

Conspicuity of blinking LED lights of various temporal frequencies and duty ratios in a wide visual field

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Introduction

LEDs are often used for road signs and some of them are utilized as intermittently on and off. The temporal frequency of flashing is, however, determined by local manufacturers according to their experiences. No studies have been reported on the relation between conspicuity/visibility of blinking LEDs and their temporal frequency. Thus, we conducted experiments to evaluate the conspicuity of a LED matrix of different colors blinking at various temporal frequencies lit in various places in the visual field. In addition to that, visual impression of blinking LEDs of several duty ratios was examined.

Experiment

The left part of Figure 1 shows the top view of the experimental apparatus, and the insertion in the right indicates the LED pole composed of five LED matrices of different colors. One matrix was composed of 3 X 3 dots of LEDs, and one cluster was composed of five matrices of red, yellow, green, blue and white LEDs. They are respectively marked as R, Y, G, B, and W as stimulus codes in this study. Background was dark. Only the central cluster (indicated by the arrow in Figure 1) was used. Five positions (pole # of 1, 3, 5, 7, and 9 in Figure 1) were used in the following experiments.

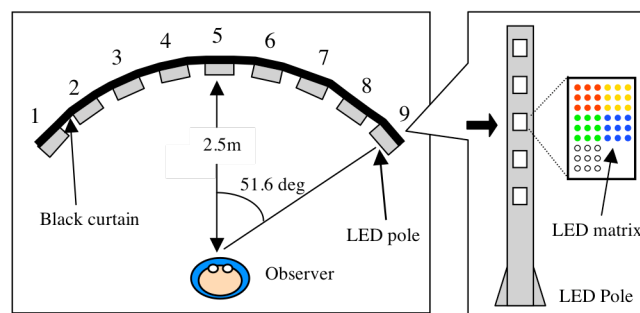


Figure 1. Left: the top view of the experimental apparatus. Numerals indicate the number of pole.

Right: LED Pole.

In the experiment 1, the conspicuity rank order among eight different temporal frequencies (1, 2, 3, 4, 5, 6, 8, and 10 Hz) were determined for each of five colors, at each of five positions. The duty ratio was kept constant. Two stimuli of the same color blinking at different temporal frequencies were successively presented on one of the five poles. Duration of each stimulus was 3 sec and the interval was 2 sec. The observer was asked to determine which stimulus was more conspicuous as a warning sign (pair comparison method). The observer was instructed to gaze at the center pole, thus in the cases of pole numbers of 1, 3, 7, and 9, they saw the stimuli using peripheral vision.

In the experiment 2, visual impression of four duty ratios (1:1, 1:5, 1:10, and 1:20) was examined. Notation of the duty ratio is as follows; 1:1 indicates 50% on and off, 1:5 indicates 17% on and 83% off, etc. Two stimuli of different duty ratios, but the same color (R or B) and the same temporal frequency (1 or 6 Hz), were successively presented at the center pole (pole No.5). Visual persistence of on-duration, conspicuity, brightness, and glare were evaluated.

Results and Summary

Thurstone's case V method was applied to derive the interval scale of conspicuity for the eight temporal frequencies under each of five colors and each of five positions. Figure 2 shows the results of R and B at pole numbers of 5 (center) and 9 (right periphery). As shown in the figure, the R stimulus shows band-pass type at both the center and periphery, whereas the B shows band-pass type at the center but high-pass type at periphery. It is interesting that the Y stimulus shows the results similar to R, while G and W show the results similar to B. Curves in Figure 2 are the band-pass and high-pass filters typically used in electronic circuit. Results of the experiment 2 indicated that visual impression does not show clear difference between the stimuli that differ about twice in duty ratio, for example 1:5 and 1:10, or 1:10 and 1:20.

Our previous study showed that color appearance of B does not change with eccentricity while those of R and Y drastically change in periphery¹⁾. Underlying mechanism for the difference between R, Y stimuli and G, B, and W stimuli will be discussed.

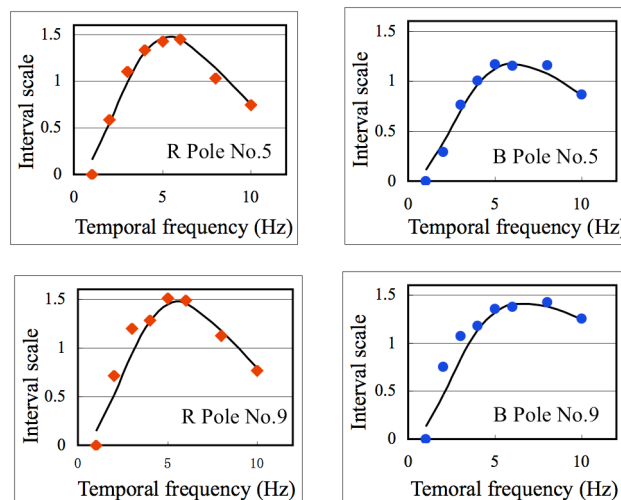


Figure 2. Interval scale of conspicuity for different temporal frequencies.

- 1) K.Hagiwara, M. Ayama, T. Fujima, G. Yamamoto, N. Ikeda, M. Nagata, "Visibility of Color Stimuli using LEDs in Driving Situation", Proceedings of CIE Expert Sympo.; LED Light Sources: Physical Measurement and Visual and Photobiological Assessment, pp.41-44, 2004.