Transportation Research Part C 58 (2015) 760–771

Contents lists available at ScienceDirect

Transportation Research Part C

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

Personalised feedback and eco-driving: An explorative study

R.F.T. Brouwer [a,*], A. Stuiver [a], T. Hof [a], L. Kroon [a], J. Pauwelussen [b], B. Holleman [a]

[a] TNO, Kampweg 5, Soesterberg, The Netherlands
[b] TomTom Telematics, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 15 September 2014
Received in revised form 28 April 2015
Accepted 28 April 2015
Available online 2 July 2015

Keywords:
Green driving support
Driver behaviour change
Value orientation
Goal orientation
Adaptive HMI
Personalisation
Driver segments
Acceptance

ABSTRACT

Conventional road transport has negative impact on the environment. Stimulating eco-driving through feedback to the driver about his/her energy conservation performance has the potential to reduce CO_2 emissions and promote fuel cost savings. Not all drivers respond well to the same type of feedback. Research has shown that different drivers are attracted to different types of information and feedback. The goal of this paper is to explore which different driver segments with specific psychographic characteristics can be distinguished, how these characteristics can be used in the development of an ecodriving support system and whether tailoring eco-driving feedback technology to these different driver segments will lead to increased acceptance and thus effectiveness of the eco feedback technology. The driver segments are based on the value orientation theory and learning orientation theory. Different possibilities for feedback were tested in an exploratory study in a driving simulator. An explorative study was selected since the choice of the display (how and when the information is presented) may have a strong impact on the results. This makes testing of the selected driver segments very difficult. The results of the study nevertheless suggest that adapting the display to a driver segment showed an increase in acceptance in certain cases. The results showed small differences for ratings on acceptation, ease of use, favouritism and a lower general rating between matched (e.g., learning display with learning oriented drivers) and mismatched displays (e.g., learning display with performance oriented drivers). Using a display that gives historical feedback and incorporates learning elements suggested a non-verifiable increase in acceptance for learning oriented drivers. However historical feedback and learning elements may be less effective for performance oriented drivers, who may need comparative feedback and game elements to improve energy conserving driving behaviour.

1. Introduction

1.1. Providing feedback to change driving behaviour

The negative impact of road transport on the environment has been well documented (see, e.g., Fuglestvedt et al., 2008). Much technological development has been focussed on increasing the fuel efficiency of engines and a number of support systems have been developed to aid the driver in a more eco-friendly driving style. On the latter topic, research has shown that providing feedback is a powerful tool for instigating a behaviour change (e.g. Fischer, 2008; Allcott and Mullainathan,

* Corresponding author. Tel.: +31 888 665 969.
E-mail address: rino.brouwer@tno.nl (R.F.T. Brouwer).

http://dx.doi.org/10.1016/j.trc.2015.04.027
0968-090X/

2010; Stern, 2011). Stimulating eco-driving using feedback technologies has the potential to reduce CO_2 emissions and promote fuel cost savings of 1–8% (Tulusan et al., 2012). On an operational level (Michon, 1985) eco-driving refers to implementation of eco-driving techniques while driving which encompasses keeping the speed down, efficient gear shifting, anticipatory, calm and steady driving, and efficient braking (Strömberg et al., 2015). In-vehicle feedback technologies provide drivers with real-time, continuous feedback about their eco-driving behaviours. A recent naturalistic driving study shows an average decrease of between 2% and 8% in fuel consumption, depending on feedback design (Stillwater and Kurani, 2013). From interviews with 46 drivers Stillwater and Kurani (2013) conclude that the information content of the display (e.g., maximising MPG or savings, or minimising CO_2) plays an important role in stimulating drivers to drive economically. Different drivers seem to be attracted to different types of information and feedback. He et al. (2010) argue that presenting feedback in the same way to differently motivated drivers may not be that effective. In their reflection on different energy feedback technologies they bring forward that an improvement would be to consider the specific values and goals of each individual when providing feedback to drivers. As such, the visualisation could provide personalised feedback of the positive results of eco-driving behaviours, highlighting for example for one person health benefits and for another person monetary gains. This is in line with Anable's (2005) work on segmenting the driver population based on psychographic variables (e.g., attitudes, values, personal norms) instead of based on demographic variables (e.g., gender, age). Also, in the field of consumer behaviour and marketing it is common practice to approach different people in different ways because they are motivated by different factors (Wedel and Kamakura, 1998). The goal of the research described in this paper is to explore whether tailoring eco feedback technology to different driver segments with specific psychographic characteristics will lead to increased acceptance and effectiveness of the eco feedback technology. The remainder of this paper starts with a short discussion of the value orientation theory and learning orientation theory. Both these theories offer a good starting point to distinguish different driver segments. Based on insights from these theories we describe four driver segments and propose four variants of the same eco feedback display that, supposedly, match the different driver segments. These different displays were tested with respect to acceptance while drivers drove in a driving simulator. The results and implications of this explorative study are discussed.

1.2. Value orientation theory

Values are principles that guide and influence behaviour. Values are seen as enduring behavioural ideals that are firmly incorporated within persons. As behavioural ideals, values guide a person's sense of what is good and bad and which goals to pursue (Rokeach, 1973). Regarding understanding pro-environmental behaviour three types of values are important: pro-self, pro-social, and ecocentric values (Stern, 2000; De Groot and Steg, 2008, 2009; Van Vugt et al., 1995; Stern et al., 1993). People with a strong pro-self value orientation will especially take into account the costs and benefits of pro-environmental behaviour for them personally. People with a strong pro-social value orientation include in their decision on behaving pro-environmentally the perceived costs and benefits for other people. People with a strong ecocentric value orientation will consider the perceived costs and benefits for the ecosystem and biosphere when deciding to act pro-environmentally (De Groot and Steg, 2009). Stern and Dietz (1994), however, found that in a general population sample the ecocentric value orientation does not differentiate from social-altruism. Therefore, and in line with He et al. (2010) who suggested to improve feedback by matching it to an individual's values, we hypothesise that matching the eco feedback technology to people's value orientation (pro-self vs. pro-social) will increase the attractiveness and effectiveness of eco-feedback technologies.

1.3. Goal orientation theory

Motivating people to drive eco-friendly can be considered to be a learning process. Drivers will need to learn new skills, which hopefully will form into habits. Receiving feedback can therefore be seen as an important part of the learning process. Eco feedback technology aims to make drivers learn the connection between their driving behaviours and certain outcomes, for example, the amount of fuel they use. Feedback is an essential component of learning, and its principles are rooted in educational theory (Darby, 2001). Goal orientation theory is a social-cognitive theory of achievement motivation and originally examines the reasons why children engage in their school work (Dweck, 1986). Earlier work of Dweck (1986) contrasted two types of goal orientations: learning goal orientation and performance goal orientation. People with a learning goal orientation wish to acquire additional knowledge or master new skills. They are self-referential, focusing on the development of skill and competence relative to the task and one's own past performance. People with a performance goal orientation want to demonstrate their competence and to make a good impression on others. They are trying to outperform others and strive to be the best in a group (Harackiewicz and Elliot, 1993). We assume that aligning the provided feedback to people's goal orientation (learning orientation vs. performance orientation) increases attractiveness and effectiveness of eco feedback technology.

1.4. Four driver segments

To enable developing and testing tailored eco feedback, we used insights from these theories to distinguish four driver segments based on their value orientation and goal orientation.