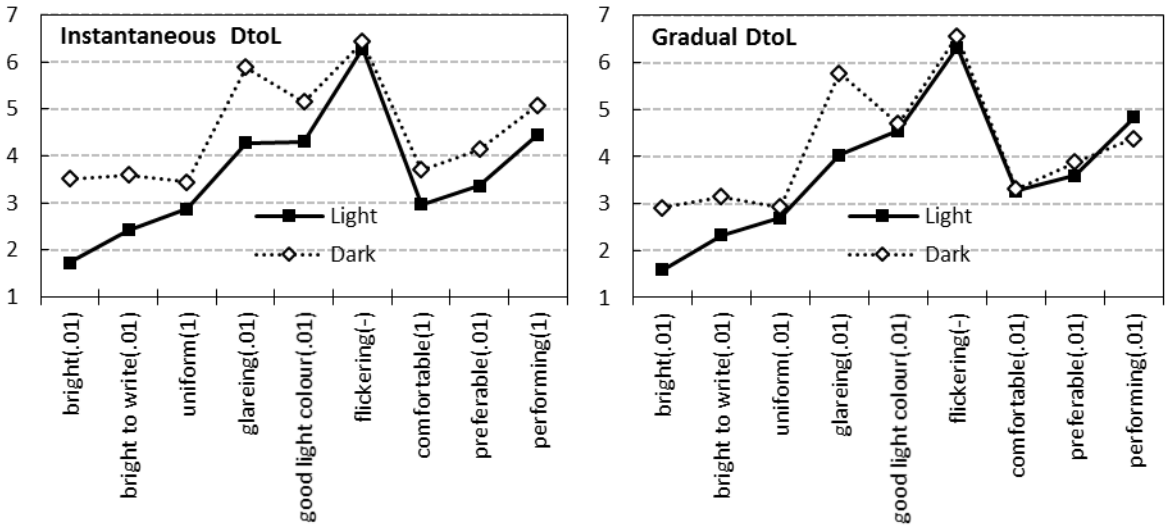

Fig. 2 Light environment evaluation (Lightening experiments: DtoL)

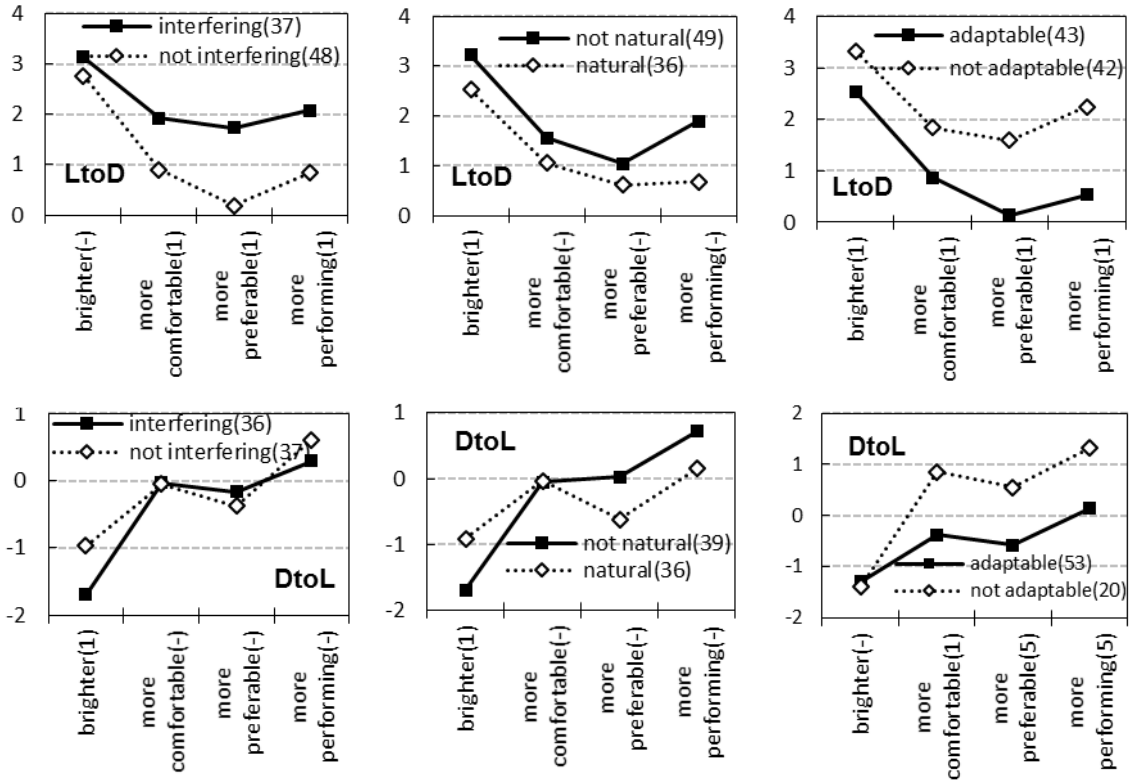

Fig. 3 Difference by awareness of the change (Gradual change experiments)

Fig. 5 presents a comparison between high and low vigour clusters. Light environment evaluation does not differ by vigour in instantaneous change experiments. The low vigour cluster evaluates less comfortable and preferable for gradual change in Light to Dark experiments. Furthermore, the low-vigour cluster was evaluated as more glaring (p<0.01) and more bright (p<0.2) for gradual change in Dark to Light experiments.

Impression evaluations also do not differ by vigour for instantaneous change for both Light to Dark and Dark to Light experiments. However, it differs for gradual change in the sense of coziness and clearness factor in Light to Dark experiments and in the activity factor in Dark to Light experiments.

4. CONCLUSION

Light environment and impression evaluations were compared for darkening and brightening, and between instantaneous and gradual change. 1) In darkening experiments, the evaluations of comfort, preference and the sense of coziness are degraded by gradual change, although the evaluations are not changed by instantaneous change. 2) In brightening experiments, evaluations of comfort, preference, performance, sense of coziness and sense of clearness are improved by instantaneous change, although they do not differ with gradual change. 3) Awareness of changing illuminance in gradual change experiments affects the brightness, comfort, preference, and performance evaluation, 4) mood states affect evaluation by gradual change, although they do not affect evaluation by instantaneous change.

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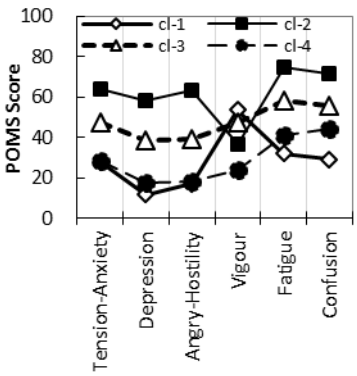

Fig. 4 Classification by POMS

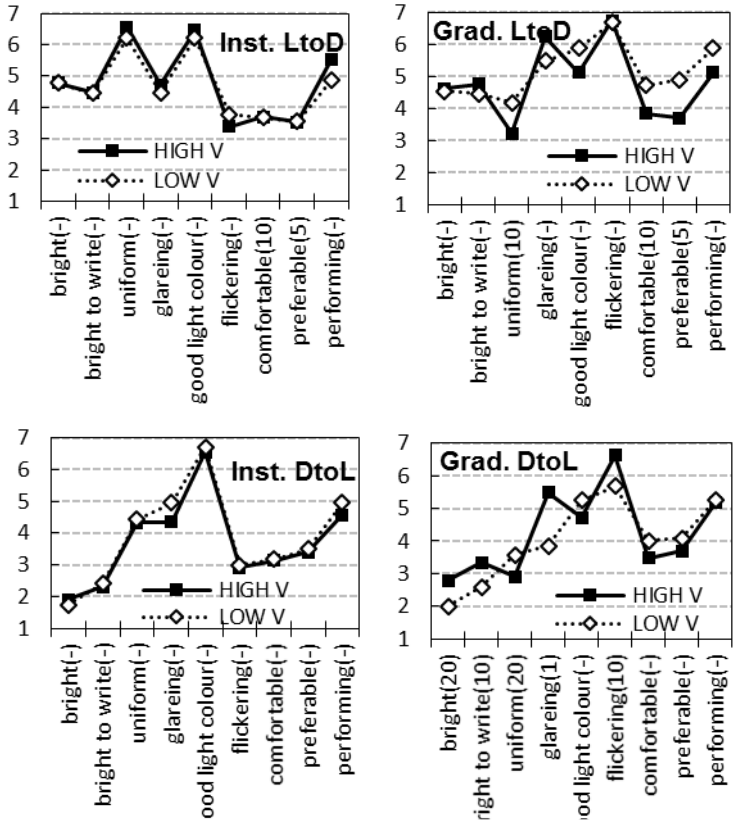

Fig. 5 Comparison between high and low Vigour

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