Transportation Research Part D 52 (2017) 277–288

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

The combined effects of driver attitudes and in-vehicle feedback on fuel economy

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ARTICLE INFO

Article history:
Received 5 January 2015
Revised 20 November 2016
Accepted 17 February 2017

Keywords:
Fuel economy
Feedback
Behavior change
Driver behavior
Automobile
Efficiency

ABSTRACT

This paper presents results from a study of driver feedback, driver attitudes, and the adoption of ecodriving behaviors. The study ran for one year; each driver was engaged in the experiment for four weeks. Narrowly defined, ecodriving represents the set of behaviors that a driver can use to minimize the energy use of a trip after the trip has begun. The general ecodriving behaviors are moderating acceleration, top speed, and braking. Ecodriving has long been recognized as a potential source of reductions in transportation energy use, with reduction estimates ranging widely from less than 5% to over 20% depending on context. In-vehicle feedback that provides drivers with salient information suited to their personal goals may be one way to motivate ecodriving. Although many studies have tested unique feedback designs, little research has been conducted into the cognitive precursors to driver behavior change that may underlie the adoption or rejection of ecodriving practices, and therefore underlie the effectiveness of any feedback design. This study examines both precursor cognitive factors and driver behavior changes with the introduction of energy feedback, using a framework hypothesizing that attitudes, social norms, perceived control, and goals influence behavior and behavior change. The study finds that the introduction of a feedback interface can both activate these cognitive factors and result in behavior change. Furthermore, the study finds that there was an overall 4.4% reduction in fuel consumption due entirely to one group that showed increases in their knowledge of fuel economy and reported high levels of technical proficiency during the experiment. Statistically significant relationships are found in this group between the magnitude of cognitive change and the magnitude of behavior change – supporting the theoretical framework. The second group made no improvement and may have been confused by the feedback. The effect of baseline (pre-feedback) performance of the drivers indicates drivers that already have highly efficient driving styles do not benefit much from feedback.

1. Introduction

This paper presents results from a year-long study on driver feedback, driver attitudes, and the adoption of ecodriving behaviors. Broadly defined, ecodriving is the adoption of driving styles that reduce energy consumption. Ecodriving is distinguished from buying behavior, e.g., buying a higher fuel economy car, and travel behavior, e.g., trip-chaining or trip reduction. In effect, ecodriving as discussed here represents only the set of in-vehicle behaviors that a driver can deploy to

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http://dx.doi.org/10.1016/j.trd.2017.02.013
1361-9209/

minimize the energy use of a trip taken by car after the trip has begun. Although it is beyond the scope of this study, the definition of ecodriving is still in flux, and ecodriving can be defined more broadly than it is here depending on the context (Sivak and Schoettle, 2012). The general ecodriving behaviors relevant to this study are moderating acceleration, top speed, and braking. Ecodriving has long been recognized as a potential source of reductions in transportation energy use, with reduction estimates ranging widely from 5% to 25% depending on context (Barkenbus, 2010; Greene, 1986; Sivak and Schoettle, 2012). The wide range in reported effects is likely due to a handful of distinct causes: differences in the duration of the experiment, the vehicle and drive-cycles included, the type of experiment (track, road, or natural driving), and of course the effectiveness of the feedback design.

Although many studies have tested unique feedback designs, little research has been conducted into the cognitive precursors to driver behavior change that may underlie the adoption or rejection of ecodriving practices, and therefore underlie the effectiveness of any feedback design. This study examines both precursor cognitive factors and driver behavior changes with the introduction of energy feedback. Underlying the design of the experiment is a conceptual framework based on the Theory of Planned Behavior (Ajzen, 1980) as amended by the Extended Model of Goal Directed Behavior (Perugini and Conner, 2000); the framework hypothesizes that attitudes, social norms, perceived control, and goals influence behavior and behavior change. Although these behavior change theories are widely applied in other contexts, this exploratory analysis maintains an open view of the experimental effects. Given that it is currently unclear how contextual factors, e.g., traffic density and drive cycle, might interact with behavior, an exploratory analysis is particularly important.

1.1. Background

The experiment and analysis are grounded in two distinct areas of literature: behavior change and fuel economy feedback. Below we present a brief overview of the relevant prior findings and how they intersect in the current analysis.

1.2. Behavior change theories

A brief discussion of the social science concepts of agency and structure provides the context for the use of agent-based behavior theories in this study. As in all cases, the model choice limits the bounds of the possible hypotheses and resulting analysis.

While individuals are often assumed to control their own behavior, the agency of drivers—their freedom and ability to choose—is often limited by the structure of both society and socially produced systems. Such structure provides the context in which an individual can act. Driver choices are constrained by social norms and rules, such as traffic flow and speed limits, as well as socially constructed infrastructure such as freeways and traffic calming infrastructure that limit the driver's ability to enact a particular driving style. More importantly, structural factors such as driving laws or roadway infrastructure are not directly influenced by any single instance of driving—any one driver's trip to the grocery store is not going to change the rules of the road, but in that trip the driver may enact an ecodriving style. For these reasons, we use a behavioral model that emphasizes drivers' agency, but includes structural factors in the analytical model to help explain fuel economy variance. Finally, these structural factors may play a role in the formation of driver goals or attitudes, including some pertinent to ecodriving, e.g., traffic signal coordination may create the context in which a driver may form the goal to cruise at a steady speed.

The theory of planned behavior (TPB) forms the core framework for this study (Ajzen, 1980). The TPB is one of a number of rational behavior models that include decision-making pre-cursors such as attitudes about the behavior, perceptions of

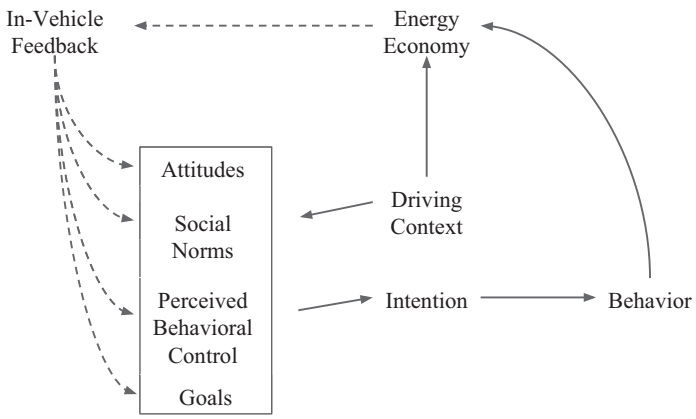

Fig. 1. Theoretical cognitive framework showing feedback. Solid lines show the relationships hypothesized by TPB and the EMGDB adapted to the driving context; dashed lines show the additional effects of feedback as hypothesized in this experiment.