Effect on Legibility of Surround Luminance and Background/Character Color

Legibility Problem and Test Method

During presentations or work with a computer, it is often difficult to read characters on the display when other light sources such as a fluorescent lamp and sunlight are present in the room and thus affect the contrast of the display. However, when lights are completely eliminated (except the light from the display itself) by drawing a curtain or so, people sometimes frown in the direct light from the display, especially when the display character is bright itself over a dark background. A previous study showed that the increase in contrast threshold (%) was smallest when a background and surround were at equal luminance, and the contrast threshold increased rapidly when the surround became brighter, while it increased slightly when the surround became darker (Ireland et al, 1967). The illegibility caused by luminance discord not only disturbs visibility, but also distracts audiences' or users' attentions. To provide the best legibility for normal display viewers in order to achieve a successful presentation or undisturbed work, the best surround luminance was found out from an experiment for both displays with black characters on a white background (White BG) and white characters on a black background (Black BG). Also, outcomes were compared with the previous study to assess the value of experimental results.

Total 5 volunteers whose average age was 26.2 years (range 23 to 29) participated in the experiment. Four of them were males wearing glasses (myopia) whose visual acuity ranged from 0.9 to 1.2 with glasses on, and one female subject who wore no glasses had visual acuity 0.9. A laptop, AMILO D 7820, made by Fujitsu Siemens Computers, was used to present a letter "E" in the center of 9" height ×12" width (image size) LCD display, played by Microsoft PowerPoint version 10.0. Two PowerPoint files for Black BG and White BG were made with their first slides showing only background color in order to let subjects adapt their eyes between trials and while surrounding brightness was being set. From second slides, a letter "E" (Arial, not bold, not italic, no underlined) was placed in the center with its font size in an ascending order from 4 to 23 (total 21 slides each) and the slide number on the low right corner. Both files were programmed to automatically switch to the next slide after 5 seconds except for the first slides which were operated by a space bar. The experiment was conducted in a photo dark room in order to eliminate surround luminance variation. Luminance was measured by light meters, L-508 CINE 700M MASTER, made by SEKONIC. The display luminance was 0.3 ft-L for a black background, 1.0 ft-L for a black character and 21 ft-L for a white character/background. Surround luminance was 0 ft-L with no light except the LCD, 0.83 ft-L with a distant lamp on and white surround, 14 ft-L with a close lamp on and brown surround, 20 ft-L with the close lamp on and dark khaki surround, and 65 ft-L with the close lamp on and white surround. The lamps were aimed at the surround of the LCD. Subjects were seated with their eyes 12 ft distant from the computer display. The monitor was set vertical and its center was at the same height as the subjects' eyes as shown in Figure 1.

A subject was informed that the experiment was to examine a legibility of a display and it had two sessions (Black BG and White BG), 5 surrounding conditions for each session, and 3 trials for each surrounding condition, with 30 seconds rest between sessions. Three trials under

surround luminance 0 ft-L were conducted first, followed by 0.83, 65, 14, and 20 ft-L for Black BG, and the opposite order (20 ft-L → …→ 0 ft-L) for White BG. Before starting an each session, an instruction was given to subjects; "Say "Yes." only if you are absolutely sure that you exactly distinguish the displayed character." The slide number at which the subject said "Yes" was recorded before the slide show was stopped and the file was restarted in the slide show mode for next trial from the first slide. A post-experiment interview was done for each subject about difficulties of reading a character in various conditions.

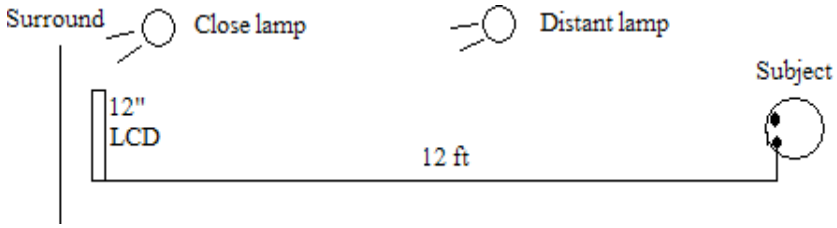

Figure 1 Arrangement in a photo darkroom

Result and Conclusion

The minimum font sizes for distinguishing a character "E" under various surround luminance conditions and Black BG/White BG are shown in Figure 2. Since different displays would have different characteristics, the minimum font sizes cannot be absolute. Minimum font sizes were consistently smaller for White BG than Black BG. For White BG, the minimum font size was smallest at the surround luminance of 20 ft-L where the surround was as bright as the background, which is consistent with the previous study (Ireland et al, 1967) even though a different luminance range and a different independent variable were used. For Black BG, however, the minimum font size was smallest when sufficient light (14-65 ft-L) existed, not when the background and surround were at equal luminance. The illegibility when both surround and background were dark (0-0.3 ft-L) can be explained by spherical aberration caused by a big pupil size and it was supported by the interview in which subjects reported that characters looked Blurred and were hard to distinguish. It was left to be discovered whether a too bright surround (above 65 ft-L) degrades legibility for Black BG. The illegibility when the surround was much brighter than the background can be explained by diffraction or lack of light stimuli caused by a small pupil size. In conclusion, White BG is better than Black BG in terms of legibility, and White BG works better under the surround luminance as equal as background luminance. If Black BG is used, a proper amount of light should be provided for legibility.

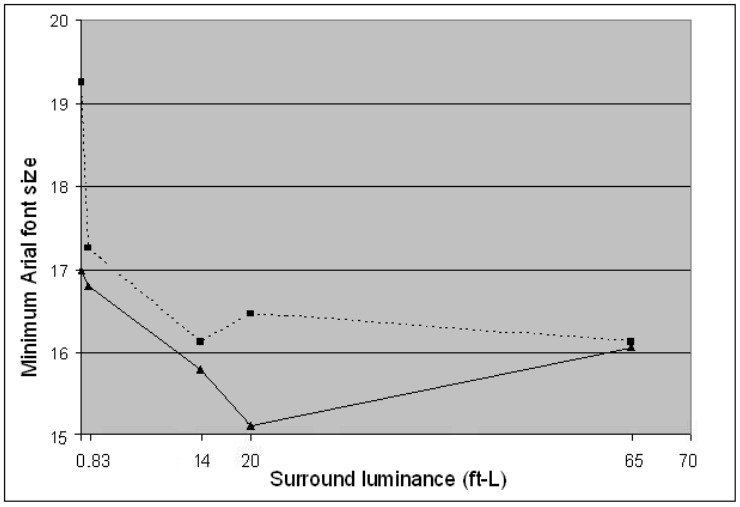

Figure 2 Minimum required font size and surrounding luminance (Dot line: Black BG, Rigid line: White BG)

References

Ireland, F.H., Kinslow, W., Levin, E., & Page, D. (1967). Experimental study of the effects of surround brightness and size on visual performance, Report No. AMRL-TR-67-102. Ohio: WPAFB, Aerospace Medical Research Lab.