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Will correlated colour temperature affect peoples' thermal sensation outside the laboratory?

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Abstract. Earlier studies have shown that low Correlated Color Temperature of lighting (CCT) may induce a warmer thermal sensation than high CCTs at the same ambient temperature. The current study investigated if the association between CCT and thermal sensation would persist when subjects worked on computers, were exposed for longer duration and when the study population included older subjects whose vision may have changed with age. The study was carried out in a climate chamber with controllable LED lighting and where CCT could be gradually changed. Generally, the association between CCT and thermal sensation was weak and not significant. However, at 22°C and short-term exposure, the results indicated that high CCT caused a cooler thermal sensation. This association disappeared with more prolonged exposure duration and when subjects worked on a computer. Comparison of responses to lighting exposure of the two groups of subjects with mean ages of 24 years and 44 years showed no difference in their perceived thermal sensation when the CCT was changed. However, the older group of subjects could not distinguish differences in CCTs above 4000 K.The findings suggest that the magnitude of the effect of lighting on thermal perception is modest and only visible under exceptional and tightly controlled conditions that do not mirror actual buildings.

1. Introduction

Several earlier studies have documented significant effects on the thermal sensation of the correlated colour temperature of lighting (CCT). A comprehensive list of these was recently compiled by Brambilla et al. [1]. Generally, low CCTs induced a warmer thermal sensation than high CCTs at the same ambient temperature. However, most of the studies that found an association between CCT and thermal sensation were carried out under ideal experimental conditions, i.e. with no disturbance from daylight, computer monitors or coloured surfaces, and short exposure durations of less than 60 minutes. The current study investigated if the association between CCT and thermal sensation would persist when subjects worked on computers, were exposed for longer duration and when the study population included older subjects whose vision may have changed with age.

2. Methods

2.1 Exposure room

In a climate chamber simulating an office, perceptual and physiological responses of 35 human subjects exposed to varying CCTs were investigated. The chamber had no windows and thus no daylight access. All surfaces except the light-grey floor were white. The lighting system consisted of nine Phillips PowerBalance Tunable White fixtures; five squared fixtures to illuminate the table area, and four rectangular fixtures to illuminate the wall in front of the subjects. The CCT could be controlled in a nominal range from 2700K to 6400 K.

2.2 Experimental exposures

Both subjects' immediate response and their response after a longer-term (30 minutes) light exposure were considered. Experiments with PCs were conducted to determine if the light from the monitors would reduce the effects of CCT. Two operative temperatures were assessed; 22 °C and 24 °C. The illuminance was kept constant at 500 lux on the work plane. CCT was the only variable that changed from 2700 K to 6100 K or reverse during an experimental session. The influence of CCT on the subjects was evaluated by questionnaires, a performance test and skin and tympanic temperatures. Questionnaires and performance tests were either paper-based or online in experiments where subjects used a PC. Only questionnaire responses will be reported here. Environmental measurements included spectral power distribution and CCT, operative temperature, airspeed, air humidity and CO_2 concentration.

3. Results and Discussion

Previous experiments with an illuminance of 1000 lux indicated that CCT significantly affected thermal sensation at a comfortable operative temperature of 22ºC [2]. With an illuminance of only 500 lux in these experiments, the effect of CCT on thermal sensation was no longer significant. Figure 1 shows the association between CCT and thermal sensation and between CCT and the perceived brightness of the lighting. When subjects used computers, the association between the CCT and thermal sensation was very weak and far from significant, and the light was generally experienced as being very bright, independent of the CCT of the lighting in the room. In contrast, when the subjects were not using a computer, the light was experienced as clearly more bright with increasing CCT.

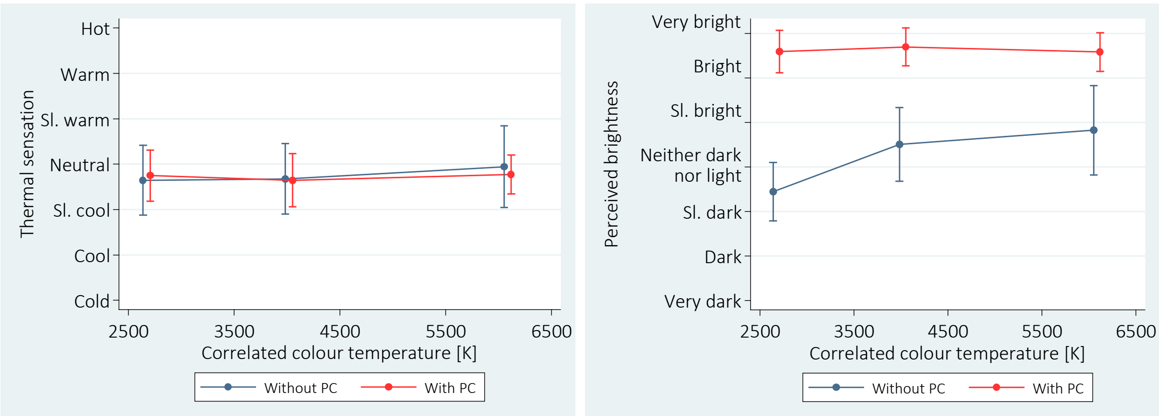

Figure 1. Influence of PC use on the association between CCT and thermal sensation (left) and between CCT and perceived brightness of the lighting (right).

CCT has been shown to influence thermal sensation with shorter-duration exposures, but the body's heat balance will likely dominate the perceptive response during longer exposures. Figure 2 compares thermal sensation recorded during periods of 30 min at CCTs kept constant at the highest and lowest of the applied levels. Although not significant, Figure 2 indicates that thermal sensation decreased slightly with time even though operative temperature, CCT, clothing insulation and activity were kept constant. The figure also indicates that thermal sensation decreased at a marginally higher rate at a CCT of 6090 K. Comparison of responses to lighting exposure of two groups of subjects with mean ages of 24 years and 44 years showed that there was no difference in their perceived thermal sensation when the CCT was changed. However, the older group of subjects could not distinguish differences in the CCTs above 4000 K.

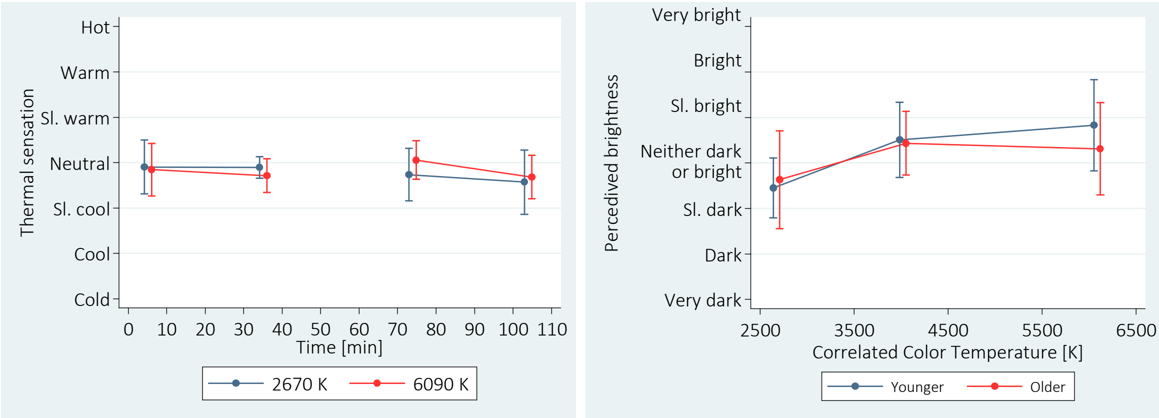

Figure 2. Association between CCT and thermal sensation after 30 min constant exposure at lowest and highest applied CCTs (left) and between CCT and perceived brightness for younger and older subjects (right).

The findings of this study suggest that the magnitude of the effect of lighting on thermal perception is rather modest and probably only visible under exceptional and tightly controlled conditions that do not mirror actual buildings. In buildings in practice, it may therefore not be feasible to use lighting properties to modify uncomfortable thermal exposures and save energy used for heating or cooling.

4. Conclusions

The magnitude of the effect of lighting on thermal perception was rather modest and only visible under idealized and tightly controlled conditions that do not mirror actual buildings. Daylight, use of computers, and a diverse age range may affect occupants' visual stimulus and perception and thereby reduce the effect of CCT on thermal responses. However, the findings of this study suggest that the different domains of the indoor environment interact to some degree, but also that the strength of the interaction varies with the domain and the type of perceptual outcome.

Acknowledgement

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