Traffic Safety Facts
Vehicle Safety Research Notes

NHTSA
www.nhtsa.gov

DOT HS 811 321

May 2010

Fuel Economy Driver Interfaces: Driving Simulator Study of Component Concepts

A fuel economy driver interface (FEDI) gives a driver an indication of fuel usage or efficiency. Many passenger vehicles in recent model years have FEDIs and they have been included in some vehicle models for decades. FEDIs present fuel economy information in a variety of forms. Some show fuel economy in miles per gallon (mpg) while others provide a relative measure of economy or provide an alert if fuel economy is especially poor. The appearances of FEDIs vary drastically between vehicle makes and models. FEDIs can provide numerical output, analog or digital gauges, bar charts, illuminator lamps, and a variety of other display features. With the recent emergence of high-resolution LCD screens in cars, detailed and complex color displays are possible, and these make feasible a variety of new FEDI concepts. FEDIs may even include vehicle-adaptive features that influence some aspect of vehicle performance in response to inefficient driver behaviors.

While FEDIs have the potential to encourage efficient and safe driving, it is possible that the displays themselves might cause distraction at the expense of attending to the roadway. Overall goals of this research program are to understand how characteristics of FEDIs influence driver behavior, and to identify best practices for FEDI design to meet drivers' needs and minimize the potential for distraction and undesirable behavior. Previous work on this project included documenting the range of existing FEDI designs and conducting focus groups with vehicle owners to discuss fuel-efficient driving behaviors and FEDI designs (Jenness, Singer, Walrath, & Lubar, 2009). Usability testing of several FEDI concepts (FEDIC) was conducted to select display types for testing in the driving simulator.

The purpose of the driving simulator study presented here was to investigate the effect that two specific FEDIC displays would have on fuel economy and driving behavior (Figures 1 and 2). Both FEDICs represented average fuel efficiency for a trip by showing an increasing (or decreasing) number of "leaves" as drivers drove in a fuel-efficient (or inefficient) manner. FEDIC-FE showed instantaneous fuel efficiency with a variable length horizontal bar that moved to the right when fuel efficiency (mpg) was high. A hatched region to the left indicated when fuel efficiency was poor. FEDIC-B showed instantaneous acceleration and deceleration. Hatched regions appeared on each end of the display to indicate when a participant's acceleration or deceleration was excessive and would decrease fuel economy.

Figure 1.
FEDIC-FE represented average fuel efficiency plus instantaneous fuel efficiency.

Figure 2.
FEDIC-B represented average fuel efficiency plus instantaneous acceleration and deceleration.

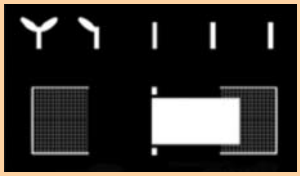

Figure 3.
Driving environment for the Stop-and-Go scenario.

Methods

Three different driving scenarios were used in the driving simulator evaluation of FEDICs:

- Stop-and-Go — an urban setting requiring multiple stops (Figure 3);
- Free Driving — several miles of traffic-less highway;
- Car Following — A highway setting where each participant followed a lead vehicle.

Thirty participants were recruited and drove through each scenario twice. On the first drive, participants were instructed to drive normally. On the second drive, participants were instructed to drive in a fuel-efficient manner. During their second drive, one group of 10 participants had access to FEDIC-B, another group of 10 had access to FEDIC-FE, and a third group of 10 did not have access to any FEDIC. This experimental design allowed for the following key comparisons:

- Normal driving versus driving in a fuel-efficient manner without a FEDIC;
- Normal driving versus driving in a fuel-efficient manner with a FEDIC;
- Driving in a fuel-efficient manner with a FEDIC versus without a FEDIC;
- And driving in a fuel-efficient manner with FEDIC-FE versus FEDIC-B.

Selected Results

Overall, there was a 41-percent increase in average fuel economy during Drive 2 as compared to Drive 1 for the Stop-and-Go scenario with the greatest improvement for those using FEDIC-FE (Figure 4). In the Free Drive scenario there was an overall 5.6-percent increase in fuel economy during Drive 2 as compared to Drive 1. However, a similar increase in fuel economy was not found during the Car Following scenario.

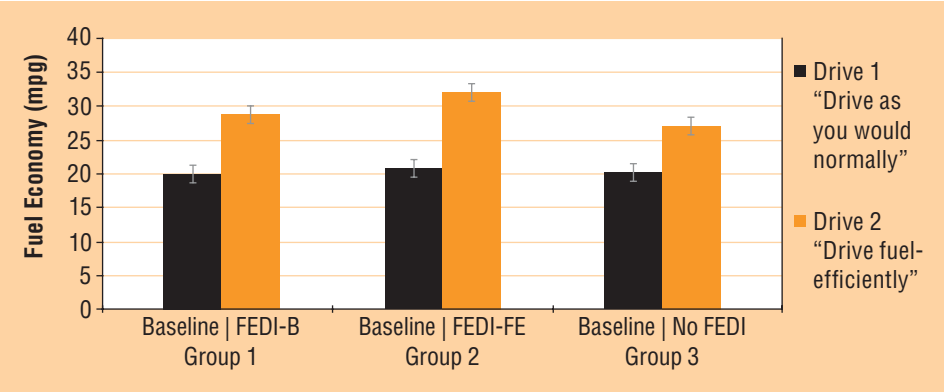

Figure 4.
Average fuel economy (mpg) during the Stop-and-Go scenario. Error bars represent ± 1 standard error from the mean.

Key findings

- Participants made significant improvements in fuel economy just by being asked to drive fuel-efficiently.

- Although providing fuel economy information (FEDIC-FE) did not instruct participants how to modify their driving, participants using this display made changes to their driving behavior that improved their fuel economy within the Stop-and-Go and Free Drive scenarios to a greater extent compared to participants who drove without a FEDIC or with FEDIC-B. Participants drove the smoothest with FEDIC-FE, although it did not present information about acceleration.
- The behavioral FEDIC, which did not show participants how fuel-efficiently they were driving, was associated with an increase in fuel economy similar to participants who drove fuel-efficiently without a FEDIC. Interestingly, this FEDIC was associated with driving that was similar in smoothness compared to driving without a FEDIC within the Stop-and-Go scenario.
- As would be expected by introducing a visual display in a vehicle, drivers made more glances away from the road while the FEDIC displays were present. This indicates there may be safety implications to using a FEDIC display.

Considerations for further testing

- A longer-term evaluation in a real-world setting is recommended to explore long-term use and adaptation that was not possible in this evaluation.
- Presenting fuel economy information allows drivers to improve their fuel efficiency, perhaps better than presenting information on their behavior (e.g., acceleration). Examination of this relationship in longer-term and real-world settings would help to determine how robust this relationship is over time.
- FEDIC designs should be optimized to display information during slower-speed or most stop-and-go scenarios, because drivers' capacity to improve fuel economy was shown to be the greatest in these types of situations.
- Because the act of asking drivers to drive fuel-efficiently was shown to improve fuel economy, the presence of a FEDIC alone may be sufficient to remind drivers to drive fuel-efficiently.
- Viewing the displays was shown to draw attention away from the road. Therefore, FEDICs should be designed in a way that limits the amount of attention required to view and to understand the information presented.

References

Jenness, J. W., Singer, J., Walrath, J., Lubar, E. (2009). Fuel economy driver interfaces: Design range and driver opinions. Task 1 and Task 2 Report. DOT HS 811 092. Washington, DC: National Highway Traffic Safety Administration.

This Vehicle Safety Research Note is a summary of the technical research report: *Fuel Economy Driver Interfaces: Develop Interface Recommendations. Report on Task 3.* (DOT HS 811 319). This report can be downloaded free of cost on the Vehicle Safety Research section of NHTSA's Web site (www.nhtsa.gov).

U.S. Department of Transportation
National Highway Traffic Safety Administration