Traffic Safety Facts
Vehicle Safety Research Notes

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Fuel Economy Driver Interfaces: Usability Study of Display Component Concepts

A fuel economy driver interface (FEDI) gives drivers 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 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 distraction and undesirable behavior. Previous work on this project has 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). The purpose of the usability study presented here was to narrow down the range of possible FEDI designs so that the most usable concepts could be tested in a subsequent driving simulator study.

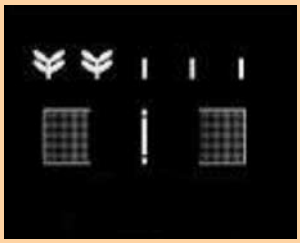
Usability tests

Overview of usability evaluations:

- Based on a formal analysis of user needs, nine recommended prototype FEDI component sets (FEDI-CS) were created.
- Each CS included two components and two separate types of fuel economy information (e.g., instantaneous, trip average, and overall average).
- Thirteen participants completed three usability evaluation tasks.
- Initial Comprehension task - determined if users understood the CS after a short exposure. More specifically this task evaluated how well partici-

Select FEDIC Concept Sets

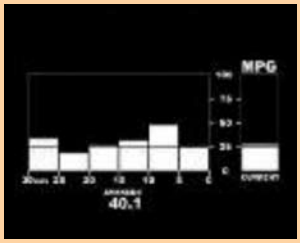
CS01: Intensity-changing light + Text MPG



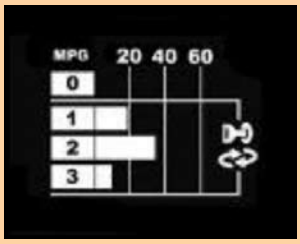
CS02: Representative picture + Acceleration/Declaration Bar

CS03: Representative picture + Horizontal MPG Bar

Select FEDIC Concept Sets



CS04: Vertical Graph of Instantaneous + Trip MPG



CS05: Horizontal Graph of Trip + Horizontal Graph of Average MPG

CS06: Horizontal Graph of Instantaneous + Trip

CS07: Leftward Dial + Text MPG

pants identified state changes and understood information presented on each CS. Good performance by users indicated, for some of the FEDI displays, that the participants understood the information. We inferred that the designs that scored high were simple and straightforward such that distraction should be low as users would have to spend less time deciphering the information.

- Fuel Economy Comprehension task - determined if users could accurately comprehend how changes in CS state related to fuel economy. This task evaluated whether participants could discriminate fuel efficient driving from fuel inefficient driving based on the CS state that was displayed. These results identified which components provided users with comprehensible and (more importantly) "differentiable" CS states. Good performance on these measures indicates users will find it easy to tell how fuel efficiently they are driving based on the FEDIC-CS state.
- General Usability Measures – determined subjective reactions to the various CS by asking several specific questions that revealed whether users found each CS to be useful and satisfying.

Results on fuel economy comprehension task

Seven of the evaluated FEDIC-CS designs are shown along the bottom of Figure 1 along with the overall percentage of correct answers that participants gave when asked to determine if the display indicated that they were driving fuel efficiently. CS02 had the best overall performance on this task. CS07 and CS05 also had good performance. As an example of the features on these FEDIC-CS, the upper portion of the CS02 display shows average fuel efficiency over the current trip. The number of "leaves" are added to the five stalks gives a qualitative indication of fuel efficiency. The lower portion of the CS02 display shows instantaneous acceleration and deceleration levels. When the vehicle accelerates or decelerates a horizontal bar emerges from the center post to indicate the magnitude of forward acceleration (to the right) or deceleration (to the left). The hatched regions at either end of the scale represent large magnitude acceleration and decelerations, which should be avoided to support good fuel efficiency. See the technical report for complete descriptions of all FEDI-CS.

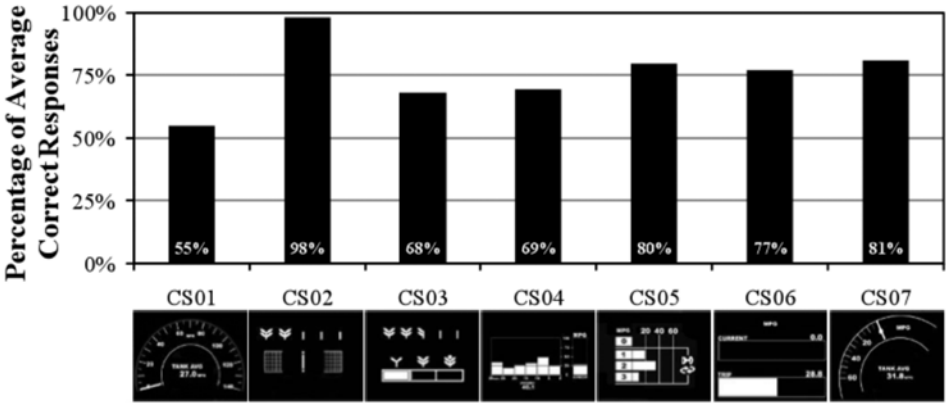


Figure 1.
Overall fuel economy comprehension for seven FEDIC-CS.

Results on general usability measures

General usability measures are summarized in Figure 2:

- Participant responses on nine usability scale questions were reduced into usefulness and satisfying scores ranging between -2 and +2 for each CS evaluated.
- CS that populate the upper-right quadrant of Figure 2 were perceived by participants as being both satisfying and useful. These included CS05, CS03, and CS02.

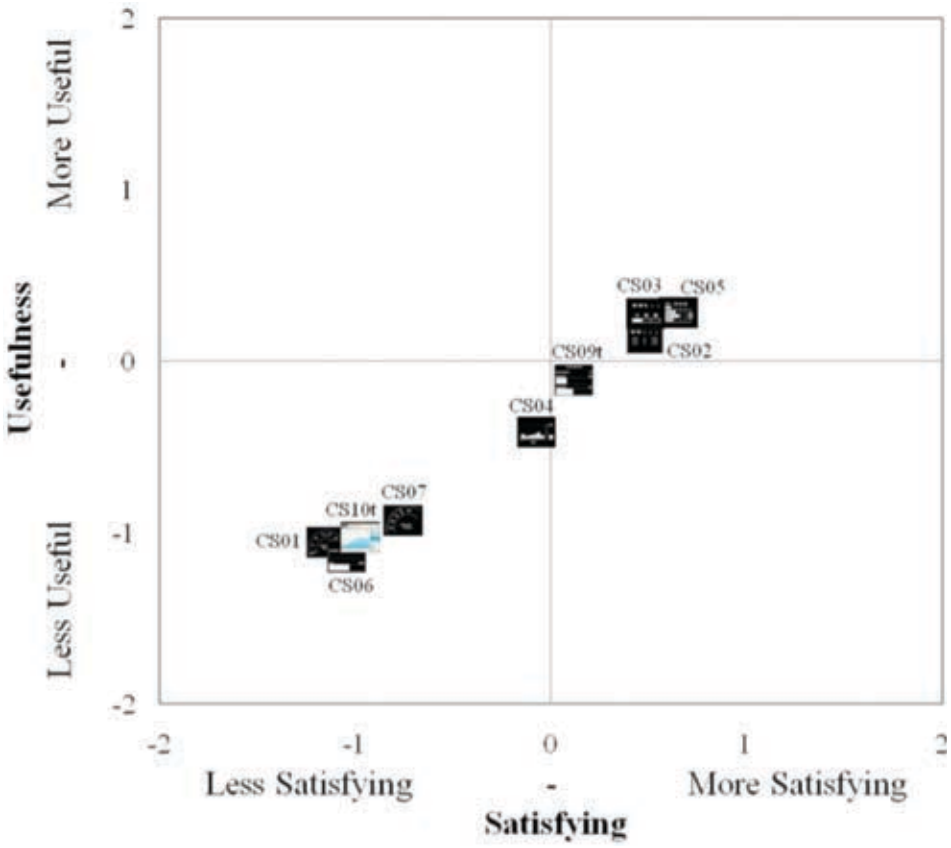


Figure 2.
Overall fuel economy comprehension for seven FEDIC-CS.

Key findings

- Horizontal bars and/or simple representations (i.e., pictures) of fuel economy information were the most usable.
- Participants preferred representational or symbolic forms of fuel economy information (e.g., bars or pictures) as compared to text representation.
- Text representation can improve comprehension when presented along with representative component features.
- Presenting information relating directly to behavior (e.g., acceleration) may be as useful as presenting fuel economy information.

- One FEDIC-CS (CS10t) did not include any in-vehicle display. Unlike other CS tested, fuel efficiency information and other driving data were accessible for viewing on a website only after a trip had been completed. This CS was generally well received by participants despite its low general usability scores.

Limitations

Initial usability and preference are important for a good display. However, other aspects such as longer term motivation, engagement with the display and potential for driver distraction could not be assessed in this testing.

Designs selected for further testing

Based on the results of the usability tests, two fuel economy driver interface designs were considered for further testing to determine their effects on fuel economy and driving behavior. This work was conducted in a driving environment simulator to allow for a controlled and statistically rigorous assessment.

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.

Participants preferred representational forms of fuel economy information as compared to text, although text may improve comprehension.

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).

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