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FEASIBILITY OF EVALUATING DESIGN IDEAS FOR REDUCING VEHICULAR ENTRAPMENT AT RAILROAD CROSSINGS USING A LABORATORY EXPERIMENT

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Summary: The number of accidents at railroad crossings is particularly high at places where streets run parallel to the railroad tracks. Existing grade crossings were investigated for potential problems and studied for design solutions. The present study reports progress of the first phase of a NJ DOT sponsored project. A laboratory experiment was designed for evaluating various design ideas before they are implemented in the second phase field study. The laboratory study used images taken from actual scenes of railroad crossings in New Jersey, instead of graphical drawings commonly used in driving simulations. Possible design ideas were edited using image processing software. Those design ideas were saved in different layers for generating design combinations which were superimposed on the background images to create virtual railroad crossing scenes. Nighttime images were also made possible by retouching the digital daytime images. Preliminary results of the in-lab experiment were presented. The experience learned from the current project indicates that use of actual images with superimposed design ideas is a cost-effective approach of evaluating and redesigning display layouts.

INTRODUCTION

Railroad crossings in urban areas in general pose a potential hazard for drivers on the road, even under the presence of warning signs and devices. The New Jersey Transit authority recorded a total of 91 accidents at railroad crossings in New Jersey between 1994 and 1998. All the crossings were equipped with either active or passive devices or a combination of both. The number of accidents at railroad grade crossings was found to be particularly high at places where streets run parallel to the railroad tracks. Such accidents were found to happen when the drivers were confused between the railroad and the roadway, or trying to go around the gate systems when they were already activated. The former type of human error may be related to incorrect human information processing (Wickens and Hollands, 1999), whereas the latter type can be attributed to mainly risky driving behaviors (Zeitlin, 1994) and to a less degree of inability of controlling the vehicle under a high time pressure condition.

There are basically two types of devices that exist for reducing vehicle accidents occurring at the grade crossings, namely active and passive devices. Typical active devices are two-quadrant gate systems, four-quadrant gate systems (Coleman, 1996) and full crossing closures (Coleman & Moon, 1998a). Devices that use sensors (Coleman & Moon, 1998b) or video monitoring

(Coleman, 1996) for detecting vehicles being trapped at the grade crossing were also considered as active devices. Computer simulation had been frequently used in laboratory experiments in transportation research (Padmos & Milders, 1992; Allen, 1995; Sidaway, Sekiya, & McNitt-Gray, 1996; Hopkins & Allen, 1997). Scenes were typically developed through 2D and 3D graphics in the simulation where resolution and fidelity was limited. It may be desirable to display scenes of the actual grade crossings, which contain all sources of traffic-related-and-unrelated information, in order to investigate the effectiveness or problem of current display layouts and possible design solutions for such a unique vehicle entrapment problem.

METHODS

A simulation was developed using real images retouched in Adobe Photoshop® and controlled by Java® programming as shown in Figure 1. The background images of the simulation were taken from different railroad crossings in New Jersey. An In-lab experiment was conducted for identifying effective design solutions.

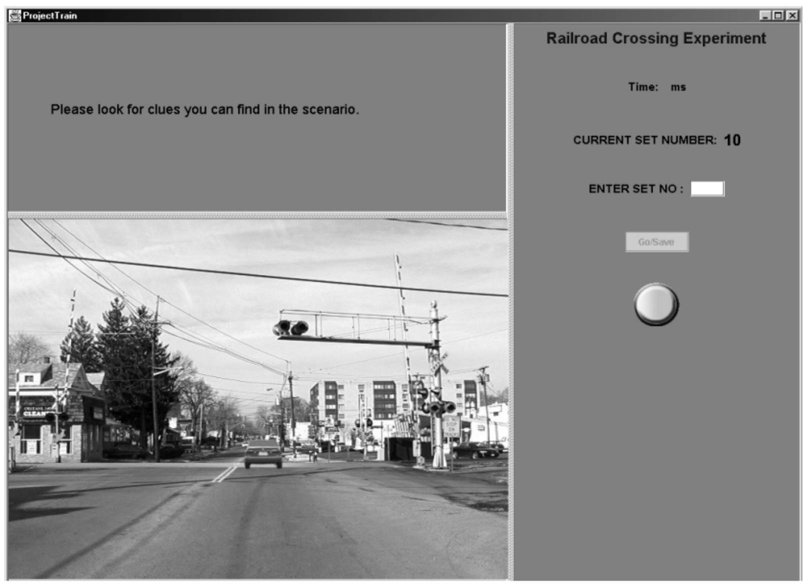


Figure 1. A view of Simulation developed in Java

Development of Design Ideas

Based on accident records, critical factors were identified for directing design guidelines. Possible design ideas were then selected from existing research studies (Bonneson & McCoy, 1994; Pant & Xie, 1995; Zwahlen & Schnell, 1995; Bowman, Stinson, & Colson, 1998) and were also generated by brainstorming of the authors. The design ideas were strictly scrutinized to check if the ideas answer the effects described above. Existing standards (Federal Highway Administration, 1988) and issues in standardization (Aurelius, 1995) were also reviewed in order to integrate the developed design ideas into the overall NJ Transit standards. The selected design ideas were combined in various ways based on the experimental design and the geographical conditions of the selected crossings.

Apparatus

The equipment utilized for the experiment was a PC (Pentium III 1000 MHz) along with a standard keyboard, mouse and loudspeakers. The images were displayed on a screen using a computer projector (Epson Powerlite 7250). The projected image on a screen was 6 feet diagonal in size. The subject was positioned 9 feet from the screen.

Subjects

There were 28 subjects, 14 males and 14 females, recruited for this experiment. All subjects were New Jersey residents with a valid driver's license. Other demographic factors such as educational background, driving experience, and driving records, although not analyzed in the current study, were obtained in the in-lab experiments for future data analyses.

Procedure

Subjects were given practice trials prior to the experiment and the order of trial sets were counter-balanced between subjects. The first scene showed an image taken from 80-90 meters away from railroad crossing for 3 seconds. The second scene showed an image taken from 60-70 meters away from the crossing depending on the surroundings and road. The second image had possible design ideas that might indicate a railroad crossing. Subjects looked carefully and identified any clues or no clue can be found that might indicate a railroad crossing. After six seconds the second image disappeared and a list of possible clues were presented for subjects to choose.

In the next step, subject can start the simulation by pressing space bar of the keyboard. The car can take any one of the following three possible routes. First, the car can go straight which is a proper pass. Second, the car can make a turn to the road parallel to the tracks, which was also a proper pass. Lastly, the car can turn on to the tracks, which represents an improper pass. Subjects gave their responses (proper and improper passes) by pressing either the red or green button indicating improper and proper turn respectively. Figure 2 depicts the flow of the experiment.

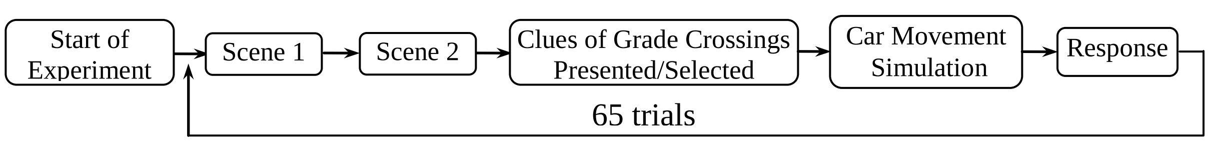


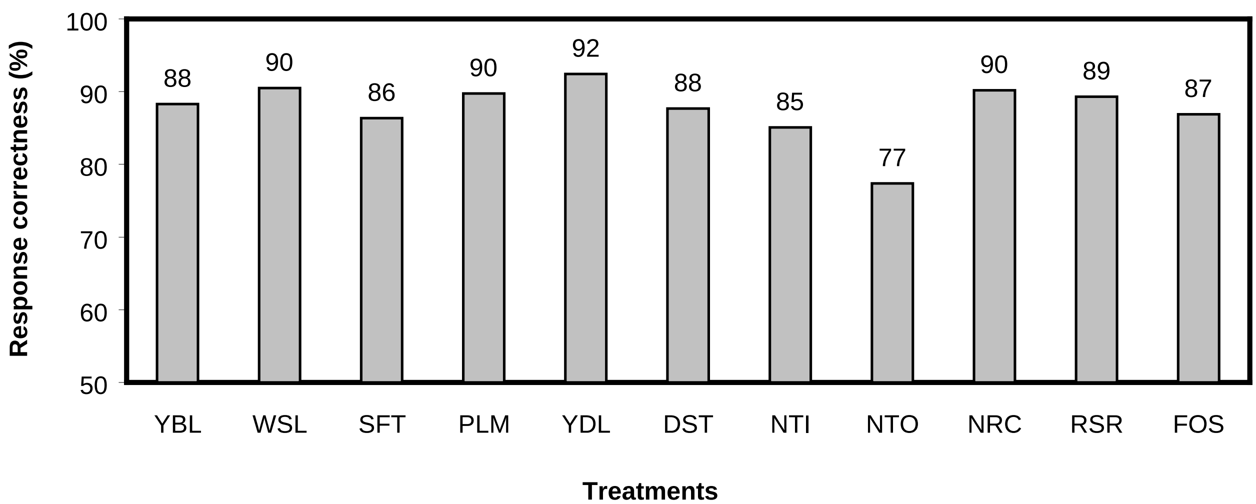
Figure 2. Experiment procedure in sequence of steps

RESULTS

Fourteen locations from four cities were identified and used in the study based on the maximum number of accidents for a location. Photographs and video shots of the locations were taken and the driver behavior as well as the crossing traffic was studied. The photo images were carefully analyzed and the design ideas were superimposed on the original images according to the experimental design.

A total of 65 sets of background images were generated based on the 14 locations. They included 52 sets of daytime conditions and 13 nighttime scenarios. There were 6 sets which were images taken from the actual locations without any additional treatment superimposed. Eight sets of backgrounds which contained no railroad crossings were served as catch trials for discouraging subjects from guessing. The design ideas or treatments includes *yellow full barrier line, white solid line* for road boundary, grade crossing *surface treatment, pavement left turn intersection marking, reflective yellow delineators, "Do Not Stop On Tracks"* warning sign, *rumble strips,* and *flash/on-track sensors.*

Subjects' response, in terms of percent correctness, to different treatments in the car movement judgment task was presented in Figure 3. There was a significant performance difference among the treatments ($F_{(10, 297)} = 2.18$, $p < .05$). A *post hoc* analysis using Duncan's multiple range test indicated that subject's performance in scenarios where original grade crossings were used was significantly lower than in scenarios where additional treatments were superimposed onto the original background ($p < .05$). Further analyses are needed in order to contrast performance differences among individual treatments since there were more than one treatment added to the original backgrounds in most of the scenarios.



YBL- Yellow Barrier Line
WSL-White Solid Line
SFT- Surface Treatment
PLM- Pavement Left Turn Marking
YDL- Reflective Yellow Delineators
DST- Do Not Stop On Tracks
NTI- Night Time Images
NTO- No Treatment (Original)
NRC-No Railroad Crossing
RSR- Rumble Strips on Road
FOS- Flash/On-Track Sensors

Figure 3. Percentage of Correct response for each treatment type

DISCUSSION & CONCLUSIONS

The results of an overall significance among different background treatments suggested that some design treatment(s) may be helpful to improve drivers' perception when they attempt to make left turns to roads paralleled to the railroad crossings. The correct response percentages among different treatments ranged between 77% and 92%. The results that the incorrect response percentage was at least 8% from any of treatments should be carefully interpreted. Since the task involved in the in-lab experiment was different from the actual driving behavior, the error rate from the subjects cannot be directly translated into error rate of driving occurred at those railroad crossings.

The approach of using actual images superimposed with possible design ideas was a cost-effective approach in the current project. The in-lab experiment used a static background-moving vehicle display mode and recorded subject's reaction time and error rate while watching the simulated car movement. The use of JAVA programming in presenting sequences of image and recording subject responses was achieved successfully. It was anticipated that the selected design solutions would aid the drivers in safely crossing the railroad tracks. A second phase field study is under preparation which will test those treatments that have shown the best performance in the in-lab experiment.

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