Capturing Attention to Brake Lamps in a Single Fixation

Rear-end collisions and distraction are major concerns in automotive transportation. This study investigated the conspicuity of current rear automobile lighting (red brake and red tail lamps) compared to a proposed arrangement (red brake lamps with yellow tail lamps) in a task where participants only had time to perform one saccade and fixation (200ms) to identify the presence or absence of brake lamps across 60 static traffic scenes projected on a screen. The hypothesis that separating brake and tail lamps by color alone would result in greater conspicuity as evidenced by fewer errors and faster RT was supported. Conspicuity of vehicle brake lamps will be improved in the situations tested by implementing the proposed yellow tail-lamp coloring on vehicles

INTRODUCTION

The AAA Foundation for Traffic Safety enumerates 13 categories of driver distraction some of which are unrelated to the task of driving but others of which are integral, such as checking mirrors and gauges (AAA, 2005). Data indicate that more than 60% of accidents and tens of thousands of rear-end collisions each year can be attributed to some form of inattention (NHTSA, 2002; Sullivan & Flannagan, 2003). Many studies have examined the effects of using in vehicle devices (cell phone, GPS, audio) that demand driver attention (Strayer, Drews & Johnston, 2003). Currently the approach to redirect driver attention to the roadway rather than in the vehicle is through legislation and enforcement. However, another approach might be to ensure important signals are salient even to distracted drivers.

One signal that drivers need to detect is the brake lamp. Currently, both brake lamps and tail (rear position) lamps on motor vehicles are required to be red. This vehicle lighting standard is mandated in the United States and Europe (NHTSA, n.d.a; UNECE 2006, 2008). Historically, the efforts to compensate for this color similarity and make the brake lamp more conspicuous have been to add luminance and location cues to the brake lamps (NHTSA 2002, 2003). However, luminance cues are moderated by a variety of environmental factors such as ambient lighting conditions, distance from the source, and vagaries of size and shape used on different vehicles. In addition, while change in luminance may seem obvious to drivers attending vigilantly to such signals, distracted drivers may not observe the onset of a luminance change and may not devote sufficient visual attention to detect absolute luminosity and location differences between numerous red signals.

It seems pragmatic to assume drivers will be distracted and attempt to devise signals that can be detected under such suboptimal circumstances. The approach that is suggested in this paper is to enhance brake lamp conspicuity by changing the distractors (tail lamps) rather than the target (brake lamps) as has previously been the approach to mitigating the problem of color similarity. We know from previous studies that differentiating tail lamp color from brake lamp color reduces reaction time (RT) and error in a variety of situations (Cameron, 1995; McIntyre, 2008; NHTSA, 2002 & 2003). This study attempts to simulate a specific distraction situation where a driver uses a 200 ms single saccade and fixation as may happen when a driver is switching visual attention between in vehicle devices (phone, GPS, audio) and the road ahead.

METHOD

Participants

Thirteen undergraduates (mean age = 27; 8 females, 5 males) were recruited from an Introductory Psychology subject pool for a within-subjects experimental task. Binocular visual acuity (with corrective lenses if needed) using a Snellen chart on a self-illuminated stand at 4m and 2m, and color vision using the Farnsworth D-15 test were evaluated for all participants prior to the experiment. All subjects included in the study had acceptable acuity at both distances (20/20 or better at 4m) and passed the Farnsworth D-15.

Apparatus

Cedrus Superlab$_{TM}$ software was used to program the presentation of stimuli projected onto a screen through a personal computer and portable projector in a 3 m X 3 m unlit room with no windows and no artificial lighting. Participants sat in a chair facing the screen holding a Cedrus Superlab$_{TM}$ 610 response box in both hands. The distance from the participants eyes to the screen was 2.43 m and the size of the display on the screen was 90 cm X 122.5 cm.

Stimuli

Sixty digital pictures (30 with at least one vehicle braking, 30 with no vehicle braking) of traffic scenes were randomly presented. For the Red condition, tail lamp color was left unedited (red tail lamps, red brake lamps). The Yellow condition pictures presented proposed lighting (yellow tail lamps, red brake lamps) using the same pictures as the Red condition but with red tail lamps replaced by yellow tail lamps edited in Adobe Photoshop$_{TM.}$

To test the efficacy of the brake signal independent of spatio-temporal cues, still pictures are used as stimuli in this experiment. Individual slides also allow detection of brake lamp onset to be precluded in order to examine performance with inattention to such an event due to previous distraction.

In order to simulate the complexity of real world driving circumstances, the traffic scenes vary in traffic conditions (highway, intersection, local), ambient lighting conditions (day and night), number of distractor vehicles (vehicles with tail lamps illuminated but not braking), and number of target vehicles (braking vehicles), as well as the location of the target vehicle(s). Pictures were taken through a vehicle windscreen and attempt to simulate the perspective of a following driver. All identifying markers such as road signs, license plate numbers, and personal images were obscured with computerized editing.

Design and Procedure

A repeated measures design was used. Participants experienced 60 randomly presented trials in both the Red and Yellow conditions. . Each traffic scene was displayed for 200 ms followed by a 2000 ms solid gray screen before the next test stimulus was presented. Before beginning each condition, a sample picture with only one automobile braking was presented and the experimenter asked the participant to identify which automobile in the scene was braking. Whether or not the participant could detect the correct vehicle, the vehicle was pointed out and an explanation given on how to identify a brake lamp. Participants were given oral and visually presented instructions to press the left key in response to the presence of a brake lamp on any automobile in the scene and the right key in response to the absence of brake lamps in the scene. Participants were instructed to respond as quickly as possible but if they did not know whether a target was present or absent they did not have to respond and the next scene would appear after 2 seconds. When participants indicated they understood the instructions and felt comfortable in identifying a brake lamp, they began the trials. Misses, no response and false-alarms were counted as errors.

RESULTS

A dependent *t*-test with a .05 alpha level was used to compare errors and RT for both color conditions. RT was significantly faster with yellow tail lamps in target present (Yellow: $M = 459.10$ ms, Red: $M = 570.48$ ms; $t(12) = 5.01$, $p < .01$) and target absent trials (Yellow: $M = 565.66$ ms, Red: $M = 664.98$ ms; $t(12) = 2.23$, $p < .05$). Errors were significantly lower for the Yellow condition (M = 15.92, SE = 1.64) than the Red condition (M = 30.31, SE = 2.06), $t(12) = 6.73$, $p < .001$, $r^2 = .79$. Figure 1 displays mean errors and SE across 60 slides in both conditions. Signal detection calculations were also performed for Yellow (d' = 1.6) and Red (d' = .7).

DISCUSSION

The results support the hypothesis that separating the function of tail lamps and brake lamps by color significantly increases conspicuity of brake lamps as evidenced by reduced RT and error compared to the current lighting system, when drivers do not have the cues of lamp onset and perceptual differences in lamp luminance. When brake lamps and tail lamps share the color red as they do currently, participants were performing at chance level in detecting brake lamps under such circumstances.

While the overall result of reduced error for the proposed lighting are the same as found by Cameron (1995), McIntyre (2008) and others (NHTSA, 2002) the current methodology has attempted to extend these findings by examining the proposal during a single fixation to simulate a driver switching visual attention. It is suggested that changing the (distractor) tail lamp coloration rather than further tinkering with the (target) brake lamp will provide distracted drivers immediate sensory confirmation of brake lamp activation without needing to make perceptual judgments of dissimilarity of luminance or location between multiple red brake and tail lamps, and may reduce rear-end and other collisions.

REFERENCES

AAA Foundation for Traffic Safety (2005). *The role of driver distraction in traffic crashes*. Retrieved December 20, 2004, from http://www.aaafoundation/projects

Cameron D. L. (1995). Color-specificity to enhance identification of rear-lights. *Perceptual and Motor Skills, 80*, 755-769

McIntyre, S. E. (2008). Capturing attention to brake lamps. *Accident Analysis and Prevention, 40(2),* 691-696.

NHTSA. (n.d.a). *Federal motor vehicle safety standards and regulations*. Retrieved February 11, 2004, from http://www.nhtsa.dot.gov/cars/rules/standards/safstan2.htm

NHTSA. (2002). *Enhanced rear lighting and signaling systems: Literature review and analyses of alternative system concepts.* (DOT HS 809 425).

NHTSA. (2003). *Enhanced rear lighting and signaling systems task 2 report: Testing and optimization of high-level stopped/slowly-moving vehicle rear signaling systems.* (DOT HS 809 597).

Strayer, D.L., Drews, F.A., Johnston, W.A., (2003). Cell-phone induced failures of visual attention during simulated driving. *Journal of Experimental Psychology: Applied, 9*(1), 23-32.

Sullivan, J.M., Flannagan, M.J. (2003). Risk of fatal rear-end collisions: Is there more to it than attention? *Proceedings of the Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design.*

UNECE. (2006). E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.6/Rev.4. Retrieved July 13, 2008, from http://www.unece.org/trans/main/wp29/wp29regs1-20.html.html

UNECE. (2008). E/ECE/324, E/ECE/TRANS/505, Rev.1/Add.47/Rev.5. Retrieved July 13, 2008, from http://www.unece.org/trans/main/wp29/wp29regs41-60.html.html

Figure 1. Mean errors for Red and Yellow tail lamp condition