Traffic Safety Facts
Vehicle Safety Research Notes

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Assessing the Attention-Getting Capability of Brake Signals: Evaluation of Candidate Enhanced Braking Signals and Features

Rear-end crashes account for more than 29 percent of all crashes; these types of crashes often result from a failure to respond (or delays in responding) to stopped or decelerating lead vehicles (NHTSA, 2007). The work described here is part of a larger program of research intended to develop and evaluate rear signaling applications designed to reduce the frequency and severity of rear-end crashes by redirecting drivers' visual attention to the forward roadway (for cases involving distracted drivers), and/or increasing the saliency or meaningfulness of the brake signal (for attentive drivers).

This study quantified the attention-getting capability of a set of candidate rear brake lighting configurations, including proposed approaches from automotive companies. This study was conducted to provide data for use in a simulation model to assess the effectiveness and safety benefits of enhanced rear brake light countermeasures.

Rear Signaling Mock-Up

Assessment Methods

Testing was performed with a group of 152 naïve participants under static conditions; individuals did not actually drive the vehicle. Signal eye-drawing capability was assessed using a series of uninformed lighting event detection trials in which participants were exposed to candidate brake signals while engaged in a secondary task. These trials were administered before participants were informed about the true purpose of the study. The uninformed event trials were intended to supplement subjective ratings with performance-based values (i.e., incidence of glances to the forward view when otherwise occupied).

During the uninformed trials, participants were asked to complete in-vehicle tasks using an in-car navigation system; this task was designed to direct their gaze away from the forward roadway and the brake lighting mock-up (refer to the picture). The mock-up was outfitted with candidate brake signals and positioned straight ahead of the subject vehicle. Brake lights on the mock-up were activated when the participant was glancing toward the navigation system display.

These triggering events occurred three times as follows: once while receiving instruction but looking at the navigation system display, once when selecting among menu items in the navigation system, and once during text entry at the navigation system. These three events were chosen to reflect increasing levels of visual, cognitive, and manual loading. The number of occurrences of eye-drawing (participants looking up) and the times it took them to redirect their gaze forward were measured and served as key dependent measures for assessing eye-drawing capability. Ratings of attention and glare were also captured for all the candidate rear signal lighting configurations.

Initially, the study examined the following brake light signal configurations (all except the Traffic Clearing Lamp (TCL) used LED units):

- **Baseline** (Conventional, Steady Burn at 130cd); n=16
- **Traffic Clearing Lamp** (Incandescent) combined with outboard lamps at increased steady brightness (1420cd); n=16
- **Simultaneous Flashing of All Lamps With Increased Brightness (1420cd)**, optimized in frequency according to previous experiments under the current project; n=16
- **Simultaneous Flashing of All Lamps With No Increase in Brightness (130cd)**, optimized in frequency according to previous experiments under the current contract; n=16
- **Outboard Simultaneously Flashing, CHMSL Alternately Flashing (1420cd)**, optimized in frequency according to previous experiments under the current project; n=16

The following conditions were added to further examine additional effects of brightness level and distance from the signal source (vehicle mock-up):

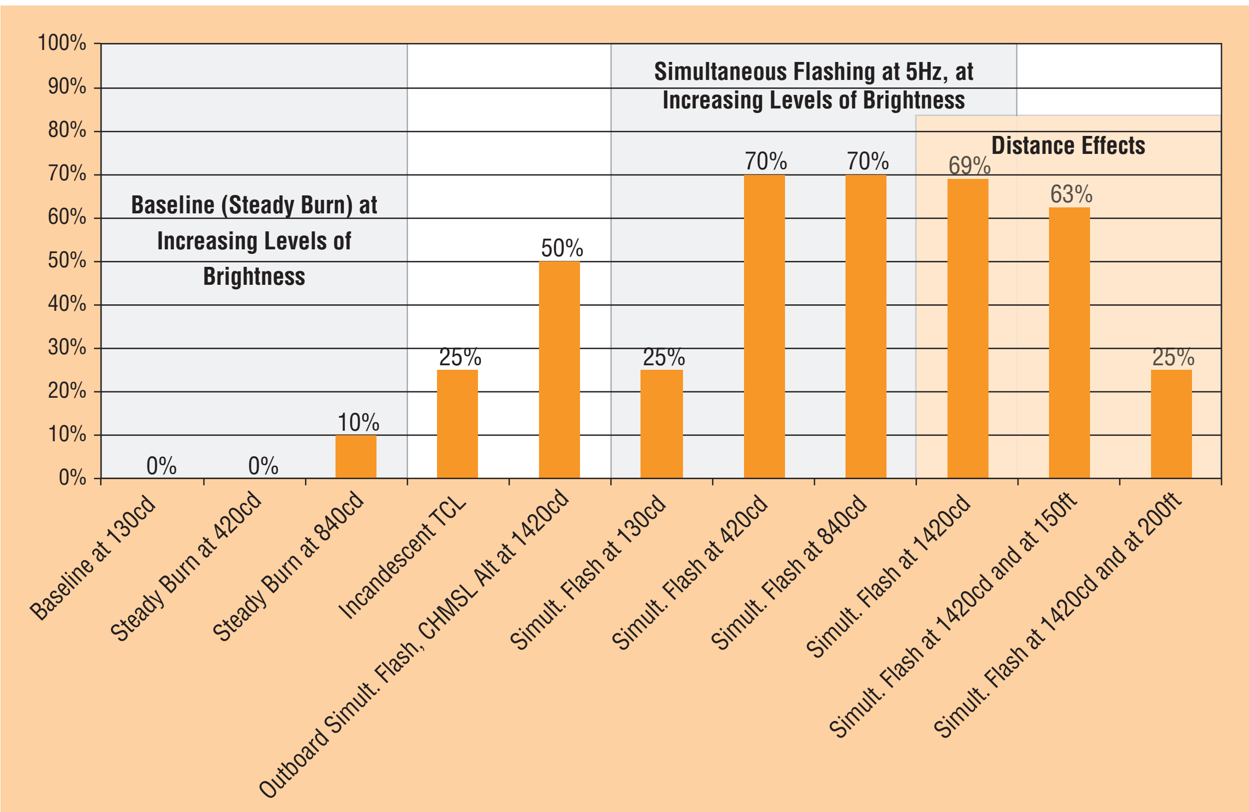
- **Steady Burn at 420cd;** n=10
- **Steady Burn at 840cd;** n=10
- **Simultaneous Flashing of All Lamps at 420cd;** n=10
- **Simultaneous Flashing of All Lamps at 840cd;** n=10
- **Simultaneous Flashing of All Lamps With Increased Brightness (1420cd) at 150ft;** n=16
- **Simultaneous Flashing of All Lamps With Increased Brightness (1420cd) at 200ft;** n=16

Eye-Drawing Results

After evaluating the first set of conditions the results generally supported the Simultaneous Flashing of All Lamps With Increased Brightness (1420cd) as most effective in drawing the participants' eyes back to the forward view, a full 69 percent of participants noticing the lighting on at least one occasion. As this brightness level is more than three times the current legal limit, this same condition was retested at lower brightness levels; 840cd (twice the limit) and 420cd (current limit). The percentage of participants responding to the lights under each of the new brightness with flashing conditions was 70 percent, suggesting that increases beyond a certain brightness threshold will not return substantive performance gains under flashing conditions. More important, all three represent significant enhancements compared to current rear lighting. Increasing the steady-burn brightness to levels of 420cd and 840cd resulted in little or no improvements (0% and 10% look-up respectively), suggesting that increasing the brightness of steady-burn brake lamps does not appear to be an effective means of drawing attention to the brake signal.

The effects of distance on detection performance of these signals was also examined, using the Simultaneous Flashing of All Lamps With Increased Brightness (1420cd) at distances of 150 ft and 200 ft from the signal source. Signal effectiveness for this particular conditions dropped slightly to 63 percent (down from 69%) at 150 ft, and fell sharply at 200 ft where detection rates of 25 percent were observed. This suggests that detection rates may remain fairly stable out to distances of 150 ft (equivalent to 1.7 sec headway traveling at 60mph), but can be expected to drop at distances beyond this range.

Percent of Drivers Who Were Observed to Look-Up in Response to the Lights During Any of the Presentations



Conclusion

It appears that present-day LED lamps are capable of competing with incandescent lamps in terms of attention getting by using multiple units or assemblies along with narrow beamwidths. This research demonstrated that flashing all lights simultaneously or alternately flashing is a promising signal for use in enhanced brake light applications, even at levels of brightness within the current regulated limits.

In summary, the following conclusion bullets summarize the key findings of relevance to the development and implementation of effective brake signals:

- Increases in brake signal brightness (illumination levels) do not necessarily translate into increased signal detection or faster response times; effectiveness appears to be moderated by signal type, among other factors.
- Substantial performance gains may be realized by increasing brake lamp brightness levels under flashing configurations; however, increases beyond a certain brightness threshold will not return substantive performance gains.
- Signal viewing distance also appears to moderate detection performance, particularly at longer distances out to 200 ft.

References

NHTSA. (2007). Traffic Safety Facts 2005: A compilation of motor vehicle crash data from the Fatality Analysis Reporting System and the General Estimates System. DOT HS 810 631. Washington, DC: National Highway Traffic Safety Administration.

This Vehicle Safety Research Note is a summary of the technical research report, *Evaluation of Enhanced Brake Lights Using Surrogate Safety Metrics. Task 2 & 3 Report: Development of a Rear Signaling Model and Work Plan for Large Scale Field Evaluation*. (DOT HS 811 329). This report can be downloaded free of cost on the Vehicle Safety Research section of NHTSA's Web site (www.nhtsa.gov).

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