Learning eco-driving behaviour in a driving simulator: Contribution of instructional videos and interactive guidance system

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Abstract
The present paper deals with how to design and test an eco-driving training tool in the form of a digital educational game, including a specific guidance system interface to teach eco-driving rules. We tested whether learners could reproduce the eco-driving behaviour and implement the rules once they were autonomous. We also aimed to validate the method as a relevant eco-driving teaching tool that does not distract drivers or affect safety behaviour. We examined the contribution of the guidance system to teach procedural skills compared with traditional teaching methods such as video instruction. Results reveal that both methods lead to reduced CO₂ emissions, but that the reduction is greater with the interactive guidance system. Further analysis and an eye-movement study revealed no increase in driving time or effect on safety.

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1. Introduction

The aim of the study presented in this paper was to test the learning value of training programs to teach eco-driving in an immersive simulated environment and a multimedia learning tool interface embedded in the simulator.

Programs were designed in such a way that participants could complete the training on their own, without the presence of an instructor. The goal was to propose a complete training tool for eco-driving, enabling participants to learn autonomously how to apply each eco-driving rule efficiently and thus reduce their fuel consumption.

Two programs were tested, one based on instructional videos, the other combining instructional videos with an interactive guidance device embedded in the simulator. A baseline program was added for experimental control. The design principles of the interactive guidance device were based on recent research and the results of studies on multimedia learning in the field of educational psychology (Mayer, 2014).

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1.1. Eco-driving

“Eco-driving” is a concept used to describe energy-efficient use of vehicles. It is a driving strategy that aims at reducing fuel consumption, so that less fuel is used to travel the same distance. It is proven to be a driving style that encompasses road safety, consideration, comfort, and efficiency. It is also seen as an economic, environmentally friendly method that leads to reduced air and noise pollution, fuel savings for the individual and corporate organizations (UK Road Safety Lf, 2012).

There are several eco-driving operations referred to as “rules” that drivers can learn. Once acquired, their use could lead to significant fuel savings (e.g., Ericsson, 2001; Van der Voort, 2001). In a study by Ford Motor Company (2008) the authors claimed that implementation of rules improve by 25% fuel economy during short-term context situation (see also Hennig, 2008). While, in sustained, casual driving practices, others report that fuel savings are conservatively calculated at 10% (International Transport Forum, 2007).

However, this driving “style” is a complex activity, comprising over hundreds of separate tasks (Walker, Stanton, & Young, 2001). Previous studies tend to show that a full training (that includes theoretical learning, then practice with an observer) leads to higher improvement comparing to “classroom” teaching, that is to say theoretical learning only (Andrieu & Saint Pierre, 2012; Symmons, Rose, & Van Doorn, 2008).

Furthermore, even when drivers show immediate improvement, it had been reported that they will eventually return to their usual driving patterns on long-term period (Beusen et al., 2009).

The explanation could be that learning an eco-driving style requires acquiring and transforming declarative and procedural knowledge (the eco-driving rules) into practical skills (Anderson, 1993). A full training might be more prone to enable efficient integration of eco-driving behaviour into an operational mental model. Yet organizing periodic reminders requires time and the financial resources to afford the presence of an instructor.

To address this issue, an alternative teaching method we chose is providing training with the help of a multimedia educational interface, embedded in a high scale simulator for practice. Immersive simulation is mainly used for driving learning, experimental research on human behaviour, and automotive engineering (Parodi-Keravec et al., 2011; Azzi et al., 2010; Kemeny, Kelada, & Liano, 1997). Full scale driving simulation enables eco-driving skill acquisition with a practical experience in an interactive, dynamic environment. The drivers can exercise and reiterates the trials autonomously, without being apprehensive of physically damaging accidents. Moreover, elaborated road scenarios can support the learning of the targeted behaviour in a custom-built-way, and ultimate assessments can be objective, precise and extensive.

Numerous researches also experiment eco-driving learning efficiency with the help of eco-driving assistance systems embedded in the driving simulator’s cockpit (Rakauskas, Graving, Manser, & Jenness, 2010; Voort et al., 2001), and highlighted their positive impact on fuel consumption and CO2 emissions. That type of system contributes to reach higher eco-efficient behaviour by offering a more refined guided learning experience. Literature states that if the system is appropriately designed (Vicente & Rasmussen, 1992; Jamson et al., 2015; Vaezipour, Rakotonirainy, Haworth, & Delhomme, 2017), not only it can teach to the drivers “what” to do, it also enables to know “when” to implement the rules and “how much” (e.g. immediate feedback indicates how much emissions increase as more pressure is put on the accelerator), therefore it leads to a more comprehensive learning of eco-driving behaviour.

Although this raises the question of the impact eco-driving and other types of in-vehicle systems on driver’s safety (Vaezipour et al., 2017). Any additional interaction with the drivers during driving activity may cause distraction due to the increased complexity of the task. As a result, it may be demanding regardless of whether or not it is designed for eco-driving or safe driving style (Oviedo-Trespalacios, Haque, King, & Washington, 2016). The increasing amount of visual information may compromise the driver’s safety. Therefore, these concerns are taken into consideration during the design process and development of in-vehicle systems. The objective is that the eco-safe in-vehicle systems have minimal impact on driver’s attention distribution processes. The driver’s glance patterns must be recorded to evaluate this impact.

1.2. Eco-driving learning interface

Reinforcement of legislation and, for example, the banning of hand held mobile phone use (Young, Regan, & Hammer, 2003) is directed to help tackle the symptom of the distraction issue. However, a more ergonomic approach would be to treat the root cause of the problem by focusing on the instructional design of the interface. There’s an important database in the field of ergonomics, transportation and Human Machine Interfaces (HMI) focusing on driver’s distraction and driver’s workload with the aim to generate guidelines to help integrate complex and real-time-changing information into onboard interfaces – namely design concepts based on Ecological Interfaces Design principles (“EID”; Burns & Hajdukiewicz, 2004).

In the context of our study, the training tool is not aimed at giving providing the drivers with assistance once he is on road. The objective is to teach eco-driving to the drivers with the perspective to allow them to implement the autonomously in their daily life, without any assistance. In addition to taking into consideration the EDI principles mentioned above to design our interface, we took the decision to base the design of the critical features of the interactive device on an approach usually used in cognitive educational psychology. More specifically, the researches on learning with multimedia supports offer relevant data for the elaboration of instructional design dedicated to help learning processes. The scientific basis for the design of the guidance system is The Cognitive Theory of Multimedia Learning (“CTML”, Mayer, 2014). It states that any additional information is more information to process, even if it was intended to help (Mayer, 2005, 2014). The driver’s environment is dynamic and transient. Learning a new behaviour, even within a familiar driving activity context, could be
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