Use of Animated LED ‘Eyes’ Pedestrian Signals to Improve Pedestrian Safety

Florida Department of Transportation

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Final Report:

The use of animated searching ‘eyes’ LED signals to elicit looking has a biological and psychological basis which is unique to traffic control signals. This basis makes such devices easy to understand and conspicuous signals that could lead to a marked increase in compliance. In this research, completed under FHWA permission to experiment, we evaluated: The use of the animated ‘eyes’ display as part of the WALK indication on pedestrian signal heads to remind pedestrians to look for turning vehicles; what percentage of the time the animated eyes should be on during the WALK display; whether the animated eyes display assists low vision pedestrians (pedestrians who are legally blind but have some vision) determine when it is their turn to cross; and a comparison of blue vs. white LEDs. The results of each of these studies are summarized below. The enclosed reports provide a more detailed description of the results of these experiments.

Multi Site Conflict Study

The LED pedestrian signal with searching ‘eyes’ display was evaluated at 8 sites in three cities using carefully controlled experimental procedures.

Apparatus. The equipment used in this research was an LED signal head. The ‘eyes’ display was populated with blue (460 nm) LEDs and consisted of two blue eyes with blue eyeballs that scanned left and right. The eyes were each 5 inches wide, 2.7 inches high and 2.25 inches apart. The WALK indication was an 11.2 inch-high outline of a walking person constructed from blue LEDs. The DON’T WALK indication was an 11.2 inch-high upraised hand constructed from orange (615 nm) LEDs. The DON’T START indication consisted of the flashing DON’T WALK, as specified in the Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, 1988). A photograph of the device is shown below in Figure 1.

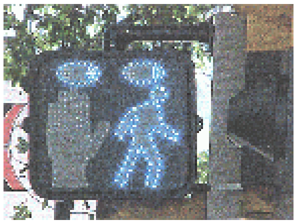

Figure 1

Results

The number of conflicts per 50 pedestrians were observed at each of eight locations, before and after the treatment (baseline vs. animated 'eyes') is presented in Figure 2. It was hypothesized that there would be a decrease in conflicts as a result of the treatment. This was tested for each location, and for the total number of conflict across all locations, using Wilcoxon-Mann-Whitney tests. This non parametric test was selected because the number of conflicts were non-normal but rather Poisson in nature. There is a significant (P=<05) decrease in median conflicts at 7 of the 8 locations, but the strongest and most interpretable result occurs across the total of all locations. In this case, the median number of conflicts drops from 8.5 (per 400 pedestrians) to just 1.0. As is seen, although actual numbers of conflicts are small in absolute term, this decrease is not just statistically significant, but can surely be considered to have practical value. The median number of total conflicts decreased in the range of 59% to 94% (95%confidence interval). The results of the Wilcoxon-Mann-Whitney procedure across all 8 sites was significant at the .001 confidence level.

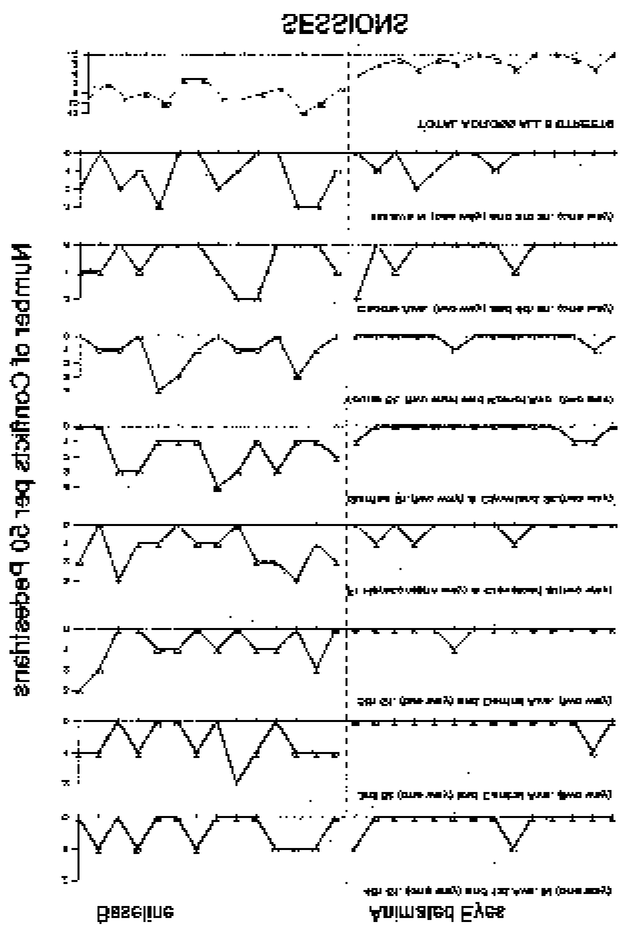

Figure 2

Discussion

These results confirm that the use of the animated 'eyes' produce a significant reduction in motor vehicle/pedestrian conflicts that could be expected to translate into a meaningful reductions in crashes at signalized intersections. These data provide a systematic replication of the findings of Zegeer, Cynecki and Opiela (1984). These researchers evaluated using a "WALK WITH CARE" indication during the crossing interval at four test sites in three cities. This was implemented by adding a yellow incandescent WITH CARE display at the bottom of the signal head. They obtained significant reductions in total conflicts at all four sites. These data taken together with the results of the present studies demonstrate that modifying the WALK indication to remind pedestrians to be more cautious leads to significantly fewer conflicts between drivers and turning vehicles. The major advantage of the animated 'eyes' display over the 'WALK WITH CARE' display is its symbolic nature.

Low Vision Pedestrian Study

In recent years the traffic safety community has begun to study the problems of blind pedestrians. 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 80-85% of the legally blind population has some remaining vision. The purpose of this study was to compare incandescent and LED pedestrian signals with and without the animated eyes features on legally blind pedestrians with some vision. A second purpose of this research was to compare the relative conspicuity of white vs. blue animated 'eyes'.

Method

Participants. Eighteen adults, 6 males and 12 females classified as legally blind served as participants in this experiment based on acuity and useful visual field. Participants ranged in age form 20 to 72.

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 animated eyes; a LED white pedestrian symbol with animated eyes; 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 EYES display was the same type as described in the previous study. Brightness was equated to an average luminous intensity of 110 Candela by adjusting the pulse width modulation of the internal power supply. Light measurements (in Lux) were made with a N.I.S.T. certified illuminance meter (Yokogowa 510-02) and converted to luminous intensity.

Procedure. Because LED signals and animated eyes are not in general use 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 the study. 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 looked like 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 in a laboratory setting 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 experiment their response. The experimenter recorded the 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 mind. If any subject changed their mind the second distance was also recorded. This procedure ensured that a distance for correct recognition was obtained for each participant on each trial.

Results

Participants were able to identify signals with the animated eyes at a 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. 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. Of the remaining 3 participants 1 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 these participants reported being able to see a large figure, such as a '7' or upside down 'L' when identifying the WALK plus 'eyes' display.

Discussion

It should be noted that the LED pedestrian signals 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. However, when brightness was controlled there was little difference in the discriminability of the LED and incandescent signals. However, 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. Although many low vision pedestrians could discrimination the 'WALK' and 'DON'T WALK' signal based on color cues there always exists 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.

Analysis of Directional Prompting and Repeated Prompting at Crosswalks

Method

This study was conducted at three signalized intersections in downtown St. Petersburg, Florida, 1st Ave North and 4 th Street, Central Avenue and 3 rd Street, and Central Avenue and 5 th Street. First Avenue North and Fourth Street are one-way, four lane streets, Central Avenue has one lane in each direction at the intersection with 3 rd Street and one lane in each direction with right turning lanes at the intersection of 5 th Street. Third Street is a one-way with four lanes carrying southbound traffic.

Data Collection. Three observers scored pedestrian's observing behavior and pedestrian/motor vehicle conflicts at these sites. Each session included the collection of data from 50 pedestrians crossing at the start of the WALK interval at all three intersections, and pedestrians who started to cross during the remainder of the WALK interval. To be scored as crossing during the start of the WALK interval the pedestrian had to begin to cross within 4 seconds of the start of the WALK indication. Pedestrians that started to cross during the remainder of the WALK indication were scored as crossing during the WALK interval. Pedestrian observing behavior was and pedestrians/motor vehicle conflicts were scored in these studies.

Apparatus. The LED signal head with the 'eyes' display described above was employed during the treatment condition at each site. The signal head used in previous research (Van Houten, Retting, Van Houten, Farmer, & Malenfant, 1999) was redesigned so that scanning rate, dwell times, and presentation duration could each be programmed on site.

Experimental Design. A reversal design was employed at each site in this research. At 1 st Avenue North and 4 th Street the 'eyes' looking both ways (equal dwell times of 0.5 seconds in each direction) was introduced following the baseline assessment. The 'eyes' display was simultaneous with onset of the WALK indication and terminated after 3.5 seconds. The 'eyes' display was then repeated after being switched off for 7 seconds. Next the 'eyes' were programmed to look one way with a dwell time of 0.7 seconds in one direction and 0.3 seconds in the other direction (a value that equated cycle duration). Next the devices were programmed to look both ways again. After 7 sessions in this condition the 'eyes' displays were programmed to be alternately on and off for 3.5 seconds duration rather than alternately on for 3.5 seconds and off for 7 seconds. Next the 'eyes' displays were programmed to look both ways and the repeat interval was again selected for 7 seconds. In the final condition the 'eyes' continued to look both ways but the repeat duration was set at 3.5 seconds.

At 3 rd Street and Central Avenue the 'eyes' looking both ways (equal dwell times of 0.5 seconds in each direction) was introduced following the baseline assessment. The 'eyes' display was simultaneous with onset of the WALK indication and terminated after 3.5 seconds. Next the 'eyes' were programmed to look one way with a dwell time of 0.7 seconds in one direction and 0.3 seconds in the other direction. Next the device was programmed to look one way again. After 9 sessions in this condition the 'eyes' display was programmed to look in one direction with a dwell time of 1 second in one direction and 0.25 seconds in the second direction (the value which gave the best perception of directed looking in the human factors test). This condition was followed with a return to the 'eyes' looking both ways for 14 sessions and a return to the 'eyes' looking one direction with the 1 second and 0.25 second dwell times for the final condition.

At 5 th Street North and Central Avenue the 'eyes' looking both ways was introduced following the baseline condition with the 'eyes' on for the first 3.5 seconds of the WALK interval and being repeated after being off for 3.5 seconds. Next the 'eyes' were alternately on for 3.5 seconds and off for 7 seconds. During the final condition the 'eyes' were alternately on for 3.5 seconds and off for 3.5 seconds.

Results

Data Analysis. An arcsin transformation was applied to stabilize the variances in each of the three statistical analysis. In addition, suspected outliers were detected and removed. This correction had no effect on the significance of any of the analyses. After the arcsin transformation there was no evidence of heteroscedasticity or non-normality ($P > .05$ in all cases). The data collected at 4th Street and 1st Avenue North were analyses with a one way anova with treatment groups broken down into baseline, eyes looking one way, eyes looking both ways, eyes repeated every 3.5 seconds and eyes repeated every 7 seconds. A significant difference among treatments was found in each case ($P= <.0001$). A Tukey's analysis revealed that overall there were highly significant differences in the percentage looking for no threats and the percentage looking twice at the start of the WALK and during the remainder of the WALK between the baseline vs the animated 'eyes' condition ($p= <.05$) and that in each case repeating the eyes after 3.5 seconds was superior to repeating them every 7 seconds ($p= < .05$). The data collected at 5th Street and Central Avenue were analysed with a one way anova with treatment groups broken down into baseline, eyes repeated every 3.5 seconds and eyes repeated every 7.5 seconds. Overall there were highly significant differences between the treatment groups ($p= <.0001$). The Tukey's analysis revealed that this resulted from the baseline vs. animated 'eyes' contrast rather than the 3.5 second repeat interval vs. 7 second repeat interval contrast. The data collected at 3rd Street and Central Avenue were analysed with a one way anova with treatment groups broken down into baseline, eyes looking one way and eyes looking both ways. Overall there were highly significant differences between the treatment groups for the percentage not looking ($F=54.14$, $P<.0001$) and the percentage looking twice ($F=8.63$, $P<.0001$). The Turkey's contrast analysis indicated that the percentage not looking during treatment differed from baseline ($p<.05$). However, the percentage not looking did not differ between the two way and one way prompting conditions.

Discussion

The results of this research demonstrated that the use of the animated 'eyes' display was effective in reducing motor/vehicle pedestrian conflicts at all major urban intersection geometries. The results also showed that prompting pedestrians to look in the direction of the threat was no more effective than prompting them to look both ways. The results also indicated that programming the eyes to repeatedly look in only one direction at 4th Street and 1st Avenue North and at 3rd Street and Central Avenue was no more effective than having the eyes look both ways. These results do not appear to warrant making the eyes directional at sites where the threat can come from only one direction. Finally, presenting the 'eyes' display for 3.5 seconds out of every 7 seconds of walk time was somewhat more effective in increasing the observing behavior of pedestrians who started to cross more than 4 seconds into the WALK interval at 4 th St. and 1 st Ave N. but did not offer a significant benefit at 5 th St. and Central Avenue. These findings when considered along with the results of earlier research (Van Houten, Retting, Van Houten, Farmer and Malenfant, 1999 support the frequent presentation of the 'eyes' display throughout the WALK interval.

Presenting the 'Eyes' Display During the Entire WALK Interval

Because no sign of cognitive capture was noted in the previous studies the purpose of this study was to evaluate the effect of presenting the 'eyes' display throughout the entire WALK interval.

Method

Subjects and Setting. This study was conducted at 1st Ave North and 4 th Street in St. Petersburg, Florida between December/98 and January/99.

Data Collection. Observers scored pedestrian's observing behavior and pedestrian-motor vehicle conflicts on weekdays between the hours of 9:00 a.m. and 4:30 p.m. Each session included the collection of data from 50 pedestrians crossing at the start of the WALK interval. To be scored as crossing during the start of the WALK interval the pedestrian had to begin to cross within 4 seconds of the start of the WALK indication. Pedestrians that started to cross during the remainder of the WALK indication were scored as crossing during the WALK interval. Pedestrian observing behavior and motorist/pedestrian conflicts were recorded in same way as described in the previous studies.

Apparatus. The equipment used in this research was the LED signal head described in the first field study.

Experimental Design. An ABA reversal design was employed in this research. The 'eyes' were programmed to look both ways (equal dwell times of 0.5 seconds in each direction) throughout the experiment. During the intermittent presentation condition the 'eyes' display onset was simultaneous with the onset of the WALK indication and terminated after 3.5 seconds. The 'eyes' display was then repeated after being switched off for 3.5 seconds. During the continuous presentation condition the 'eyes' were programmed to remain on during the entire WALK interval.

Results

The results of this study showed that fewer pedestrians starting to cross later during the WALK interval looked for no threats when the 'eyes' were presented continuously and that more pedestrians looked twice for threats when the 'eyes' were presented continuously. However, none of these differences were significant. Only one conflict was detected during this study.

Discussion

The results of this study show that presenting the animated 'eyes' throughout the entire WALK indication is not less safe than presenting the animated 'eyes' intermittently. Because it is technically easier to present the animated 'eyes' throughout the entire WALK interval it is recommended that crosswalk signals should be designed to perform in this manner.

Recommendations

The results of all this research and of previously reported studies (Van Houten, Retting, Van Houten, Farmer and Malenfant, 1999; Van Houten & Retting, 1999; Van Houten, Van Houten, Malenfant, & Andrus, in press) document that the animated 'eyes' display can improve safety in a number of sites where it is important for drivers and pedestrians to look for potential threats. These results also demonstrate that the animated eyes display is of value to a significant portion of the blind community (over 80%) and that the use of blue LEDs offers no additional value over the use of white LEDs.

As a result of these findings the following recommendations are made:

1. That the use of animated eyes be added to the MUTCD as an option.

2. That the eyes be on for the entire WALK interval but not be presented during the pedestrian clearance interval.

3. That the eyes be white rather than blue.

References

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Zegeer, C.V., Cynecki, M.J., & Opiela, K.S. (1984). Evaluation of Innovative Pedestrian Signalization Alternatives. Transportation Research Record 959, pgs. 109-121,