

# Traffic Safety Facts

## Vehicle Safety Research Notes

DOT HS 811 130

May 2009

## Initial On-Road Evaluation of Candidate Rear Lighting Configurations

This work is directed at reducing the incidence and severity of rear-end crashes by developing and evaluating rear signaling applications designed to redirect drivers' visual attention to the forward roadway (for cases involving a distracted driver), and/or increase the saliency or meaningfulness of the brake signal (for attentive drivers). The work described here is part of a larger program of research. While earlier efforts identified promising enhance brake lighting signals using laboratory and field studies, this on-road study represents the first controlled introduction of candidate rear lighting signals to the naïve driving public.

The purposes of this study were to determine how drivers would respond to the top candidate rear lighting conditions (as determined by previous static tests), helping to determine any potential unintended consequences of the lighting, as well as provide estimates of eye-drawing capability.

This experiment was set up to determine whether drivers, on encountering the new lighting, would react differently than when encountering a typical baseline braking signal. In addition, static tests have shown substantially better eye drawing capability for the top alternative candidate, and it was desired to test this capability on road to the extent possible. This would mean that the on-road experiment would require "catching" at least some drivers looking away and then activating the rear lighting.

This effort was naturalistic; drivers were not recruited for the study. Candidate lighting signals were outfitted in a research vehicle, a 2002 Cadillac Seville STS, designed so that it would look very much like a production vehicle. This research vehicle "coupled with" vehicles in the available traffic stream to create naturally occurring car following situations on two different types of roadways. The research vehicle's rear signals were manually activated under a set of pre-defined conditions during the drive (e.g., driver looking away). The research vehicle did not actually decelerate, but merely activated the brake lamps.

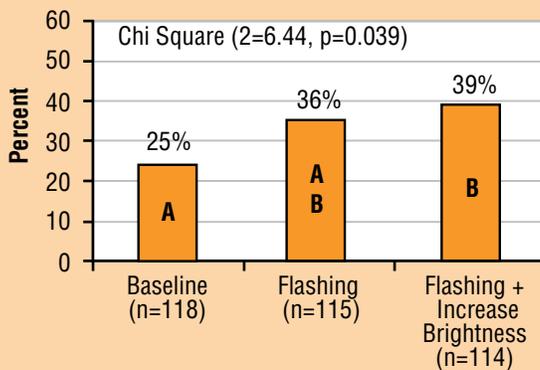
The rear lighting configurations evaluated in this study were determined by the results of earlier static tests and included the following three signals:

1. Baseline Braking Signal, constant on, at normal brake light level,

**Research Vehicle with Enhanced Signals**

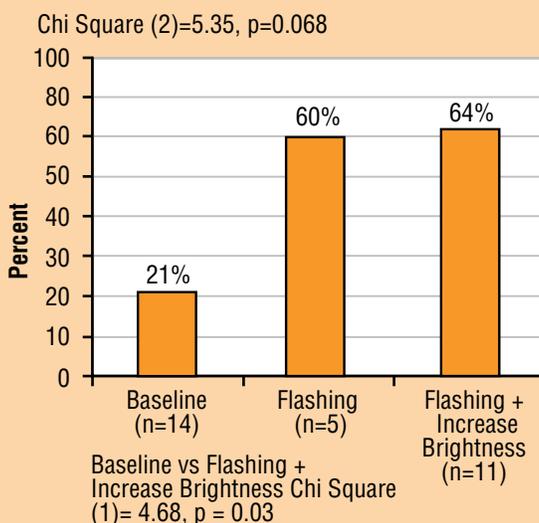


### Percentage of Drivers Who Braked in Response to the Brake Signal As a Function of Lighting Configuration (Pooled 460 & 114 Car Following Data, n=347)



### Eye Drawing Cases, Percentage of Drivers Who Braked in Response to the Brake Signal As a Function of Lighting Configuration

(Car Following, Pooled 114 & 460, n=30)



2. Optimized Simultaneous Flashing of All Lamps with normal brake lamp level (no increase in brightness) (Mercedes-Benz type signal), and
3. Optimized Simultaneous Flashing of All Lamps With Increased Brightness.

## Driver Behavior

This section explores the impact of the experimental lighting signals on driver braking behavior for car following situations – it assesses the degree to which the experimental signals evoke a braking response, independent of actual following vehicle deceleration.

The pattern of braking responses across the three lighting configurations revealed a significant relationship between signal type and braking with the highest incidence of braking associated with the Flashing Plus Increased Brightness condition (refer to the bar graph to the left).

As shown, 39 percent of the drivers in this condition were observed to brake in response to the signal. In contrast, approximately 25 percent of drivers exposed to the baseline signal were observed to brake. Thus, the enhanced signal (Flashing Plus Increased Brightness) was found to significantly increase braking response over the conventional signal.

Braking responses (for both experimental signals) were even more pronounced under conditions where the following driver was found to be looking away from the forward roadway at the onset of the braking signal. In both cases, drivers appear to be interpreting this cue as a braking signal. Note that flashing alone was found to increase braking incidence, but this result was not statistically significant (likely due to the small sample size).

## Unintended or Undesirable Behaviors

This section presents data which provide insight into potential unintended consequences associated with the experimental signals, including the incidence of braking responses from traffic in the adjacent lane as well as erratic or undesirable behavior from following vehicle drivers. Relatively few instances of erratic or undesirable behaviors (e.g., hard braking, swerving, etc.) were observed under any of the lighting configurations, both for car following and adjacent lane trials. However, both experimental signals were found to increase the incidence of braking by vehicles in the adjacent lane (see figure on next page). None of the observed reactions resulted in a near-crash situation; drivers did not swerve out of their lane boundaries, nor did braking responses appear to create a rear-end crash situation. Nevertheless, the fact that some unexpected behaviors did occur raises some concern and should be studied further to understand the locus and extent of these behaviors.

## Annoyance

Previous static tests found that the experimental signals were tolerable to drivers during a 5 s exposure (as measured by glare ratings). A set of “annoyance” trials were conducted in order to

further estimate signal annoyance, and were performed dynamically on the U.S. Route by exposing following drivers to prolonged signal exposures and affording them the opportunity to escape by passing or changing lanes.

Results showed that the incidences of passing and lane changes under the experimental signals were reduced relative to the Baseline situation. This suggests that these trials were not measuring 'annoyance' per se. Rather, the vast majority of drivers exposed to the Flashing Plus Increased Brightness condition (57%) tended to slow or decelerate in response to the signal as opposed to pass or change lanes, actions more suggestive of cautionary behavior than annoyance.

## Eye-Drawing

Relatively little data was gathered over the course of the roadway evaluation trials to allow eye-drawing effects to be reliably determined. Cases were captured in a completely naturalistic setting so that off-road glances (purpose, direction, eccentricity from the forward roadway, etc.) were uncontrolled and random, thereby increasing variability in the data set and making it difficult to study eye-drawing effects.

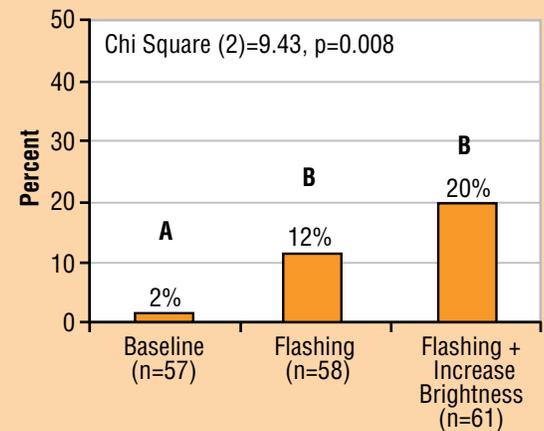
## Conclusions

Evidence gathered in this experiment suggests that the use of flashing with increased brightness represents a relatively strong cue, eliciting a braking response from following drivers, independent of actual deceleration. With respect to unintended consequences, no conclusive evidence was captured as part of this study to suggest that these experimental lighting treatments pose a hazard or are more dangerous than conventional rear lighting designs. However, vehicles in adjacent lanes were found to brake in response to both experimental signals more frequently than the baseline signal, and a few erratic behaviors (hard braking, swerving, etc.) were observed, suggesting more investigation is warranted.

Despite attempts to quantify signal annoyance, little meaningful information was captured to address this aspect. Drivers did not appear more likely to pass or change lanes under the experimental signals; rather, those exposed to the Flashing Plus Increased Brightness signal tended to decelerate.

This Vehicle Safety Research Note is a summary of the technical research report: *Evaluation of Enhanced Brake Lights Using Surrogate Safety Metrics. Task 1 Report: Further Characterization and Development of Rear Brake Light Signals*. Report No. DOT HS 811 127. Washington, DC: National Highway Traffic Safety Administration. This report can be downloaded free of cost on the Vehicle Safety Research section of NHTSA's Web site ([www.nhtsa.gov](http://www.nhtsa.gov)).

**Adjacent Lane Trials: Eye Drawing Cases, Percentage of Drivers Who Braked in Response to the Brake Signal as a Function of Lighting Configuration**  
(Route 460, n=176)



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