Brief Communication: Impact of Sign Panel Luminance on Visual Comfort

John D. Bullough, Ph.D.

Lighting Research Center,
Rensselaer Polytechnic Institute
Troy, NY

Correspondence: Lighting Research Center, Rensselaer
Polytechnic Institute, 21 Union Street
Troy, NY 12180 USA
Email: bulloj@rpi.edu
Tel.: +1.518.276.7100, Fax: +1.518.276.7199

Abstract /

Signs should produce useful visual information to road and sidewalk users without creating undue glare or visual distraction. In order to assist in navigation and wayfinding, signs must be sufficiently conspicuous. For this reason their brightnesses are often higher than the surrounding visual environment. However, if the brightness becomes too high, the sign risks contributing to visual discomfort. Several published recommendations for limiting sign brightness include limits on the maximum illuminance from the sign (in lux). There is evidence, however, that the maximum luminance of a light source can also influence visual comfort. To investigate the potential role of maximum luminance, a pilot study was carried out to assess visual responses to sign panels producing the same illuminance but differing in luminance.

INTRODUCTION

Signs need to be detected in order to be read. For this reason, signs are usually designed to be brighter than the environments in which they are located. Garvey (2015) and Bullough (2017) have summarized recommendations for brightness levels of signs in different ambient environments (e.g., daytime, nighttime, urban, rural). One concern regarding sign brightness is that the sign does not become too bright that it could serve as a distraction or a source of discomfort (Garvey, 2005) to pedestrians, drivers, cyclists and other observers, or that its legibility could be reduced (Cornog & Rose, 1967). For example, Freyssinier, Narendran, and Bullough (2006) reported that observers began to judge channel letter signs to be too bright and difficult to read if the character luminance exceeded 200 cd/m².

One approach that has been suggested for limiting the apparent brightness of a sign was published by Lewin (2008), who suggested that the illuminance from a sign at a particular viewing distance should not exceed 3 lux at the eyes of an observer. The International Sign Association (ISA, 2016) has also recommended this approach, suggesting specific measurement distances. This approach essentially limits the average luminance of the sign (at a value of approximately 300 cd/m² for the measurement distances recommended by ISA), because a uniform gray sign could produce the same illuminance at the eyes as a sign consisting of a black and white checkerboard pattern. This may be relevant to visual judgments of signs because Bullough and Sweater Hickcox (2012) reported that ratings of discomfort glare from large-area light sources were worse when the maximum luminance of the source was higher, even if two sources produced

Figure 1 / Scale model display used in the experiment.

the same illuminance at the eyes. In other words, a checkerboard pattern might be expected to be judged as more glaring than a uniformly gray sign with the same average luminance. If this finding can be extended to signs, quantifying the illuminance alone from a sign might not be sufficient to avoid problems.

In order to begin to understand whether and how maximum sign luminance might influence visual discomfort from signs, a small-scale pilot laboratory investigation was carried out.

METHOD

A total of 10 individuals (aged 20 to 47 years, mean 31) participated in the pilot experiment. Inside a darkened laboratory with black-painted walls, a modular scale-model display was set up (Figure 1). The display consisted of three illuminated panels (5 cm by 6 cm each; 15 cm by 6 cm for all three panels together) covered with white plastic acrylic diffusers. Behind the diffusers were 100 W halogen capsule lamps inside white-painted metal enclosures. The lamps could be operated independently with dimming switches to illuminate each panel.

Three luminous conditions were set up (Figure 2), each producing a vertical illuminance of 3 lux at a location 1 m in front of the display where subjects were positioned:

- All three panels illuminated with a luminance of 333 cd/m^2.
- The two outer panels only, each illuminated to a luminance of 500 cd/m^2.
- The center panel only, illuminated to a luminance of 1000 cd/m^2.

The viewing geometry simulated the angular size of a sign 15 m by 6 m at a viewing distance of 100 m, or 7.5 m by 3 m at a viewing distance of 50 m. The panel luminances were adjusted through a combination of neutral density gel filters placed in front of the display and minor dimming

a. b. c.

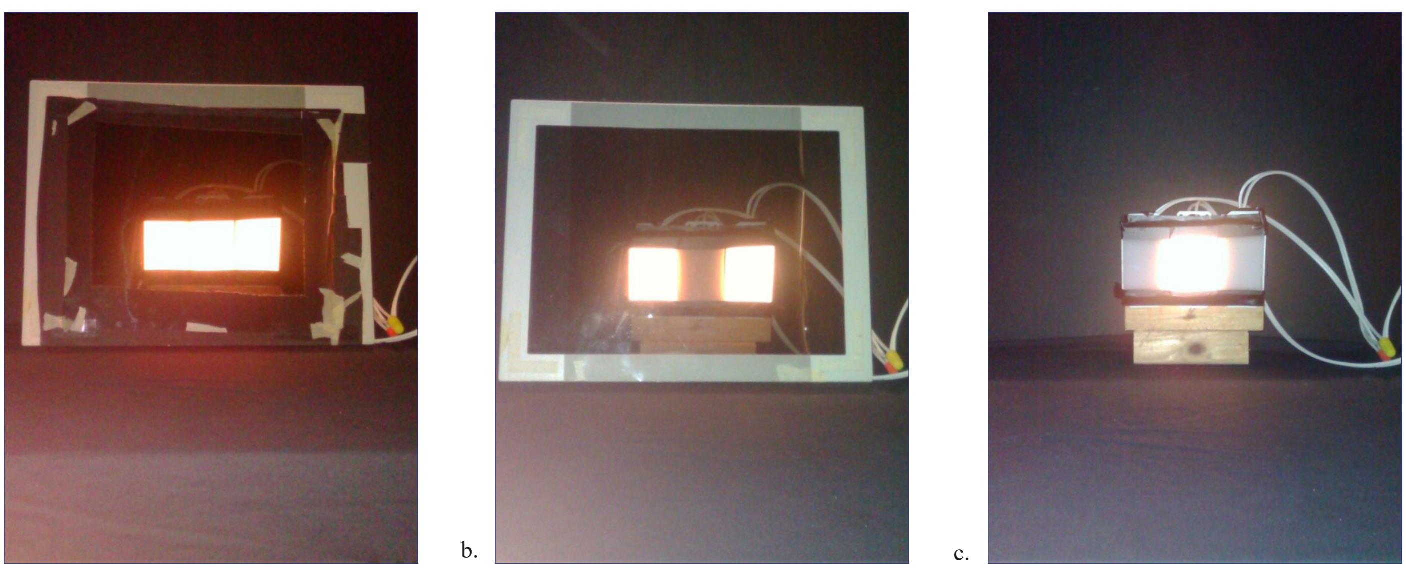

Figure 2 / a: Display with all panels at 333 cd/m^2. b: Display with outer panels at 500 cd/m^2. c: Display with center panel at 1000 cd/m^2.

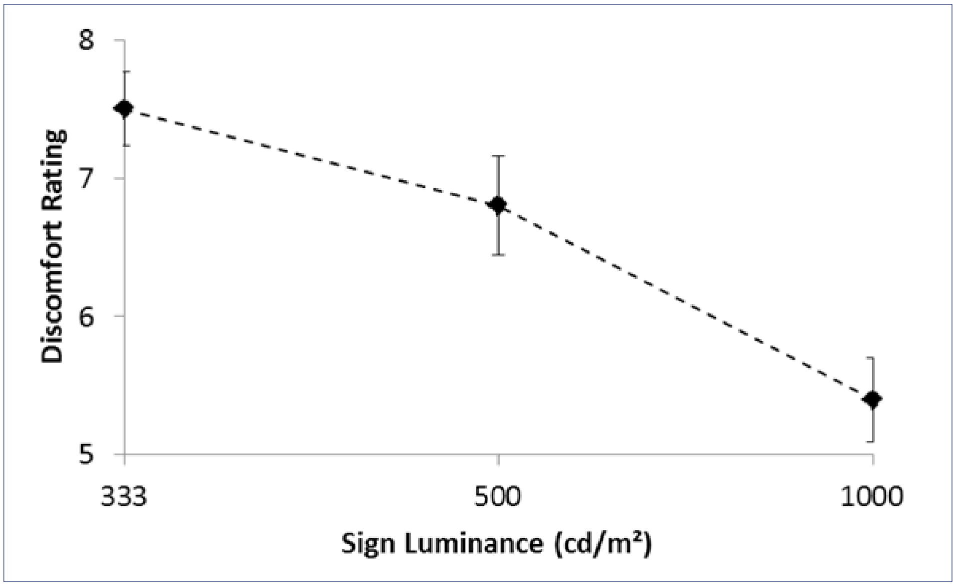

Figure 3 / Mean discomfort ratings (+/- standard errors of the mean) for each of the lighting conditions used in the present experiment.

adjustments, keeping the correlated color temperature (CCT) of each condition within a range of approximately 100 K. It should be noted that the average luminance of all three panels together (333 cd/m²) was constant for all three conditions, although the configurations differed in maximum luminance.

After adapting to the dark conditions in the laboratory for 5 minutes, subjects in this experiment were asked to look toward each condition in a random order for about 15 seconds and make judgments of conspicuity by answering the question: "How attention-getting would this be if it were a sign along the road at night (1 = not at all attention-getting, 4 = very attention-getting)?" Subjects also rated their visual comfort using the De Boer (1967) rating scale (1 = unbearable, 3 = disturbing, 5 = just permissible, 7 = satisfactory, 9 = just noticeable glare). There was a period of about 1 minute between each trial to help subjects readjust to the dark laboratory conditions.

RESULTS

A within-subjects analysis of variance (ANOVA) was conducted on the ratings for each question. No statistically significant effect of lighting condition was found for the judgments of attention-getting characteristics ($F_{2,18} = 2.25$, $p > 0.05$); mean ratings for each condition were between 3 (somewhat attention-getting) and 4 (very attention-getting). Likely, this is related to the fact that the sign display was presented in an otherwise dark room with no other sources of light visible, so that the sign panel easily attracted the participants' attention. The ANOVA revealed a statistically significant effect of lighting conditions on ratings of visual comfort ($F_{2,18} = 15.67$, $p < 0.001$), as illustrated in Figure 3.

Specifically, the mean ratings for the conditions where the display luminance increased from 333 to 1000 cd/m^2 decreased monotonically in numerical value (decreases indicate *increased* discomfort). At the highest luminance (1000 cd/m^2) the mean rating approached the “just permissible” value of 5 on the De Boer (1967) scale, and a paired t-test adjusted with the Bonferroni correction (McGuigan, 1990) confirmed that the discomfort rating for 333 cd/m^2 was statistically significantly different from the rating for 1000 cd/m^2 ($t_9 = 7.58$, $p < 0.001$).

DISCUSSION AND CONCLUSIONS

The results in Figure 3 suggest that using an illuminance criterion of 3 lux at the eyes of an observer (resulting in the same average luminance) will not guarantee a similar level of discomfort experienced by observers. Of course, the range of conditions tested in this experiment was very limited. Only a single, dark, background condition was tested with no other sources of light present, and only a single illuminance value (3 lux) was used. Additionally, the display module used in the experiment did not actually contain any information such as a business name or other graphical elements.

Further, the overall angular size of the illuminated panels changed for the different luminance conditions, and this could have influenced the subjective judgments. Future research could use an array with a larger number of elements resulting in a much more similar overall angular size, to minimize the size differences. All of these factors could influence the degree to which a sign might be judged as uncomfortable to view. Nonetheless, it seems clear that a sign’s maximum luminance can influence the degree of discomfort that the sign might produce for a driver or other observer, even if the illuminance from the sign (or its average luminance) does not change.

One argument for specifying the illuminance from a sign rather than its luminance in limiting brightness is that instrumentation for measuring illuminance is less expensive than luminance measurement equipment (Lewin, 2008). Garvey and Klena (2017) have published data on the luminances of some common illuminated sign configurations that can be useful to specifiers in estimating the maximum sign luminance.

In addition, if it is possible to approach an illuminated sign at night, its maximum luminance, if large enough, might be able to be estimated using an illuminance meter. By holding an illuminance meter so that it is facing the brightest portion of the sign (and generally, so that it is measuring the vertical illuminance from the sign) and so that the portion of the sign that is being measured (with the maximum luminance) largely fills the illuminance meter’s field of view (e.g., from less than 15 cm away, and for a portion of the sign having a radius of at least 50 cm), it is possible to estimate the luminance as follows:

$$L \cong E / \pi$$

where L is the luminance (in cd/m^2) and E is the vertical illuminance from the sign (in lux).

When making this type of measurement, it is critical that the portion of the sign being measured fills or nearly fills the illuminance meter’s field of view. This can be checked by moving the illuminance meter a few centimeters closer to and further from the face of the sign; if the measured illuminance does not fluctuate substantially as the distance changes, then this criterion is likely to be met. In addition, the illuminance meter should not cast a shadow on the face of the sign if it is externally illuminated.

If the sign consists of a matrix of self-luminous elements, moving the illuminance meter along the face of the sign should not result in large fluctuations in measured values. If this is the case it may be necessary to take the average of the highest and lowest illuminance values for a portion of a sign to use in the equation above. It should be noted that this measurement method does not, however, yield high precision, but can be used to estimate luminance within approximately 20% or less.

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