A Comparison of the Recognition Distance of Several Types of Pedestrian Signals with Low Vision Pedestrians

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Abstract

Although approximately 80-85% of the legally blind population has some residual vision, little research has examined the relative conspicuity of various types of visual pedestrian signals currently used by cities with this group of pedestrians. This research compared the relative conspicuity of an incandescent WALK sign, a white LED WALK sign, a blue LED WALK sign, and white and blue LED WALK signs that included an animated ‘eyes’ display with legally blind participants who had some vision. All WALK signals were equated for brightness using a N.I.S.T. certified illuminance meter. Participants had to discriminate whether the test stimulus was a blue/ white WALK sign or a blue/ white DON’T WALK sign. Test stimuli were presented in randomized blocks of trials and recognition distances were determined by having participants approach the test stimuli until they could identify them. Results indicated that there were no significant differences between the incandescent and LED signals without the animated eyes or between the blue and white LED signals. However, Tukey’s method showed a significant contrast between the signals with the animated eyes display and signals without this display ($F = 149.88$, P - value $< .0001$). Participants could identify the WALK signal 62 percent further away when it also contained the animated ‘eyes’ display. These results show that the addition of an animated ‘eyes’ display to the WALK sign significantly improves recognition distance for a large segment of persons with visual impairment.

In order for a visually impaired individual to cross streets independently, they must be able to determine several pieces of information including that they have arrived at an intersecting street, the configuration of the intersection, heading, and procedure for crossing. When intersections are familiar, some of this information may already be known. Much of this information is typically obtained by listening to traffic patterns and sounds of individual vehicles (Jacobson, 1993; LaGrow & Weessies, 1994; Blasch, Wiener & Welsh, 1997).

Techniques and cues used in crossing streets are diverse and vary by location and individual. Many visually impaired pedestrians have received mobility instruction from an orientation and mobility specialist to use a cane and/or dog guide to travel independently. In the most common technique utilized for crossing at signalized intersections, pedestrians who are blind begin to cross the street when there is a surge of traffic parallel to their direction of travel. Vehicular sounds are often sufficient to determine the onset of the WALK interval and the direction to the crosswalk on the opposite side of the street. However due to some intersection geometry's, acoustic conditions (quiet vehicles), and the prevalence of activated traffic control systems it is very difficult if not prohibitive for persons who are visually impaired to determine the cues necessary to cross streets independently and safely.

In response to this problem, the Transportation Equity Act for the 21st Century was passed in January of 1998 (H.R.2400). This Act specifies that "Safety considerations shall include the installation, where appropriate, and maintenance of audible traffic signals and audible signs at street crossings." However, there has been limited evaluation of these different signals and to date, there has been no research to evaluate their comparative effectiveness. The majority of the work that has been done has focused on the totally blind traveler and the use of auditory and/or haptic information with little attention to the visual signals for the partially sighted individual. This lack of research is particularly problematic when considering that approximately 80 to 85 percent of the legally blind population has some remaining vision.

The purpose of this research was to evaluate the effectiveness of different visual pedestrian signals with legally blind individuals with residual vision. Van Houten, Retting, Van Houten, Farmer and Malenfant (1999) demonstrated that adding animated ‘EYES’ to the ‘WALK’ indication to prompt pedestrians to watch for turning vehicles significantly reduced the number of conflicts between pedestrians with normal vision and turning vehicles. Because the addition of the animated eyes increases the overall size and shape of the ‘WALK’ indication, adds motion to the display, and adds to the overall brightness it could help low vision pedestrians to identify the display.

Method

Participants. Eighteen adults, 6 males and 12 females classified as legally blind, based on criteria for registration with the Canadian National Institute for the Blind (CNIB), served as participants in this experiment. The CNIB standard classifies a person as legally blind if the visual acuity in both eyes with proper refraction lenses is 20/200 (6/60) or less with Snellen Chart or equivalent, or if the greatest diameter of the field of vision in both eyes is less than 20^0 centered on fixation. Participants ranged in age form 20 to 72. The participants reported the following causes of visual impairment: macular degeneration

(4 participants - 22% of the sample; optic nerve atrophy (1 participant); congenital aniridia (3 participants); glaucoma (1 participant); Albinism (2 participants); cataracts (1 participant); cataracts and optic nerve damage (1 participant); congenital cataracts and glaucoma (1 participant); congenital columboma (3 participants); and ROP (1 participant). These maladies represent a wide variety of conditions leading to reduced vision.

Participants were informed that the purpose of the experiment was to compare visibility of a number of different pedestrian signals in use by municipalities. They were also informed they would need to approach the signals a number of times in order to obtain information on the signals visibility. Participants were each paid an honoraria of $50 for participating in the experiment.

Apparatus. The following seven stimuli were tested in this study: an incandescent white pedestrian symbol, a LED white pedestrian symbol; a LED blue pedestrian symbol; a LED blue pedestrian symbol with 11 inch wide animated eyes located above the pedestrian symbol (see Figure 1); a LED white pedestrian symbol with 11 inch wide animated eyes located above the pedestrian symbol; an incandescent white hand symbol; a LED white hand symbol; a LED blue hand symbol. The ‘WALK’ indication was an 11.2-inch-high outline of a walking person (standard pedestrian symbol) in all cases. The ‘DON’T WALK’ indication was an 11.2-inch-high outline of an upraised hand. The EYES display consisted of two blue or white eyes with eyeballs that scanned left and right at a rate of one cycle per second. The eyes were each 5-inches wide, 2.7-inches high and 2.25-inches apart. The location of the WALK (pedestrian) symbol and DON’T WALK (hand) symbol were held constant on the right side of the display. Blue LED signals were constructed with blue [460 nanometer (nm)] LEDs. White LED signals were constructed with white LEDs.

Figure 1. A photograph of an LED pedestrian WALK signal with an animated ‘eyes’ display to prompt sighted pedestrians to watch for turning vehicles.

A box was constructed which allowed the stimuli to be quickly changed between trials. The apparatus was located 8 feet above the ground to replicate the typical installation height employed by many cities. A 130 foot long path was constructed and filled with wood chips to provide a stable walkway to approach the signals.

LED Pedestrian Signal Output Normalization. Comparing he efficacy of LED traffic signals with their incandescent counterparts is not a simple task. The essentially monochromatic, saturated color of the LEDs versus the filtered broad band output of an incandescent signal is but one parameter that can affect capture and recognition of the displayed message. In the case of pedestrian signals, establishing functional equivalence between an incandescent signal and its LED variant is even more complicated. Pedestrian signals are qualified for given applications and are not specified for luminous intensity. For example, a Class 4 hand-man pictograph pedestrian head as specified in the *Equipment Material Standards of the Institute of Transportation Engineers Manual* of Nov. 1997 and the *Manual of Uniform Traffic Control Devices* suitable for use at 60 feet, has given dimensions of the signal face, but no specified minimum luminous intensity. It is apparent that traffic engineers specify the proper incandescent lamps for such fixtures based on ‘best current practice’ and on their experience. While some municipalities tend to specify relatively low Wattage lamps (54 W) to save energy, most communities utilize 90 Watt, lamps to provide an extra margin of illumination.

Tests were conducted with the standard Eagle Signal 18 inch, side by side, pedestrian signals employing the accepted hand-man pictographs screen printed on a lenticular - diffusing, planar lens. Illumination was provided by G.E. 90 Watt, 130 Volt, 8000 Hr. traffic signal rated lamps. The luminous intensity was determined by an on-axis measurement at a distance of 3.12 meters, and averaged across 0.83 meters, corresponding to a 15 degree field of view. When operated on a regulated source of 120 V.A.C. the average intensity was 110 Candela for the incandescent Lunar White ‘WALK’ man sign. Light measurements (in Lux) were made with a N.I.S.T. certified illuminance meter (Yokogowa 510-02) and converted to luminous intensity.

Adjustment of the LED signals to produce the same intensity as their incandescent counterparts was relatively easy. The average operating current (which is directly proportional to luminous intensity) was adjusted using pulse width modulation of the internal power supply. Note that unlike incandescent lamps which change chromaticity with operating current, LEDs maintain their specified color over a wide range of luminous output.

It may also be worthwhile to note that while the emission from an incandescent signal is essentially Lambertian, and very wide, the LED signal directs most of its light within a 15 degree field of view (f.o.v.). This relatively narrow f.o.v. is, in fact desirable as it generally limits the optimal observation area to the pedestrian walkway. Furthermore, the operating efficiency is greatly enhanced by directing the light and message to the pedestrian. Because of this increased efficiency the LED outline array that produced the same luminous intensity as the 90 Watt incandescent lamp consumed less than 8 Watts.

Procedure. Because LED signals and animated eyes were not in general use at the start of the study, each participant was first shown each of the stimuli at a distance of 10 feet and 40 feet indoors in order to ensure that they would be familiar with the stimuli used in this research. They were also asked what each of the stimuli resembled at the further distance in order to require them to attend to the critical features of each stimulus. Most participants mentioned: the dark area in the center of the palm and the thumb extending off at 45 degree angle on the hand for the LED hand symbol; the legs forming an inverted ‘V’ for the LED and incandescent pedestrian symbol; and that the display formed a fussy digit ‘7' (or inverted ‘L’) for the LED pedestrian symbol with the animated eyes (the pedestrian symbol being the vertical portion of the seven and the eyes forming the top of the seven).

All data were collected outdoors between the hours of 1:00 pm and 4:00 pm. Stimuli were presented in 4 blocks, with each block containing one trial with each of the stimuli associated with the WALK indication and an equal number of DON'T WALK stimuli presented in a random order. Trials were initiated by having the participant stand 130 feet from the pedestrian signal. The participant was then asked if they could identify the color or the shape. If they could not they were instructed to approach the signal until they could and then tell the experimenter their response. The experimenter recorded the recognition distance along with their selection. They proceeded until they identified both the color and shape. Participants were not given feedback on the correctness of their selection. Once they had identified the shape of the object they were asked to continue walking and report if they wished to change their response. If any subject changed their response the second distance was also recorded. This procedure ensured that a distance for correct recognition was obtained for each participant on each trial.

Data were collected by a team of two research assistants. One assistant collected data on participant responses on a data sheet while the second assistant served as a spotter to ensure that none of the participants fell. Two research assistants who were located on a deck adjacent to the signal changed the stimuli between trials.

Results

Participants were able to identify signals with the animated eyes at an average distance 57 percent further away. A two-way ANOVA using a weighted least squares showed significant effects. The subject, and treatment sources of variability, as well as the overall model, were all significant with a P value $< .0001$ (Model $F = 21.47$; Subject $F =$

17.88; Treatment F = 38.07). Tukey's method showed a significant contrast between the signals with the animated eyes display and signals without this display (F = 149.88, P - value < .0001). There were no significant differences between the incandescent and LED signals without the animated eyes or between the blue and white LED signals.

Mean recognition distance in feet is presented for each signal in Figure 1. Participants were able to identity the incandescent WALK at 63 feet, the LED white WALK at 61 feet and the LED blue WALK at 55 feet. Participants were able to identify the blue LED WALK with the animated 'eyes' at a distance of 96 feet and the white LED WALK with animated eyes at a distance of 92 feet. Recognition distance for these two stimuli were not significantly different from each other.

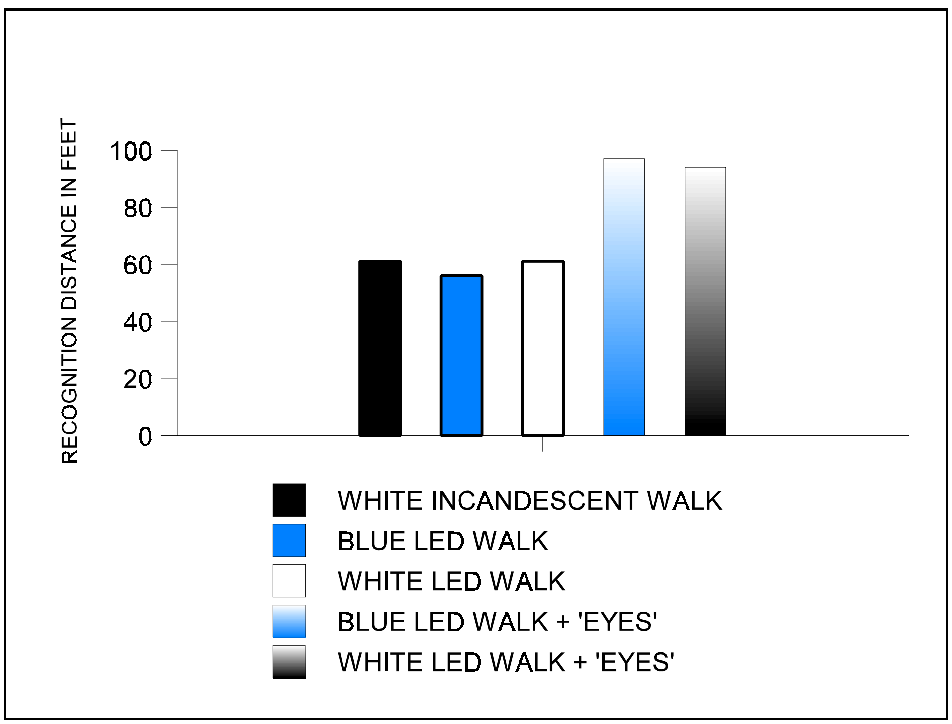

Figure 2. A graph showing mean recognition distance for each of the tested WALK displays.

Table 1 shows the mean recognition distance obtained for each pedestrian. Although recognition distances varied considerably from Individual to individual, the overall group trends are closely reflected in the individual data. For example, 15 out of 18 participants were able to recognize the WALK symbol further away when the eyes were present. All 15 of these participants said commented that they could identify this stimulus by its distinctive shape which was described as either the number ‘7' or an upside down ‘L’. Of the remaining 3 participants one could recognize WALK plus eyes stimuli at the maximum distance and the remaining 2 participants showed little difference in recognition distance. It should be noted that neither of the participants who could not identify the display with the eyes better than the WALK sign alone reported being able to see a large figure, such as a ‘7' or upside down ‘L’ when identifying the WALK plus ‘eyes’ display. All participants were able to discriminate the location and color of the display at a much greater distance than they could identify its shape.

If the two participants who showed little difference in recognition distance are excluded from the analysis the mean increase in recognition distance for the white LED WALK signal increased from 58 feet to 94 feet when the animated eyes were added. This represents an increase of 62% in recognition distance.

None of the participants ever misidentified the WALK with animated eyes as the DON’T WALK or identified the DON’T WALK as the WALK with the animated eyes. However participants mis-identified the DON’T WALK signal as the WALK indication on 18.6% of the trials, and mis-identified the WALK indication as the DON’T WALK signal on 11.3% of the trials.

Discussion

It should be noted that the LED pedestrian signals were no more effective than incandescent signals when they were equated for brightness with the incandescent signals. Normally LED pedestrian signals are significantly brighter than incandescent signals which should lead to improved recognition distance.

The addition of the EYES display to the WALK indication lead to a significant increase in the distance that pedestrians could identify the WALK indication with confidence. It should also be noted that none of the participants miss-identified the WALK indication with the ‘eyes’ as the DON’T WALK indication or the DON’T WALK signal as the WALK with the ‘eyes’ display. However, many of the participants identified the ‘WALK’ symbol without the eyes as the ‘DON’T WALK’ indication the DON’T WALK signals as the WALK indication on some of the trials. These data suggest that using the WALK with the animated eyes could reduce the frequency of pedestrians with low vision inadvertently crossing against the signal.

It was interesting to note that none of the participants detected the apparent motion of the eyes or the increase in the number of lighted LEDs in the display. All participants said they discriminated the ‘WALK’ sign with ‘EYES’ indication by its distinctive shape. Participant reports that shape was the critical feature was supported by the fact that all participants could identify the color and location of the display long before they could identify the shape of the display. Although it is not possible to determine with complete confidence that the use of animation or additional LEDs increased the recognition distance of the WALK signal when the animated eyes were present. It should be noted that the purpose of this study was to compare commercially available LED signals. It would also be possible to increase the conspicuity of the WALK display by increasing the size of the pedestrian signal. However, to obtain the same effect would require more than doubling the size of the currently available pedestrian signal or adding an arbitrary change to the display which might or might not be approved by the traffic engineering community.

Although many low vision pedestrians could discrimination the ‘WALK’ and ‘DON’T WALK’ signal based on color cues there would remain a certain degree of uncertainty because they could not always tell whether the white or orange light was actually part of the pedestrian signal. This is a particular acute problem in an urban environment where there are many white and orange lights present. A number of the participants in this study mentioned that they would not cross a street unless they could discern the ‘WALK’ symbol and avoided some intersections because they could not see the ‘WALK’ signal clearly enough to discern it.

In order to estimate the applied significance of these findings, the data were examined to determine whether participants would be able to discriminate the WALK signal on wider streets when the ‘eyes’ were present. Assuming 12 foot lanes, space for shoulders, signal setback, and medians, a typical two lane street was estimated to be approximately 40 feet in width, a four lane street, 65 feet in width and a 6 lane street 85 feet in width. Using these values the following differences were noted: three participants who could not identity a standard WALK signal at a distance equal to the width of a two lanes street were able to do so when the eyes were present; one participant who could only discriminate the WALK signal at the average width of a 2 lane street when the ‘eyes’ were absent was able to discriminate the WALK signal at the distance of a four lane street when the ‘eyes’ were present; four participants who were only able to discriminate the WALK signal at the width of 2 lane streets were also able to do so for a 6 lane street when the ‘eyes’ were present; and five participants who could discriminate the WALK sign for streets up to 4 lanes in width were able to do so for streets up to 6 lanes in width when the ‘eyes’ were present. These results show that 13 of the 18 participants would be expected to see the WALK sign across wider streets if the ‘eyes’ display were present. Of the remaining 5 participants 3 could have crossed streets up to 6 lanes in width with the conventional WALK display and therefore could not be expected to show an improvement when the ‘eyes’ were added. It should also be noted that 7 out of the 8 oldest participants were able to identify the WALK signal further away when the eyes were present. This is important because many seniors experience partial loss of vision.

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Table 1. The mean recognition distance for each WALK display for each participant in this study.

Participant Sex	Age	Incandescent WALK	Blue LED WALK	White LED WALK	Blue LED WALK+Eyes	White LED WALK+Eyes	Acuity
F	54	70	47	81	130	130	20/200
F	25	48	29	32	123	116	20/160
M	27	78	69	76	130	120	20/200
M	38	100	102	91	130	130	20/200
F	35	46	46	39	73	68	20/400
M	51	54	52	53	99	96	20/200
F	34	25	25	30	57	63	20/200
F	26	57	52	50	48		20/200
M	25	109	120	109	119		20/100
M	28	66	62	64	92	98	20/160
F	29	47	31	47	102	91	20/400
F	23	28	38	33	54	51	20/200
F	71	54	52	49	57	52	20/200+
F	47	18	16	15	34	47	20/200+
F	72	66	46	67	130	121	20/100
F	60	94	80	123	130	130	20/100
F	20	82	74	75	130	118	20/200
M	21	63	65	61	103	80	20/200
	Mean	**61**	**56**	**61**	**97**	**94**	