Accident Analysis and Prevention 65 (2014) 123–130

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

Comprehension and acceptability of on-board traffic information: Beliefs and driving behaviour

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ARTICLE INFO

Article history:
Received 26 July 2013
Received in revised form
26 November 2013
Accepted 25 December 2013

Keywords:
Co-Drive on-board traffic information system
Warning message
Recommendation message
Comfort message
Traffic pictogram
Speed behaviour

ABSTRACT

Co-Drive on-board traffic information system is a complementary tool providing a dynamic management of transportation infrastructure and traffic as well as the diffusion of accurate real-time information about the road environment and motorists' driving behaviour. The aim of this study was to examine drivers' acceptability of Co-Drive by investigating the impact of traffic information provided via on-board display devices on motorists' beliefs and behaviour.

116 drivers (Men = 46.6%), between 22 and 62 years, participated to a driving simulator experiment. They were randomly divided into two experimental groups according to the type of display device (Blackberry vs. iPhone) and a control group. The experimental groups were exposed to fourteen on-board traffic messages: warning (e.g., road crash), recommendation (e.g., the use of seat-belt) and comfort messages (e.g., the location of a gas station). They had to validate each message by pushing the headlight flashing button as soon as they understood it. At the end, all participants had to fill in a questionnaire.

Drivers evaluated positively the on-board messages, expressed a high level of confidence in the on-board information and estimated having received it sufficiently in advance for them to adjust their behaviour. Regardless of the type of display device, they took more time to read warning and recommendation messages as compared to comfort messages and complied with them. Finally, those exposed to the messages adapted their behaviour easier to the road events than those who did not receive them. Practical implications of the results are discussed.

1. Introduction

Advanced on-board systems provide accurate real-time traffic information which improves road safety by facilitating drivers' opportunity to anticipate traffic events and adapt their behaviour, ameliorates the traffic flow and encourages sustainable mobility (Jamson et al., 2013).

Co-Drive project represents a recent French initiative to validate a cooperative driving system between the driver, the vehicle, and the infrastructure, in order to obtain an intelligent and safe route in the service of sustainable mobility. More specifically, Co-Drive system represents a complementary tool providing a dynamic management of transportation infrastructure and traffic as well as the diffusion of real-time traffic information. The information should be presented via on-board display devices (e.g., mobile phones) and notify drivers' about legal speed limits, time headway, warnings on local events (e.g., slippery road, traffic jams, the location of a gas station, etc.) and be updated in a regular manner.

In order for drivers to develop safer interactions with the road environment and adopt smart mobility, any information provided via on-board traffic information systems (Bierlaire et al., 2006; Caird et al., 2006, 2008; Hanowski and Kantowitz, 1997; Lee et al., 1999; Staplin and Fisk, 1991; Regan, 2004) or variable message signs (VMS) (Dudek et al., 2006) would have to be quickly read and understood. In this regard, numerous studies examined drivers' reading and comprehension of messages provided via VMS (Dutta et al., 2005) or road-safety campaigns (Delhomme et al., 2009, 2010; Haddad and Delhomme, 2006).

Thus, some studies explored the factors with potential influence on reading and comprehension such as *length of the message* (Arditi, 2011), *colour use* (Lai, 2010; Shaver and Braun, 2000), *the presence* vs. *absence of pictograms* (Collins and Lerner, 1983; D'Onghia et al., 2008; Dowse and Ehlers, 2005), *type of display device* (Delhomme et al., 2013), *type of message* (Wang et al., 2009), and *motorists' characteristics* such as *driving experience* (Tijus et al., 2005), *age* (Allen et al., 1980), *gender* (Al-Madani and Al-Janahi, 2002), and *fatigue* (Lum et al., 1983). Thereby, motorists require approximately

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http://dx.doi.org/10.1016/j.aap.2013.12.017

one second per word presented on VMS or 4-units information (1-unit information = one word) to accurately process and understand the information and still pay attention to the driving activity (Dudek and Huchingson, 1986; Ullman et al., 2005). Red is associated with warnings and increases compliance behaviour (Braun et al., 1994, 1995; Rudin-Brown et al., 2004). Drivers prefer pictograms over text messages and their reading time is shorter for messages accompanied by pictograms as compared to text-only (Houts et al., 2006; Jaynes and Boles, 1990; Monteiro et al., 2013; Shinar and Vogelzang, 2013; Tijus et al., 2005; Wang et al., 2007). Furthermore, drivers spend more time reading warning messages as compared to other types of message (Delhomme et al., 2013). Young (<19 years) and elderly drivers (>54 years) have difficulties in understanding and recognizing warning traffic signs (Otani et al., 1992; Richards and Heathington, 1988). Female drivers between 40 and 60 years recognize faster "speed limits" warning signs as compared to male drivers between 25 and 40 years (Schmidt, 1982). Finally, fatigue was associated with difficulties to focussing attention on stimuli provided via advanced on-board traffic systems (Hancock and Verwey, 1997).

Other empirical studies examined the impact of traffic messages on drivers' behaviour (Ullman et al., 2005). For example, Rämä and Kulmala (2000) investigated the effects of the presence vs. absence of the message "slippery road" provided via VMS on motorists' speed behaviour. A reduction of approximately 2 km/h in the average speed was registered among those exposed to the message. Similarly, Luoma et al. (2000) observed that drivers refocused their attention on seeking cues of potential danger and drove more carefully on the slippery road segments when exposed to a "slippery road" message via VMS. Erke et al. (2007) investigated the effects of the presence vs. absence of a "closed road segment" message recommending an alternative route displayed on two VMS in Oslo on drivers' route choice and speed behaviour. Larger speed reductions and higher compliance with taking alternative routes were found among the drivers who had seen the message as compared to those who had not been exposed to it.

The aim of our study was to investigate motorists' comprehension of on-board traffic messages provided on two types of display devices (Blackberry vs. iPhone) and their acceptability of Co-Drive. More specifically, we tested the effects of these messages on motorists' beliefs and driving behaviour during a simulator driving task, according to the type of message (warning, recommendation, and comfort messages), gender, and age. In this regard, we formulated the following hypotheses in accordance with the previous literature review:

H1. Warning messages inform motorists about imminent dangers therefore, we assumed that motorists will take less time comprehending warning messages as compared to recommendation and comfort messages.

H2. Motorists' from the experimental groups will express high acceptability of on-board traffic information systems, positive attitude towards on-board traffic messages and pictograms, and confidence in on-board traffic information, will report changing their behaviour after being exposed to on-board information, and will declare themselves satisfied with on-board traffic information and Co-Drive.

H3. Motorists will adjust their driving behaviour according to the type of message by reducing speed when confronted to warning or recommendation messages and maintain it when confronted to comfort messages which do not require any particular behavioural change.

H4. Motorists from the experimental groups will adapt their driving behaviour easier to the road events as compared to those from the control group.

2. Method

2.1. Apparatus

In order to achieve the aims of this study, we used the driving simulator with a fixed platform belonging to the Mobility and Behaviour Psychology Lab (IFSTTAR). The equipment is composed of ten parallelepiped-shaped panels and visual channels (2.44 m × 1.83 m) as well as an instrumented vehicle (Peugeot 308). Seven of these panels are equipped with a classic video projector (F22 Projection Design) while the other three with a Titan stereoscopical video projector (Digital Projection, 3D). The instrumented vehicle is positioned in the centre of seven panels with a triptych facing the driver while the other three panels are fixed in the back of the vehicle. The retro lateral vision is ensured by external fixed visual panels and the refresh rate of these panels is 60 Hz. The driver has a 360° field of view. Different driving parameters (e.g. speed, acceleration, braking, wheel movements, etc.) are registered in accordance with the virtual traffic situation to which the driver is exposed (see Fig. 1).

2.2. Experimental design

Two designs were used

(1) Without the control group. To test the effects of the type of message (warning, recommendation vs. comfort messages) according to type of display device (Blackberry vs. iPhone), gender (men vs. women) and age category: young (22–34 years), middle-aged (35–44 years) vs. older (45–62 years) on drivers' comprehension, acceptability of Co-Drive, and speed behaviour (Hypotheses 1, 2, and 3).
(2) Including the control group. To the effect of the presence vs. absence of the messages according to the experimental condition (Blackberry, iPhone vs. control group) gender (men vs. women), and age category (young, middle-aged vs. older) on motorists' driving behaviour (Hypothesis 4).

2.3. Participants

The sample consisted of 116 drivers (Men = 46.6%) between 22 and 62 years (M = 38.73, SD = 10.65). Participants had their driving license for 17.63 years (SD = 10.74) and had driven over 16,537 km/year (SD = 12,314). They declared driving at a general average speed of 128.33 km/h on highway (SD = 13.37) and a maximal average speed of 135.04 km/h (SD = 10.00, Min = 100; Max = 160). We divided them by median split into three categories according to their age: young (42.2%), middle-aged (27.6%), and older drivers (30.2%).

2.4. Procedure

Participants were selected by a recruitment agency according to the criteria provided by the experimenter (i.e., gender, age, and driving experience) and received financial incentives for their participation. They were randomly divided in three groups: two experimental groups which received on-board traffic information via Co-Drive and displayed on a Blackberry (N = 43 drivers) vs. iPhone (N = 37 drivers) situated on the dashboard of the vehicle and a control group (N = 36 drivers) (see Table 1).

They were equally distributed among the three groups according to gender (χ^2 = .594, p = .74), age (χ^2 = 3.446, p = .17), and driving experience (χ^2 = 3.570, p = .16).

We have chosen two types of display device used by drivers to communicate or receive information on a daily-basis: an iPhone 4S (screen sizes: 8.89 cm × 7.39 cm × 4.93 cm; screen resolution: