Haptic Feedback in Eco Driving Interfaces for Electric Vehicles: Effects on Workload and Acceptance

Jaume R. Perelló-March [1], Eva García-Quinteiro [2] and Stewart Birrell [1]

[1] WMG, the University of Warwick, CV4 7AL, Coventry, UK
[2] CTAG, Polígono Industrial a Granxa (Porriño), 36400, Pontevedra, Spain
jaume.perello-march@warwick.ac.uk
eva.garcia@ctag.com
s.birrell@warwick.ac.uk

Abstract. The pervasive inclusion of electric vehicles on our roads is already a reality and is here to stay in the future. Many car manufacturers are including full electric or hybrid models in their catalogues and more will come in the near future. However, since the electric vehicles' range is still insufficient to compete with combustion-engine vehicles, for many electric vehicle owners reducing energy consumption, in order to increase available range, has become a matter of increasing concern. This paper is based on previous work conducted as part of the European Commission project ecoDriver. EcoDriver's main purpose is to teach efficient driving strategies and facilitate drivers' decision-making processes through several feedback modalities, in order to help increase driving efficiency. Here, the Full ecoDriver System combined with a haptic feedback gas pedal was tested in real driving conditions. In this paper, the drivers' subjective assessments in terms of effectiveness, workload and acceptability are presented. The sample profile was composed by thirty young but experienced drivers who had to drive around an open track which allowed several possible scenarios. The main results suggest that the system effectiveness depends on the event type and the feedback modality provided. The haptic feedback did not increase workload compared to visual feedback, however, as a prototype, it showed some acceptance constraints. Results presented in this paper advance further research concerning human factors in eco-driving and haptic feedback systems research.

Keywords: acceptance, cognitive workload, eco-driving, haptic feedback.

1 Introduction

Being zero carbon does not exclude the Electric Vehicles (EV) to increase its energy efficiency, as until the production of electrical energy is completely sustainable, producing it is still pollutant. Therefore, besides technological innovations, drivers' behaviour is a potential area of improvement in order to increase vehicles' efficiency. In this sense arose the eco-driving campaign promoted by European institutions with the main objective of teaching efficient driving behaviours. EcoDriver - supporting the driver in conserving energy and reducing emissions - was a four-year European project that supported the drivers in adopting an eco-driving behaviour adapted to them and to their vehicle's characteristics through different feedback applications (for more details regarding this project see [1–5].

Some strategies for EV were proposed in the Energy Efficient VEhicles for Road Transport project (EE-VERT) [6]. These behaviours have been shown to reduce energy consumption [7, 8]. Currently, for EV owners particularly, saving energy is also necessary to increase the autonomy range of their vehicles. Until the arrival of new generation extended-range batteries, current EVs cannot compete with the range of internal combustion engine vehicles. This phenomenon, also known as "Range Anxiety", can increase EV drivers' anxiety and cognitive workload [7] as they fear that their vehicle will have insufficient range to reach its destination and would thus leave the vehicle's occupants stranded. Several authors [7–9] have suggested that feedback from diverse eco-driving systems are recommendable to support users in changing their driving habits and reducing energy consumption in EV. These systems are a potentially achievable and efficient measure for private transport to contribute saving energy and consequently reducing greenhouse emissions without increasing drivers' cognitive workload [10].

However, when designing such a new interface, researchers also have to ensure that users will accept this new technology in order to make it successful. Therefore, it is of great importance to discover at a very early stage of development which issues in its design are decreasing the acceptance of the new systems [11]. In the case at hand, the rate of learning of eco-driving skills during experience with such a system is an important factor to consider in order to increase its acceptability. This will allow the delivery of information to be tailored, identifying of the point in time at which it is appropriate to reduce or eliminate the guidance to prevent the presentation of redundant information and thus, to optimise learning [12]. Indeed, it may become annoying for drivers if advice is provided too frequently, and therefore influencing overall acceptance and ultimately engagement with the system. For this reason, a key premise behind the ecoDriver project is that as soon as drivers learn the appropriate skills readily they do not need constant eco-driving support.

The interface modality (or method of interacting with the driver) has to be also considered when designing an assistance system for prolonged use, which should be the most effective and least distracting. The visual modality is the most commonly used [13] and has proven to be effective providing detailed driving-related information. Nevertheless, since driving is mainly a visual task, it is easy to overload the drivers with visual information and distract them from the primary driving task [1]. The negative effect on driving performance due to visual information overload has been consistently reported as in event detection [14], lateral control [15] and with impairment observed in driver reaction times [16, 17]. Regarding the auditory modality, whereas previous studies reported a reduction in the distracting impacts of a visual eco-driving interface when combined with a complementary audio signal [1], there is still substantial evidence in the literature of adverse effects of an auditory task on driving performance measures such as brake reaction time [18–20], longitudinal control [21, 22], event detection [19] and steering performance [23]. Taking this evidences into consideration suggested the need for an alternative modality. The haptic modality – as adopted in this paper via the Haptic Gas Pedal (HGP) – which presents information to the driver by the sense of touch or vibration, has been used before in forward collision warning systems [24] and speed management systems [25] to produce favourable effects on driving performance [1] and reducing cognitive workload [26]. Furthermore, other modalities of haptic feedback such as the haptic steering-wheel, helped reducing time to redirect attention towards the road and kept the drivers more engaged in driving tasks [27].

Thus, our main objective in the present study was to assess the acceptance and the cognitive workload of two different haptic feedback modalities (force and stiffness of the HGP, as described in the method below) combined with the ecoDriver system. Expectations are that either both haptic gas pedals will help reduce drivers' cognitive workload compared to visual feedback, which would also increase their acceptance, as suggested by [26]. It is expected that when presenting the information through a sensorial channel – the haptic channel – which is not competing for attentional resources, this information will be processed faster than when presented isolated in visual modalities that are competing for multiple attentional resources in the primary driving task [28]. That is, allowing the information to be diverted into two different sensory channels will help reducing the visual overload, and consequently reduce perceived cognitive workload.

Taking everything into consideration, we hypothesized that when combining visual feedback with both HGP modalities, workload punctuations will be equal or lower than those obtained in the visual feedback modality. Furthermore, it was also considered that this combination would be associated to higher acceptance scores than visual feedback. Finally, we also assumed that the visual feedback modality alone would register the highest workload values in experimental conditions compared to those combined with HGP.

2 Method

The design of this research takes as a methodological reference the study conducted by [1] at the University of Leeds. They found that eco-driving advice improved driving performance, and that visual feedback was the most effective. However, this modality increased subjective workload as it reduced driving attention to the forward view. Although haptic force feedback's effect on subjective workload was lower, it was less effective than a visual feedback system. This study was later brought to a real-world driving situation in the work carried out by [29] where all the details regarding the instruments, the Full ecoDriver System (FeDS) and energy efficiency metrics are available. The present document is part of unpublished work from this study and focuses into participants' subjective assessments of the FeDS -combined with HGP- cognitive workload and acceptance.

The sample was formed by 30 participants, of whom four were women. Their average age was 33 years old (M = 33.67; SD = 5.55). All of them received 20€ as an economic compensation when they finished the trials. None of the 30 participants were

familiar with haptic gas pedals usage, though 25 of them had already participated in a previous study with the ecoDriver system and had already driven the Nissan Leaf used in the present study.
The equipment used in this study included the FeDS as a visual feedback nomadic device (smartphone app) (see Figure 1) and was combined with a Force Haptic Gas Pedal (FHGP) or Stiffness Haptic Gas Pedal (SHGP) (see all details in [29]). The FeDS provided feedback to achieve better energy efficiency when the driver faced certain events (Speed limit, Curve, preceding vehicle and intersection). Both HGP triggered when the FeDS detected inappropriate driving behaviour (i.e. exceeding the speed limit). The FHGP triggered hampering the driver's pressure on the gas pedal. On the other hand, the SHGP triggered vibrating when inappropriate gas pedal usage was detected. These systems were equipped in a 2010 Nissan Leaf full EV, the vehicle used to run the tests.

Fig.1. FeDS advice for speed limit event (left) and FeDS advice for curve event (right).

2.1 Questionnaires and scales

Questionnaires utilised included a battery of items to establish the profile of the sample relating to socio-demographic data such as age, gender, driver experience (years), annual mileage (km) and employment. It also included items related to in-vehicle technologies experience (e.g. using GPS navigation, ACC, etc.), willingness to use new technologies (Technology readiness scale) and attitudes towards efficient and green behaviour (Attitudes towards green behaviours scale). More details regarding the sample profile can be found in [29]. This information will be helpful to better understand and interpret the main results.
Secondly, they also included completing the NASA-Task Load Index [30] after finishing each of five trials. This scale has been used in many different studies, such as

for evaluating driving distractions [31–33] or assessing in-vehicle assistance systems [1, 26, 34]. The NASA-TLX consists of six subscales that represent independent clusters of variables: Mental demand, Physical demand, Temporal demand, Frustration level, Effort, and Performance.

In the experimental conditions, the Van der Laan acceptance scale [35] was also included. It has been used and validated in several transport studies such as with a Tutoring and Enforcement system [see citations in 35], Intelligent Cruise Control [see citations in 35] and with a Collision Avoidance System [see citation in 35]. This scale is directed towards evaluation of user-acceptance of the system's ergonomics and includes a set of items related with the FeDS system's perception. Individual item scores run from -2 to + 2, except items 3, 6 and 8 which are reversed compared to the other items. The first subscale contains an assessment in terms of useful, good, effective, assisting and raising alertness, and could be interpreted as denoting the system's usefulness. The second subscale contains an assessment in terms of pleasant, nice, likeable and desirable, and could be interpreted as reflecting satisfaction with the system.

2.2 Research design

A multifactorial repeated measures design was produced. Independent variables were: the FeDS with the traditional accelerator pedal; FeDS with Force Haptic Gas Pedal; and FeDS with Stiffness Haptic Gas Pedal. For each independent variable four events were proposed: speed limit, curve, intersection or roundabout, and preceding vehicle (aka car following). Dependent variables registered in each situation were the participant's cognitive workload and system acceptance.

2.3 Procedure

The experiment lasted approximately one hour in which each participant had to complete five laps in the open road track. Each lap took 10 minutes to complete and included four events within each lap: speed limit, preceding vehicle, curve and intersection. The only instruction given was to drive normally and respecting all traffic rules. The first and the fifth lap were used as baselines and in this case, driving did not include interacting with any FeDS modality but included all the events. The second, third and fourth lap where the experimental conditions including one different feedback modality per lap. Experimental conditions were randomised to avoid the repetition of a previous condition. So all participants tested the three feedback modalities, each one in each lap, but in a different order. NASA-TLX questionnaires were filled out after each experimental condition in order to achieve greater reach higher accuracy with scores. Other questionnaires were filled out on the same day or on following days, at most one week later.

3 Results

3.1 Sample profile

Demographic data revealed that the sample was primarily formed by young but experienced drivers. Participants mainly had experience with route navigation, cruise control and reverse parking aid. Other participants also had experience with other recently-developed systems such as speed limit change and fuel efficiency advisor, and which are especially related to the FeDS tested in the present study. Lastly, a few participants had experience with other brand-new technology, and although they represent one out of four participants, this suggests that the sample drivers in the present study are up-to-date with in-vehicle technology. Based on the Technology readiness scale, participants were really familiar with the latest technology as they knew quite well how technology can be misused nowadays. Finally, regarding the Attitudes towards green behaviours scale, participants strongly agreed that they had a good knowledge of environmentally-friendly behaviour and that they were interested in saving as much energy as possible while driving. In contrast, they did not think that eco-driving was currently a common practice with drivers; perhaps participants thought that environmentally-friendly behaviour is not often ingrained in most drivers' minds.

3.2 NASA-TLX

In this case data failed to meet the normality assumption, so a non-parametric test for multiple related samples was performed to investigate differences between NASA-TLX scores within baseline 1, FeDS condition, FeDS + FHGP condition, FeDS + SHGP condition, and baseline 2. The rating data were analysed using Friedman's and Wilcoxon tests were used for the post hoc tests of means.

NASA-TLX total score was low in all conditions, as the maximum median score was 15.7 out of a total of 60. Median total workload scores were analysed for each condition separately. Experimental conditions reported the highest workload values, especially those with HGPs (FHGP Md = 15.7; SHGP Md = 15.4). FeDS median workload values (Md = 14.9) were similar to those observed in Baseline 1 (Md = 13.9). Baseline 2 reached the lowest total workload values (Md = 11.05). The results of the related samples Friedman's ANOVA evidenced the existence of statistically significant differences between the workload medians of HGP conditions and the Baseline 2 [F (4) = 10.708; p = .003)]. Wilcoxon tests were used to follow up this finding. Results of the test evidence that both Haptic Gas Pedals supposed an increase in driving workload for our participants compared to Baseline 2 driving: FeDS + FHGP condition compared to Baseline 2 (T = 15.000; r = -.512), and FeDS + SHGP condition compared to Baseline 2 (T = 94.000; r = .406).

3.3 Acceptance Scale

The Acceptance scale data was analysed using its two subscales as acceptance indicators. As previously mentioned, data failed to meet normality assumptions so the non-parametric tests for related samples were performed.

For the Usefulness subscale, descriptive statistics suggest that FeDS was useful in its all modalities, but especially those combined with HGP, as the medians were rated positively (FeDS Md = .6; FeDS + FHGP Md= .8; FeDS + SHGP = .7). However, the Friedman's ANOVA test revealed no statistically significant differences between experimental conditions. On the other hand, Satisfaction subscale descriptive statistics suggest that FeDS was less satisfying when combined with both HGP. Median for FeDS was Md = .5, meanwhile for FeDS + FHGP was Md = -.125; and for FeDS + SHGP was Md = .0. These differences were found to be statistically significant using the Related Sample Friedman's ANOVA [F (2) = 8.186; p = 0.017]. Wilcoxon tests used following up this results evidenced this finding: FeDS compared to FeDS + FHGP (T = 51.5; r = -.438); and FeDS compared to FeDS + SHGP (T = 25.5; r = -.456).

3.4 Other self-reported questionnaires

The questionnaire set also included various items asking participants to assess the system modalities in terms of effectiveness, usefulness, satisfaction and affordability.

Inspection of Effectiveness median values showed an increase in scores from FeDS (Md = 3), when combined with FHGP (Md = 4) and SHGP (Md = 4). Usefulness median values showed a decrease in scores from FeDS (Md = 4) to FHGP (Md = 3), and a further increase in SHGP (Md = 4). Satisfaction median values showed equal scores in all conditions (Md = 3). Affordability scores were also similar, equal in FeDS (Md = 2) and FHGP conditions (Md = 2); but increased in SHGP (Md = 2.5). However, no significant differences were found among these variables.

3.5 Free text responses

Participants also filled in some free text gaps with their opinions concerning the effectiveness, usefulness and satisfaction of the several Full ecoDriver System modalities tested in trials. In an attempt to organise these expressions, we have classified them in frequencies. For instance, the frequency of expressions referring what is more effective and what is less effective.

First, regarding systems' *Effectiveness*, (Figure 2) participants suggested that FeDS in all modalities was especially effective for speed management when noticing speed limit changes while driving. HGP do not seem to increase the effectiveness of this feature. Where HGP does stand out as being more effective is when for maintaining the safety distance with a preceding vehicle. Furthermore, surprisingly, participants thought that HGP do not increase the FeDS' energy-saving effectiveness. Lastly, Stiffness Haptic Gas Pedal seems to be more effective as an early warning system than Force Haptic Gas Pedal.

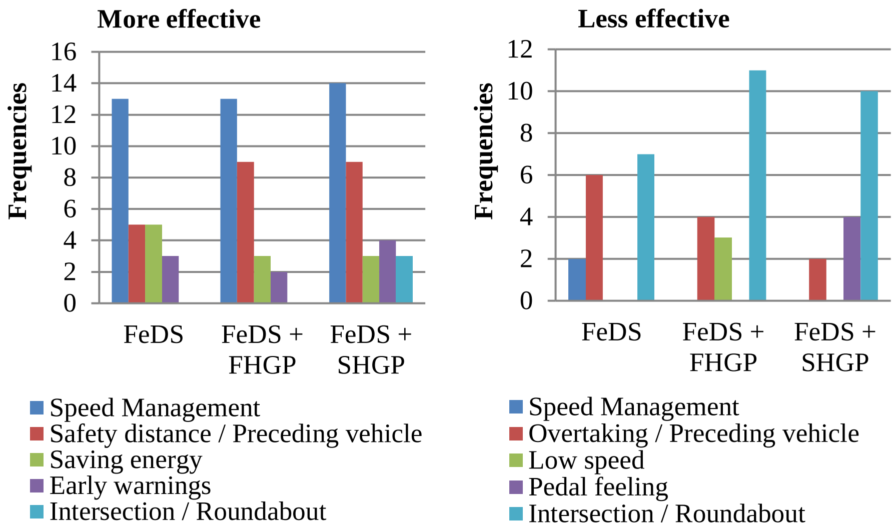

Fig. 2. Compared *Effectiveness* frequencies.

Participants' reports related to less effective FeDS tested modalities are also depicted in Figure 2. As the reader may see, all modalities, and especially with both HGP, are seen as less effective in intersections and roundabouts. Participants reported that the system is not effective when following vehicles at low speeds and it may difficult overtaking manoeuvres when the HGP turns on. They also reported that the feel of the SHGP is not as intuitive as the FHGP, although its early warnings were rated as being more effective. The reason may be, as participants declare, because SHGP only "warns to", meanwhile FHGP "orders to".

Secondly, results concerning participants *Usefulness* reports are presented in Figure 3. In this case, speed management is rated as the most useful feature in FeDS, and especially with both HGP. FHGP seems to be more useful in maintaining safety distance with a preceding vehicle. Moreover, participants also reported that all FeDS modalities were primarily useful in motorway driving and during long journeys. Another relevant issue is that participants declared that visual feedback was necessary and very useful for understanding the functioning of FeDS with FHGP. This suggests that when drivers are not used to haptic feedback, they need another kind of feedback more familiar to them (visual) in order to guide and support their eco-driving learning. In this case, FeDS without HGP seems to be seen as more useful when it comes to saving energy

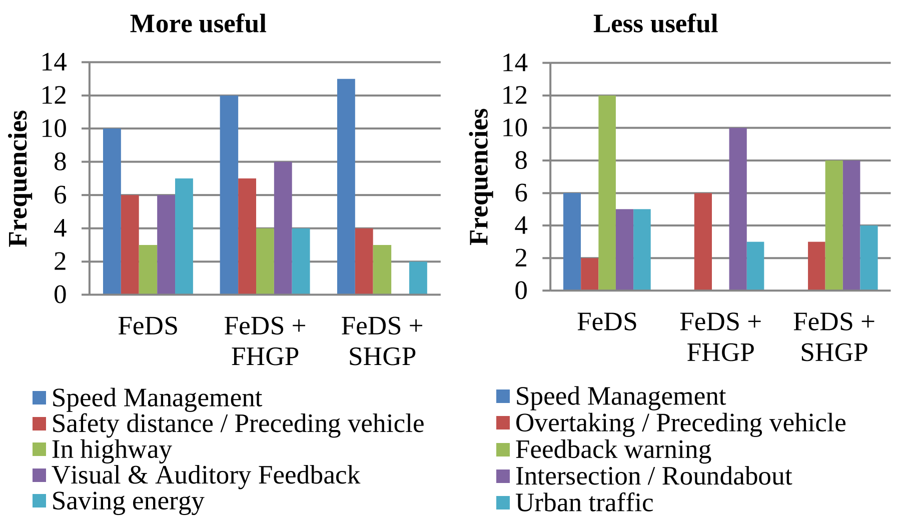

Fig. 3. Compared *Usefulness* frequencies.

On the other hand, "Less useful" ratings suggest that participants thought that FeDS with HGP modalities was less useful at intersections and roundabouts. FHGP seem to be the least useful in this scenario and also for overtaking when following other vehicles. This, together with ratings of urban traffic, suggests that FeDS modalities are not useful in urban driving for these purposes. Moreover, participants also complained that FeDS visual feedback warnings (e.g. curve warnings and behavioural feedback) were not at all accurate, and sometimes confusing. Furthermore, they also suggested that a HUD or an integrated display would be a better solution for presenting this visual information without taking their attention from the roadway. In addition, they reported that the HGP response was too early in some cases and that it should be configurable. They also reported that HGP sensation was less informative than a standard pedal, and it lacked real perceptible information.

Satisfaction reports (Figure 4) were in line with those previously mentioned, as FeDS was primarily more satisfactory for speed management on a dual carriageway. HGP, and in particular FHGP modality, was especially satisfactory for this purpose, followed by maintaining safety distance with preceding vehicle, where SHGP was rated as the most satisfactory modality. Furthermore, as in previous *Effectiveness* reports, HGPs were not perceived to be as satisfactory as FeDS for saving energy. Regarding feedback warnings, FeDS visual warning was stated to be very precise and clear, visually friendly, easy to learn and not intrusive. Moreover, FHGP feedback was more intuitive than SHGP feedback.

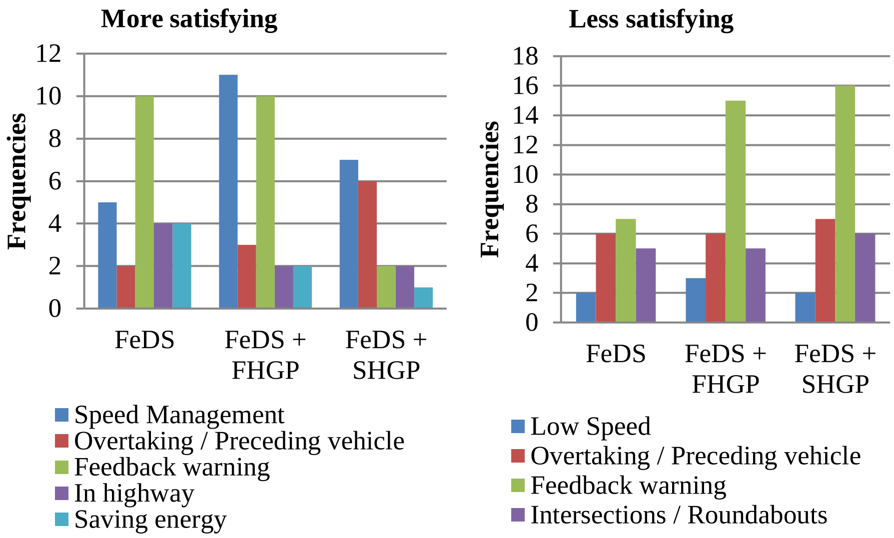

Fig. 4. Compared *Satisfaction* frequencies.

Lastly, FeDS and HGPs were unsatisfactory in both inter-urban traffic and low speed driving, at intersections and roundabout, and in particular, when accelerating to the dual carriageway with preceding vehicles. In this situation the HGP turns on abruptly and unnecessarily, making the manoeuvre disturbing. Thus, participants suggested that both HGP feedback warnings should be revised to improve their haptic feel and their operation. They also suggested that FeDS visual feedback should be more intuitive and clear, offering alternative driving strategies.

4 Discussion

The objective of this study was to assess participants' perceptions and self-reported assessments in terms of cognitive workload and acceptance of the Full ecoDriving System modalities tested. NASA-TLX as a workload measure and Acceptance Scale were the main measurement tools. However, in order to gather the most information possible, questionnaires also included a set of items regarding users' Technology readiness and Attitudes towards green behaviours scale; and the system's effectiveness, usefulness, satisfaction and affordability and free text gaps.

Results evidenced that, as hypothesised, no workload differences were observed between feedback modalities, suggesting that HGPs do not increase drivers' workload when combined with a visual feedback system. Despite this, HGPs differences were observed in comparison to a Baseline 2, the increase experienced is minor (+ 7.75% for FHGP, and + 7.25% for SHGP), as the highest workload values were low (Md = 15.7 out of 60) and this increase should not suppose a driving impairment in any condition. In fact, this workload increase when driving with the HGP might be considered as a positive outcome, as it might suggest that HGP made drivers being more cognitively activated when driving, making them more aware of their environment. In other words, the little increase in workload might suggest that drivers raised their cognitive resources towards the event faced when the HGP was activated. This reasoning can be argued considering the Usefulness subscale results of the Acceptance Scale, as participants considered that FeDS, both pedals included, were Useful in their purpose across the events. Moreover, ratings of self-reported Effectiveness also reported higher values for both HGP. This trend was also observed in free text responses as participants highlighted the Effectiveness of both HGP, especially for keeping a safety distance with the preceding vehicle, which is in accordance with the findings of [24]; and its Usefulness for speed management, as found by [25].

However, unexpectedly, statistically significant differences were not observed in the Satisfaction subscale of the Acceptance scale scores when the HGPs were combined with the visual feedback. However, driving with either of the HGPs was rated as being less satisfying than driving only with visual feedback. These results might found an explanation taking into account the participants' expressions in free-text responses. They reported that both HGPs were less satisfying because the pedals turned on/off abruptly and unnecessarily, making the overtaking manoeuvre disturbing. This was especially reported in urban traffic and low speed driving conditions. Furthermore, the lower satisfaction rates for both HGP might be linked to a lack of predictability as to when the pedal would trigger. Indeed, participants manifested in free-text responses the need of guidance and support to understand the functioning of FeDS with HGP. This issues may help explain the results observed in terms of Affordability, as participants manifested they would not want to pay for installing the HGP in their own vehicles. However, they also claimed that if the system was improved in certain aspects, they would be happy to have it in their car. Similar results were found by [36], where participants would not accept paying for ecodriving features but they would pay for safety features. This suggest that further improvement of the system when it turns on/off, and providing haptic feedback only in those events where HGP were reported as being effective, useful and satisfactory such as speed management and keeping safety distance with preceding vehicles.

When taking this results under consideration, it is also important to note that in the present research, haptic feedback was never given alone (as did by [3]), here it was always combined with visual feedback following [12]. This multi-modal combination implies having one main guiding modality –in this case visual- and a second modality –haptic- supporting the former, which has evidenced having its pros and cons. While having such a multi-modal combination could help reduce drivers' visual distraction, having a main visual guidance feedback also give rise to the driver expecting visual cues to understand the haptic pedal behaviour. This considerations should be taken into account for future research and implementation of haptic feedback systems.

5 Conclusion

The present work is part of the first study performed in a real-world driving scenario with the FeDS and its HGPs modalities [29]. We hypothesised that by adding haptic

feedback to help the drivers following the FeDS advices, we could mitigate the drivers' cognitive workload and increase the system acceptance. Therefore, having partially confirmed our initial hypothesis, with a sample that is used to test new in-vehicle technologies, is promising for further work with different sample profiles.
Taking the results into consideration, it was evidenced that the haptic feedback modalities did not increased drivers' workload when combined with visual feedback. However, these results are not in agreement with those found by [1] in the driving simulator studies. They found that visual feedback increased subjective workload, whereas in this study we did not find significant workload differences across feedback modalities. These results suggest that further research is needed to validate its effectiveness before they are integrated in modern vehicles. On the other hand, driving with visual feedback combined with both HGPs was deemed less satisfying than driving with visual feedback alone. As we found in the free text responses, this is probably because the haptic feedback was sometimes cumbersome and unclear, therefore it should be followed by visual guidance increase its acceptance. Maybe the usage of tactical throttle advice using Pop-Up messages as did by [10] would be a proper solution. Additionally, their haptic feel should be improved in many aspects in order to make it less disturbing. On the other hand, FeDS visual feedback would be better if integrated into a different display modality in order to avoid restricting the view of the road, as the nomadic device is sometimes hard to read. Moreover, additional behavioural advice or instructions could be given (by auditory signals for instance) in order to facilitate eco-driving strategies, because sometimes the visual feedback is confusing and drivers do not know what they are doing wrong. The free text responses results suggest that each feedback modality had its particular benefits for different scenarios, as found in previous research by [29]. However, these reports should further be studied in a controlled experiment as they lack for empirical evidence in the present research.
To conclude, this research provides the methodology and the background for assessing the human factors involved in the testing procedure for new in-vehicle technologies and encourages future research in performing Field Operational Tests [37] to test and validate these technology for its safely inclusion in the real world.

References

1. Hibberd, D.L., Jamson, A.H., Jamson, S.L.: The design of an in-vehicle assistance system to support eco-driving. Transp. Res. Part C Emerg. Technol. (2015)
2. Hof, T., Conde, L., Garcia, E., Iviglia, A., Jopson, A., Lai, F., Merat, N., Nyberg, J., Rios, S., Sanchez, D., Schneider, S., Seewald, P., Weerdt, C. Van Der, Wijn, R., Zlocki, A.: D11 . 1 : A state of the art review and users ' expectations. (2013)
3. Jamson, H., Hibberd, D.L., Merat, N.: Interface design considerations for an in-vehicle eco-driving assistance system. Transp. Res. Part C Emerg. Technol. (2015). doi:10.1016/j.trc.2014.12.008

4. Jamson, S., Kappe, B., Louw, T.: D42.1 Performance Indicators and acceptance analysis plan. ecoDriver Project. (2014)
5. Seewald, P., Stuiver, A.: D13 . 1 : Evaluation Plan and Scenario Definition. (2014)
6. Birrell, S., Simpkin, B., Scridon, S., Rollenitz, L.: Energy Efficient VEhicles for Road Transport–EE-VERT. (2011)
7. Beloufa, S., Vailleau, B., Boucheix, J.-M., Kemeny, A., Merienne, F.: Eco-Driving with Electric Cars: Effect of Continuous and On-Demand feedback on Driving Behavior and Safety. 5th Int. Conf. Appl. Hum. Factors Ergon. 158–164 (2014)
8. Mensing, F.: Optimal Energy Utilization in Conventional , Electric and Hybrid Vehicles and its Application to Eco Driving. (2013)
9. Franke, T., Arend, M.G., McIlroy, R.C., Stanton, N.A.: Ecodriving in hybrid electric vehicles – Exploring challenges for user-energy interaction. Appl. Ergon. 55, 33–45 (2016). doi:10.1016/j.apergo.2016.01.007
10. Birrell, S. a., Fowkes, M., Jennings, P. a.: Effect of using an in-vehicle smart driving aid on real-world driver performance. IEEE Trans. Intell. Transp. Syst. 15, 1801–1810 (2014). doi:10.1109/TITS.2014.2328357
11. Meschtscherjakov, A., Wilfinger, D., Scherndl, T., Tscheligi, M.: Acceptance of future persuasive in-car interfaces towards a more economic driving behaviour. Proc. 1st Int. Conf. Automot. User Interfaces Interact. Veh. Appl. - AutomotiveUI ’09. 81 (2009). doi:10.1145/1620509.1620526
12. Jamson, S., Hibberd, D.L., Jamson, A.H.: Drivers’ ability to learn eco-driving skills; effects on fuel efficient and safe driving behaviour. Transp. Res. Part C (Emerging Technol. Spec. Issue “Technologies to Support green driving.” 1–21 (2015)
13. Graving, J.S., Rakauskas, M.E.: A Binary Response Method to Determine the Usability of Seven In-Vehicle Fuel Economy Displays. Proc. Hum. Factors Ergon. Soc. Annu. Meet. 54, 1546–1550 (2010)
14. Olsson, S., Burns., P.C.: Measuring Driver Visual Distraction with a Peripheral Detection Task., http://www-nrd.nhtsa.dot.gov/departments/nrd-13/driver- distraction/PDF/6.PDF
15. Östlund, J., Nilsson, L.: Deliverable 2 - HMI and Safety-Related Driver Performance. (2004)
16. Muhrer, E., Vollrath, M.: The effect of visual and cognitive distraction on driver’s anticipation in a simulated car following scenario. Transp. Res. Part F Traffic Psychol. Behav. 14, 555–566 (2011)
17. Summala, H., Lamble, D.: Driving experience and perception of the lead car’s braking when looking at in-car targets. Accid. Anal. Prev. 30, 401–407 (1998)
18. Alm, H., Nilsson, L.: The effects of a mobile telephone task on driver behaviour in a car following situation. Accid. Anal. Prev. 27, 707–715 (1995)
19. Beede, K.E., Kass, S.J.: Engrossed in conversation: The impact of cell phones on simulated driving performance. Accid. Anal. Prev. 38, 415–421 (2006)
20. Consiglio, W., P. Driscoll, et al: Effect of cellular telephone conversations and other potential interference on reaction time in a braking response. Accid.

Anal. Prev. 35, 495–500 (2003)
21. Rakauskas, M.E., Gugerty, L.J.: Effects of naturalistic cell phone conversations on driving performance. J. Safety Res. 35, 453–464 (2004)
22. Ranney, T.A., Harbluk, J.L.: Effects of Voice Technology on Test Track Driving Performance: Implications for Driver Distraction. Hum. Factors J. Hum. Factors Ergon. Soc. 47, 439–454 (2005)
23. Reed, M.P., Green, P.A.: Comparison of driving performance on-road and in a low-cost simulator using a concurrent telephone. Ergonomics. 42, 1015 (1999)
24. de Rosario, H., Louredo, M.: Efficacy and feeling of a vibrotactile Frontal Collision Warning implemented in a haptic pedal. Transp. Res. Part F Traffic Psychol. Behav. 13, 80–91 (2010)
25. Adell, E., Várhelyi, A., Hjälmdahl, M.: Auditory and haptic systems for in-car speed management - A comparative real life study. Transp. Res. Part F Traffic Psychol. Behav. 11, 445–458 (2008). doi:10.1016/j.trf.2008.04.003
26. Birrell, S.A., Young, M.S., Weldon, A.M.: Vibrotactile pedals: Provision of haptic feedback to support economical driving. Ergonomics. 56, 282–292 (2013). doi:10.1080/00140139.2012.760750
27. Spiessl, W., Hussmann, H.: Assessing error recognition in automated driving. IET Intell. Transp. Syst. 5, 103 (2011). doi:10.1049/iet-its.2010.0102
28. Wickens, C.D.: Multiple resources and mental workload. Hum. Factors. 50, 449–455 (2008). doi:10.1518/001872008X288394
29. Perelló, J.R., Gomila, A., García-Quinteiro, E.M., Miranda, M.: Testing New Solutions for Eco-Driving: Haptic Gas Pedals in Electric Vehicles. J. Transp. Technol. 7, 1–25 (2017). doi:10.4236/jtts.2017.71001
30. Hart, S.G., Staveland, L.E.: Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. Adv. Psychol. 52, 139–183 (1988). doi:10.1016/S0166-4115(08)62386-9
31. Harbluk, J.L., Noy, Y.I., Trbovich, P.L., Eizenman, M.: An on-road assessment of cognitive distraction: Impacts on drivers' visual behavior and braking performance. Accid. Anal. Prev. 39, 372–379 (2007). doi:10.1016/j.aap.2006.08.013
32. Horberry, T., Anderson, J., Regan, M. a., Triggs, T.J., Brown, J.: Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. Accid. Anal. Prev. 38, 185–191 (2006). doi:10.1016/j.aap.2005.09.007
33. Strayer, D., Cooper, J., Turrill, J.: Measuring cognitive distraction in the automobile. 52 (2013)
34. Jeon, M., Davison, B.K., Nees, M. a, Wilson, J., Walker, B.N., Street, C.: Enhanced Auditory Menu Cues Improve Dual Task Performance and are Preferred with In-vehicle Technologies. Billboard. 91–98 (2009). doi:10.1145/1620509.1620528
35. Van Der Laan, J.D., Heino, A., De Waard, D.: A simple procedure for the assessment of acceptance of advanced transport telematics. Transp. Res. Part C Emerg. Technol. 5, 1–10 (1997). doi:10.1016/S0968-090X(96)00025-3

36. Birrell, S., Fowkes, M., Stubbs, D.: Evaluation of smart driving advisors: smartphone apps or value added services. Driv. Behav. Train. 451–470 (2012)
37. Festa: FESTA Handbook Version 4 Revised by FOT-NET. (2011)