SESSION 1B :

DRIVERS’ NEED AND ACCEPTANCE FOR ASSISTANCE FUNCTIONS

THE IMPACT OF DIFFERENT PEDAL SOLUTIONS FOR SUPPORTING EFFICIENT DRIVING WITH ELECTRIC VEHICLES

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ABSTRACT:

The functionality of an electric vehicle enables to regenerate energy into the battery by using the electric motors for electric braking. By integrating this electric brake into the accelerator pedal, drivers are expected to use more often the electric brake and less often the hydraulic brake. However, the pedal system of a car is a crucial connection between driver and car. Any modification of this part can lead to decreasing acceptance. A driving simulator study was conducted to investigate the impact of this combined pedal solution (CPS) on acceptance and energy consumption. 24 participants performed test drives in rural and urban environment with both, the CPS and a conventional pedal solution. With the CPS, drivers used less often the hydraulic brake. This behaviour led to less energy consumption. Additionally, using the CPS resulted in higher subjective ratings due to the comfort of managing most traffic situations with only one pedal.

1 INTRODUCTION

One key feature of an electric vehicle is the partitioning between the electric and the hydraulic brake force. This fact makes it possible to combine accelerating and electric braking on the accelerator pedal (combined pedal solution (CPS)). Another more conventional solution is to implement the electric brake into the hydraulic brake pedal and thus split up braking completely from the accelerator (split pedal solution (SPS)). The CPS can be understood as an "augmentation of existing in-car interfaces" [1], because drivers can use it without the necessity of further changes of the pedal system. The idea behind this solution is simple: by integrating the electric brake into the accelerator pedal, drivers can use the regenerative brake force to decelerate the car similar to the drag torque of a conventional combustion engine. As regenerative brake forces can even be higher than the drag torque, drivers are expected to manage most deceleration manoeuvres with regenerative braking. Former research showed that such consequent usage of the regenerative braking has a significant positive impact on the overall energy consumption [2]. Thus, the CPS supports the driver in avoiding energy losses by braking hydraulically. However, the pedal system of a car is a crucial and safety-critical connection between driver and car. Any modification of this part could negatively influence the driving performance in terms of safety and usability. This paper describes a study that determined the impact of the CPS in comparison to the SPS on both the driver's acceptance and the energy consumption. In addition, frequency and duration of hydraulic brake pedal usage were recorded and examined.

2 METHOD

2.1 Pedal configurations

Figure 1 illustrates the pedal configurations of the CPS (left) and the SPS (right). The braking pedal of the CPS remains reserved for the hydraulic brake only. The electric brake is set on the first 20 % of the accelerator pedal way; accelerating starts at 30 %. The sailing area (i.e. neither acceleration nor braking) lies between electric braking and acceleration (i.e. between 20-30 % of pedal way). The vehicle brakes with maximum electric brake forces when neither the accelerator pedal nor the brake pedal is pressed.

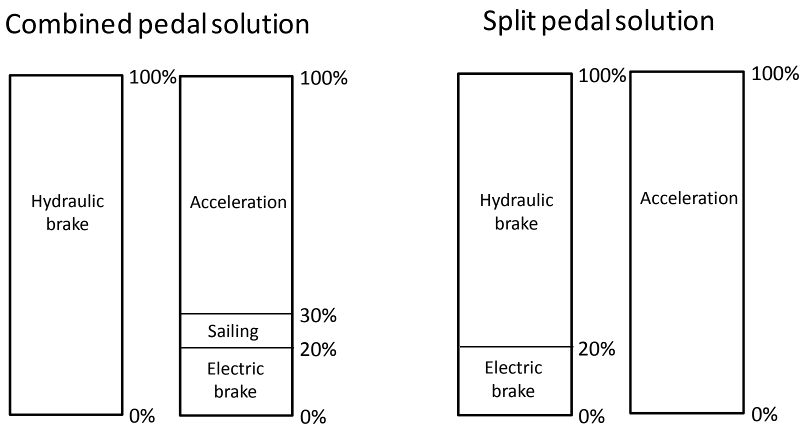

Figure 1. Configuration of brake pressure and accelerator pedal way for CPS (left) and SPS (right)

The SPS integrates the electric brake into the first 20 % of the brake pedal pressure and the hydraulic brake between 80-100 %. The accelerator pedal remains for acceleration only. The vehicle is in the sailing mode when neither the accelerator pedal nor the brake pedal is pressed.

2.2 Driving simulation

The simulator that is used for the study is a driving simulator with motion system based on a Stewart platform with six degrees of freedom (Figure 2).

Figure 2. Driving simulator (left) and an exemplary track section (right)

For the study's purpose, a vehicle and consumption model of a fully electric vehicle was implemented into the simulation including the two different pedal solutions. The maximum regenerative brake force of the vehicle model realises maximum deceleration values of about -1.6 m/s². This is much higher than simply using the drag torque with typical deceleration values for routine driving situations of -0.5 m/s² [3], and also higher than average deceleration values of -1.0 m/s² reported for normal driving in urban environments [4].

A particular instrument cluster was integrated in the vehicle including a power gauge that shows positive values (in kW) when energy is spent while accelerating and negative values if energy is recuperated into the battery while braking electrically. During sailing the gauge shows zero power.

2.3 Test procedure

The test track consists of a rural and an urban area (see Figure 2). It includes different speed sections, variations in slope, and typical traffic situations like passing intersections. The track has a total length of about eight kilometres. The test drivers were told to perform two drives, one with the SPS, the other one with the CPS. Participants were instructed to drive as efficient as possible by keeping to three advices: use the hydraulic brake as little as possible, sail as often as possible and try not to enter the highest "red area" of the power gauge when accelerating (i.e. >40 kW). After the first and the second ride participants were asked two questions answered by means of a 15 point category subdivision scale:

- What do you think, how successful have you been in driving energy efficiently? (not at all – very successful)
- How suitable is the pedal solution for driving energy efficiently? (not at all – very suitable)

At the end of the two drives participants were briefly interviewed. They had the possibility to answer how they liked the two pedal solutions, which pedal solution they would prefer and why.

2.4 Participants

24 Participants were recruited from the WIVW test driver panel. All drivers had been trained for the simulator and had taken part in at least one driving simulator study before. There were 14 men and 10 women. Mean age was 35 (sd=10) years. Mean driving experience was 15 (sd=9) years. Mean kilometres driven per year were 16854 (sd=13700) kilometres.

3 RESULTS

3.1 Pedal usage

The pedal solution clearly influences the way how subjects use the two different braking modes. Driving with the CPS leads to hardly any usage of the hydraulic brake. 10 out of 24 subjects even managed to drive the total route without any hydraulic braking compared to none with SPS. In contrast, driving with the SPS resulted on average in 15.3 times of braking with the hydraulic brake ($t(23)=8.77$; $p<.001$; Figure 3 left). No effect could be found in the mean frequency of the electric braking usage considering the total route ($t(23)=-1.96$; $p<.062$; Figure 3 right). Having a look on the rural and urban area separately, the electric brake is used more frequently in urban areas in the CPS condition compared to the SPS condition ($t(23)=-3.36$; $p=.003$). This is presumably due to more frequent changes between sailing and electric braking during stopping manoeuvres.

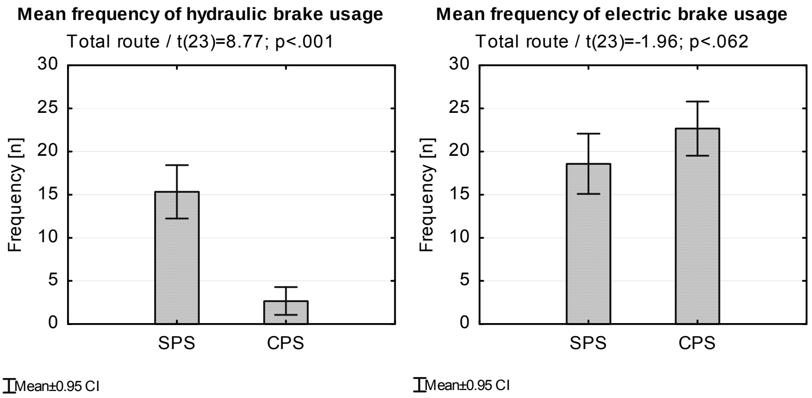

Figure 3. Mean frequency of hydraulic (left) and electric (right) brake usage per pedal solution

The pedal solution additionally affects the percentage of time in which hydraulic and electric brake were used. The share of braking time for both braking modes are larger in SPS condition (hydraulic brake: $t(23)=5.43$; $p<.001$; electric brake: $t(23)=3.39$; $p=.003$) compared to the CPS condition (Figure 4).

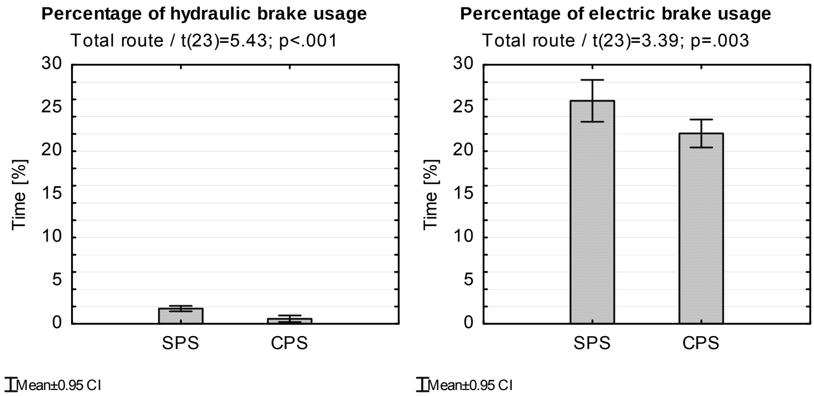

Figure 4. Mean percentage of time in which the hydraulic (left) and electric (right) brake was used

Sailing is most frequent when subjects drive in the SPS condition. This effect becomes significant only for the urban route (t(23)=2.90; p=.008). The fact that sailing is easier to perform in the SPS condition (no pedal has to be operated) is maybe the reason for the different percentage of sailing time.

3.2 Subjective ratings

There was a significant effect of pedal solution on the subjective rating on how efficient drivers were during the drive (t(23)=6.59; p<.001). Driving with the CPS made the drivers believe that they were driving more energy efficiently compared to the SPS condition (Figure 5 left).

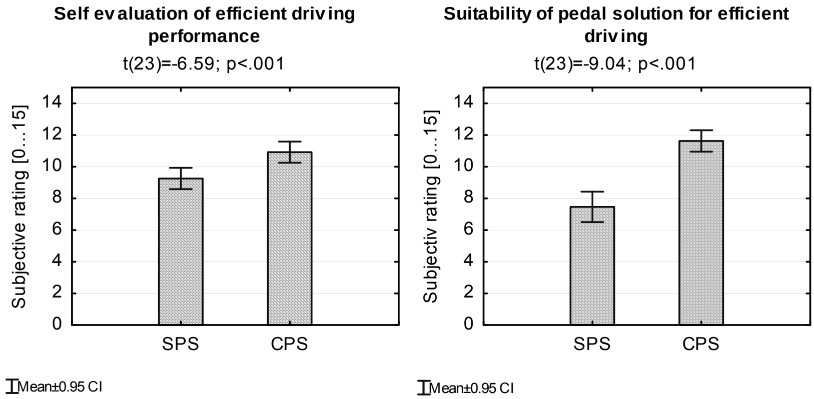

Figure 5. Mean rating of own efficient driving performance (left) and of adequacy of pedal solution for efficient driving (right)

Further, drivers rated the CPS as significantly more usable for driving energy efficiently than the SPS (t(23)=9.04; p<.001, Figure 5 right).

When asking which pedal solution drivers would prefer 23 out of 24 replied CPS. In the majority of cases the reasons were:

- CPS more comfortable, since no usage of brake pedal is needed anymore.
- Easier to regenerate energy, since the power gauge delivers exact information. The SPS lacks a gauge which delivers exact information whether the car brakes electric or hydraulic.

Points of criticism of the CPS were:

- Whilst driving with the SPS the area of sailing was much easier to find (i.e. neither stepping on the brake nor on the accelerator pedal)
- When driving with the CPS many glances to the gauge are needed in order to obtain information whether the car is sailing, accelerating, or regenerating energy.

3.3 Consumption measures

The subjective ratings were confirmed by the actual energy consumption. Considering mean energy consumption, analysis revealed a significant effect of pedal solution ($t(23)=6.84$; $p<.001$). Using the CPS results in about six per cent less energy consumption compared to the SPS as depicted in Figure 6. A significant effect of pedal solution can be found in the rural as well as in the urban section.

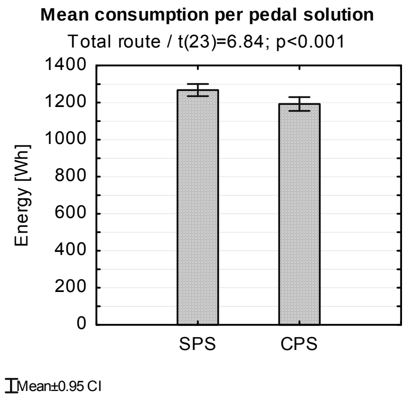

Figure 6. Mean consumption (in sum) per pedal solution (total route)

This effect of the pedal solution on the overall consumption is a consequence of significant more recuperation in the CPS condition ($t(23)=7.34$; $p<.001$). In average, more than 100 Wh more are recuperated during the CPS mode (Figure 7 right). This exceeds clearly the difference in the retrieved energy from the battery that is slightly higher in CPS condition (Figure 7 left).

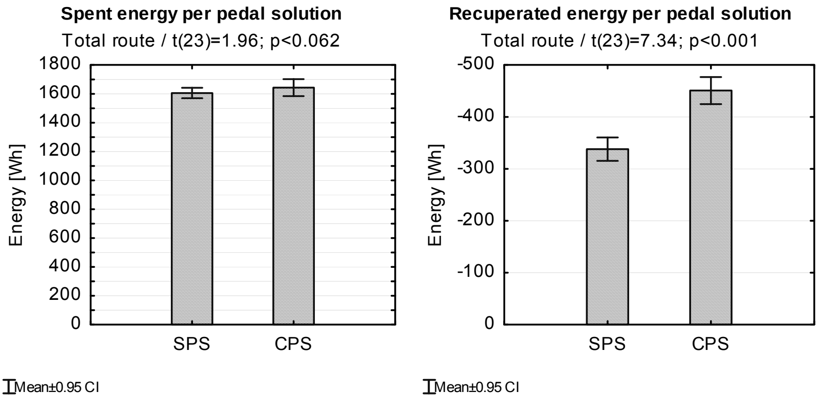

Figure 7. Retrieved (left) and recuperated (right) energy (in sum) per pedal solution (total route)

4 DISCUSSION

The study compared the SPS with the CPS to obtain knowledge about acceptance, vehicle dynamics and consumption issues. Drivers clearly prefer the CPS over the SPS. Furthermore, drivers assume to drive more efficiently when using the CPS compared to the SPS. This confirms the impression that participants felt confident with the combined pedal solution and would even like to use the system frequently. Similar results were found in the UC Davis MINI E Consumer Study [5].

The CPS also changed drivers' behaviour. By using the hydraulic brake less often, less energy was needed. Accordingly, CPS led to a more efficient driving behaviour compared to the SPS. However, while using CPS drivers complained about the need to look quite often at the power gauge in order to know whether the vehicle is accelerating, decelerating or sailing. As an alternative feedback channel, an active accelerator pedal could be a supporting feature providing continuous feedback about the current pedal position.

Additional research should address the impact of the changed driving behaviour on surrounding traffic (e.g. following vehicles). Another issue to be investigated are long term effects of using the CPS as it has to be guaranteed that the driver could still use the hydraulic brake quickly and safely in non-routine (i.e. safety-critical) situations.

5 ACKNOWLEDGMENT

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FINNISH DRIVERS AND THE USE OF IN-VEHICLE TECHNOLOGIES –

Comparison of the results of the focus group study and the internet survey

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ABSTRACT

This article focuses on three widely used in-vehicle technologies (IVT) - cruise control, navigation system and mobile phone - among Finnish car-drivers. The results of a focus group study carried out in 2009 are analyzed together with the results of a standardized internet survey carried out in 2010. The findings of these studies are presented together to create a profound picture of the patterns of use of the systems. The results indicate that these systems are considered useful but drivers also know that over-reliance on them can be dangerous.

1. BACKGROUND

This article compares the main findings of two studies [1], [2] - an internet survey and focus group discussions - and presents the main advantages of these research methods. It describes how different research methods can be used together to create a detailed and representative picture of the usage, the context of use, the benefits and indications of potential risks of using the systems.

The main objective was to obtain self-reported data from driver interaction with in-vehicle technologies in real driving context with both qualitative and quantitative approach. The focus group discussions were carried out simultaneously in 6 countries and the survey in 9 countries. The article presents the results for one country: Finland.

2. RESEARCH METHODS AND RESPONDENTS

The aim of the focus group discussions was to gather descriptive data about how and in which context drivers use in-vehicle technologies and what are their opinions about the systems. The focus group discussions also provided input for the content of the internet survey, which was designed to test the selected findings of the focus groups with a more representative sample of the driver population. The driving experience of the focus group participants varied from a couple of years to over 10 years, and all had been using the selected IVT for at least one year. The respondents for the internet survey were drawn from national panels. The characteristics of the participants and the main topics of the studies are presented in Table 1.

Table 1. Participants and main topics of the studies

	internet survey		focus group discussions
N	837		24 (five discussion groups)
Age	< 26 (years)	24%	< 24 years, N=7
	26-45	59%	35-55 years, N=17
	46-65	16%	
	>65	1%	
Gender	male	59%	male, N=17
	female	41%	female, N=7
Driving experience	< 5 000 (km/year)	18%	1-5 years of driving, N=7
	5 000 - 10 000	18%	>10 years of driving, N=11
	10 000 - 20 000	32%	> 10 years of driving, > 30 000 km/year, N=6
	20 000 - 30 000	16%	
	> 30 000	16%	
	< 2 years	6%	
	2-10 years	30%	
	> 10 years	64%	
Examples of topics	*How often do you use the system?*		*Situations to use the system*
	What are the main benefits?		*Non-use or avoiding the use*
	What is the usefulness of the system in different situations?		*Advantages / disadvantages*
	How much do you use the system?		*How did you learn to use the system?*
	What are your opinions about the system?		*Selection of speed*

3. RESULTS

3.1. Usage of the systems

The results presented in this paper are based in the findings of two previous studies [1], [2]. In the following chapters, tables and figures are used to present the results from the quantitative data, and examples of the qualitative data are highlighted with transcripted parts of the focus group discussions. Table 2 sums up the main characteristics of the user population and some system-specific findings from to the survey.

Table 2. Characteristics of the Finnish users of cruise control, navigation system and mobile phone in the internet survey

	Cruise control	**Navigation system**	**Mobile phone** (while driving)
Users of the systems (% of total, N=837)	- 55	- 85	- 83
Frequency of use (%)			
- frequently	- 29	- 4	- 23
- regularly	- 42	- 26	- 32
- occasionally	- 26	- 53	- 29
- rarely	- 3	- 17	- 15
Average time of use	4.9 years	2.7 years	
Other findings	Selection of speed - **above limit: 55%** - according to limit: 40% - below limit: 5% *) 50%: < 5 km/h, 40%: 5-10 km/h	Type of device - in-built system: 8% - navigation device: 72% - navigation function in mobile phone: 20%	Use of hands free device - all calls: 21% - > half: 25% - half: 9% - < half: 31% - none: 14%

55% of the respondents in the survey reported that they used all three systems. Nine focus group participants of the total of 24 were active users of all three systems. The focus group results indicated that the drivers had chosen their own strategies to utilize the functionalities of the systems together:

> *"I use the navigation system to check the speed limit. Then I switch the cruise control on and select the speed a little bit above the limit." (Man, 23)*
>
> *"The navigation system warns about the speed monitoring cameras, so I can adjust the speed with the cruise control." (Woman, 43)*
>
> *"I switch the cruise control on if I need to concentrate on a phone call." (Woman, 40)*

3.1.1. Cruise control

In the survey, the frequent users of cruise control were typically older and had more driving experience than average drivers. Cruise control is an in-built system and young drivers may have older cars than the experienced drivers. There may also have been variation in how the respondents reported 'average' use: whether this was an estimate of total use rate or only for the trips when the system is used [3]. Based on both studies, it seemed that cruise control is typically used on longer trips when speed limit does not vary frequently. However, automatic gears may enable wider use of the system:

> *"I use cruise control whenever I can, also in cities. My car has automatic gears so I don't have to switch the system off by pressing the clutch pedal." (Man, 47)*
>
> *"I use it mostly when I'm driving long trips, especially on motorways." (Man, 22)*
>
> *"I switch it on if I know that the speed will remain constant for a long time." (Female, 45; Man, 51)*
>
> *"I use it only in fluent traffic conditions." (Man, 23)*
>
> *"I switch it on if I don't have to beware of other road users." (Man, 40)*

A majority of the survey respondents answered that they select a speed that is above the legal limit. Over 50% of those drivers chose speed that was < 5 km/h above the legal limit. Nearly 40% chose speed that was 5-10 km/h above the limit. Also most of the focus group participants stated setting the cruise control speed slightly higher than the legal limit (up to 5 km/h):

> *"I have optimized the settings so that I know exactly how fast I can drive to avoid speed penalties." (Woman, 43)*
>
> *"I always drive peacefully and carefully. I prefer to select the speed below the legal limit." (Man, 40)*

3.1.2. Navigation system

According to the survey, the navigation system was used also in familiar environment: 26% of the drivers used the system on their regular trips and about 60% used it for more than half of the journey. The findings from both studies revealed that the use of the system was very diverse, and the differences can not be explained simply by age or driving experience.

Some of the young drivers in the focus groups thought very critically about the system and prefer to develop their own orientation skills, but others put it on every time they drive. Participants in all age and experience groups admitted that the continuous use of navigation system weakens drivers' orientation skills and creates over-trust on the system:

> *"It is very useful especially if I am driving alone, I don't have to stop at bus-stop to watch the map." (Woman, 23)*
>
> *"It is a very good device also for motorcyclists because you can plan a route where gravel roads or motorways are avoided." (Man, 22)*
>
> *"I don't plan the routes by myself anymore, I trust in the guidance given by the system." (Man, 23)*
>
> *"I feel helpless if I have to drive without the system." (Woman, 23)*
>
> *"Sometimes the instructions given by the system are not quite logical." (Man, 42)*
>
> *"I like to use it all the time because it takes away the stress of orientation." (Man, 20)*

Most of the participants in the survey answered that they enter the destination before starting the engine of the car or just before starting to drive. According to the focus group discussions, sometimes the drivers get instructions when they are already driving, so they have to type the address while driving. Participants of both studies said they use all modes of information quite equally: maps, arrows, speed and voice information were the best combination. Distance to next turn and time to destination were also found useful.

> *"I like the system very much, it is multifunctional: guidance, speed limit information, warns about traffic jams and accidents etc." (Man, 38)*

3.1.3. Mobile phone

Finnish drivers were using mobile phone very often while driving. Over 50% of the phone users in the survey reported regular use (at least once a week). Majority of the drivers had a hands free device, but they don't use it for all the phone calls, although the use of hand-held mobile phones while driving is forbidden in Finland.

The focus group participants reported that the mobile phone is usually placed in the dashboard, in the middle console of the car or on the bench where it is easily available. Those drivers who don't use hands free device admitted that they often have the phone in their pocket or bag, and they might search for the phone with one hand:

> *"I answer if someone calls me, but I make a phone call only if it is something very urgent." (Man, 21)*

> *"I have the hands free device on all the time when I am driving." (Man, 38)*

In the survey, the respondents were asked to choose whether they would favour or avoid using a mobile phone in different situations. Most drivers stated that they avoided the use when they were changing lane, overtaking or merging; turning, passing an intersection or driving in unfamiliar environment. The usage was also avoided in areas with roadworks or special warnings; in bad weather or heavy traffic conditions; when there are speed checks on the roads; when they have passengers in the car; when they feel tired or if they are driving on city roads.

According to the focus group discussions, young drivers most often make only short phone calls e.g. to get route instructions, but some experienced drivers make also long business and private calls. The use was told to be avoided in city centres, especially if they are unfamiliar or if the traffic is heavy. Most participants reported to avoid using mobile phone when it is dark, when the weather conditions are bad, or if there is a risk having for e.g. deers on the road. Mobile phone use is also avoided in intersections, parking areas, traffic jams, and if there are passengers in the car. The results of the focus group discussions reflected the consideration and assessment of the context by the drivers: whether to answer or make a phone call or not:

> *"It depends on the caller – sometimes I answer, sometimes not." (Woman, 23)*

> *"Usually I don't answer because the phone is in my bag. I wait until I am stopped in traffic lights and then I might call back if the traffic situation is peaceful." (Woman, 36)*

"The passenger can also answer my mobile phone but of course it depends on the caller." (Man, 42)

3.2. Benefits and usefulness of the systems

3.2.1. Cruise control

In both studies, cruise control was considered a system that mostly improves the comfort of driving and it is used to control speed and to avoid speeding and fines. It was most useful in long trips, especially on motorways and mainroads. According to the survey, in average, the usefulness of cruise control (calculated on scale '0...5') was 3,0.

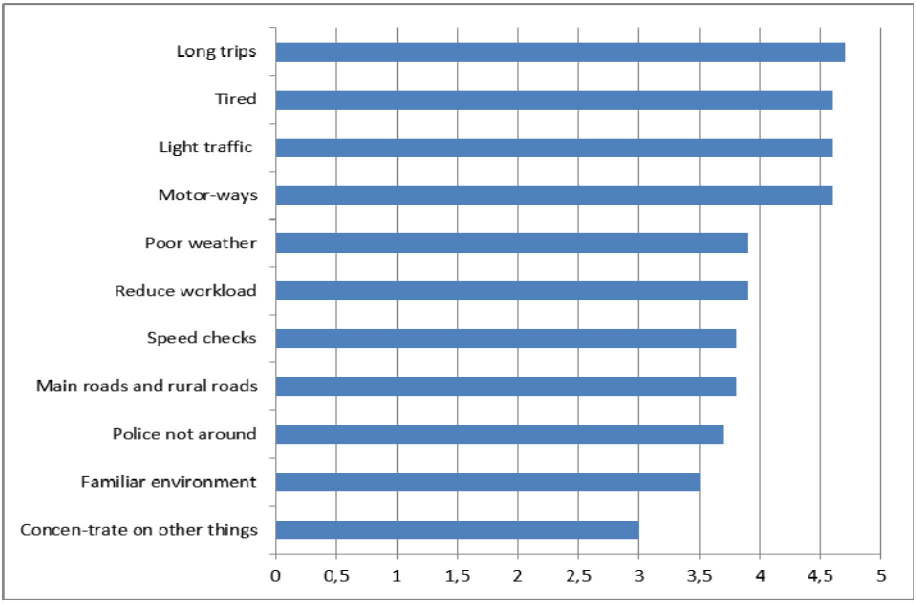

Figure 1. The driving contexts where cruise control is most useful

Also the focus group participants found the system most useful for increasing comfort and safety of the driver and passengers in long trips:

"Using the system makes the long distance driving more comfortable." (Woman, 40)

"I have noticed that I concentrate more on the driving context if I am using the system." (Man, 40)

"Cruise control takes away the stress of watching the speed all the time." (Man, 22)

"The driving position is more relaxed." (Woman, 40)

"It is more comfortable also for the passengers." (Man, 47)

3.2.2. Navigation system

According to the survey, the navigation system was most useful when the driver was lost, driving on unfamiliar roads and driving at night. Long trips and city roads were typical contexts for using the navigation. According to the responses in the survey, in average, the usefulness of navigation system (calculated on the scale '0-5') was 3,4, somewhat more than for cruise control.

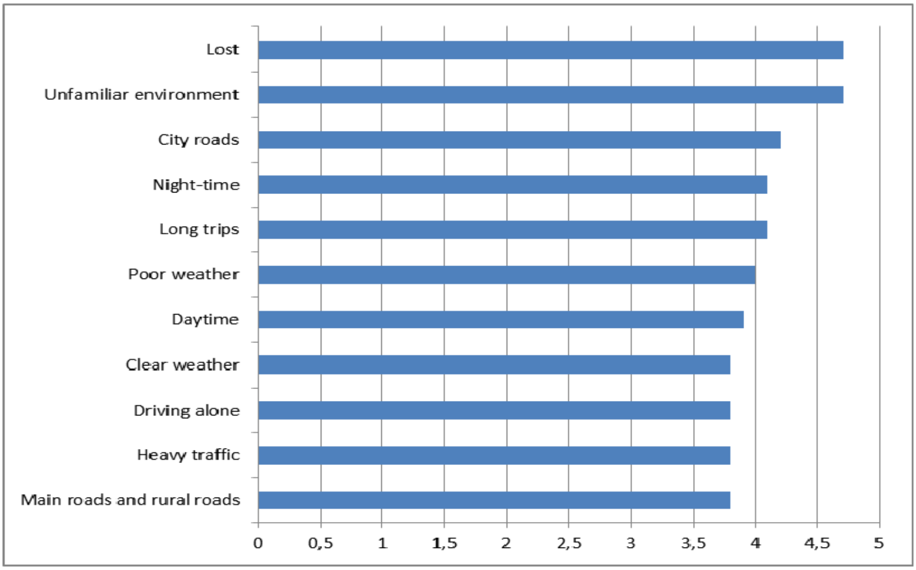

Figure 2. The driving contexts where navigation is most useful

The participants in the focus groups had been using the navigation system both for familiar and unfamiliar routes, and found it easier to concentrate on driving when the navigation system helps them in navigation task:

> *"Using the navigation system gives more flexibility to the driving, especially if I have to drive to new destinations." (Man, 40)*

> *"I use it always to check the route to unfamiliar destinations, but also to find out whether my everyday routes could be changed to faster and better ones." (Man, 42)*

3.2.3. Mobile phone

The usefulness of mobile phone while driving was not asked in the questionnaire, but it was discussed in the focus groups. The need for route instructions and informing about being late were the most common situations to use mobile phone while driving. The possibility to phone while driving gives flexibility to schedules and managing different tasks. Some participants make regularly business related phone calls and also use the mobile phone to check work-related e-mails while driving. Making emergency calls was considered the most important advantage of phoning while driving. Some young drivers mentioned that talking on the phone with someone helps the driver to stay awake while driving.

> *"I often phone while driving if I have to inform about changes in my schedule." (Woman, 40)*

> *"I use driving time efficiently for doing some of my work tasks: read email by mobile phone, make business-related phone calls, check things in the calendar of my mobile phone." (Man, 39)*

4. CONCLUSIONS

The focus group study revealed that the usage of cruise control makes it easier for the driver to carry out secondary tasks while driving because the system removes part of the driver's stress and the workload connected with maintaining the constant speed. The users of navigation system also reported that the system reduces the workload of the driver. The use of the system gives flexibility to driving and orientation, helps when driving to new destinations, and facilitates driving in traffic jams and city centres.

However, the drivers consider over-reliance on the cruise control or navigation system as a disadvantage. Situations where the driver brakes late might occur when cruise control is used or the operating of navigation system buttons disturbs the driving task. Manipulating the device during driving can lead to dangerous situations and the audio-visual information can also increase the driver's workload. Also the use of mobile phone while driving makes the steering manoeuvres, changing lane or changing gears more difficult and can lead to dangerous situations.

Based on these two studies, the drivers perceive in-vehicle technologies to be quite useful. They referred motorways as the type of road where the cruise control is most often activated. Other driving situations, e.g. night-time driving, long trips and familiar environment were also referred as adequate to use the system. Both navigation system and cruise control were given positive ratings in usefulness, and mobile phone was thought to be useful in some special occasions, e.g. in reporting a delay in arrival or changing plans or route during driving.

Drivers admit that the use of the systems can create distraction and they have also experienced it while using the system. Over-reliance on the systems is considered dangerous, and the usage of navigation system and mobile phone can increase the workload of the driver. Most drivers do not engage in secondary tasks when the driving situation is stressing, but there are drivers who make even long business-related phone calls while driving.

The findings of these studies indicate that certain users may have problems understanding the functions of the systems and may consider them to cause driver distraction. The usage of all systems was quite common also among the oldest drivers, which may be a topic for special concern in the future. The driver population is ageing at the same time when in-vehicle technologies become standard accessories. Therefore it is important to design the systems and introduce them to the drivers in a way that covers different user groups as well as contexts of use.

The use of two research approaches provided a versatile and representative combination of self-reported data. These results can be used for further development of systems as well as for providing instructions for the drivers that use these systems.

5. ACKNOWLEDGMENTS

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FACTORS AFFECTING WILLINGNESS TO ENGAGE WITH MOBILE PHONE FUNCTIONS WHILE DRIVING

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ABSTRACT: Drivers normally elect whether or not to engage with a secondary task whilst driving. This study aimed to find whether drivers’ willingness to engage with their mobile phone was affected by demands from the roadway environment. Furthermore if the effects of this were more pronounced for some phone functionalities compared to others. Fifteen video clips were played to twenty participants representing different road scenarios, and therefore demands, such as driving on an empty auto route compared to turning right on a main arterial road. The participants then used three point Likert scales to rate their willingness to place or answer a call and send or read a text. It was found that willingness to engage was affected by both the perceived roadway demands and the phone functionality intended to be used.

1. LITERATURE

Fuller [1] suggested that drivers try to maintain an acceptable level of task demand. He proposed the *task capability interface* (TCI) suggesting driver behaviour is affected by the interaction between task difficulty and the driver’s capabilities which combined lead to the level of task demand. Few studies have investigated the factors affecting drivers’ decisions on when to engage with their mobile phones and whether such behaviour is consistent with particular driver behaviour models.

As Lerner [2] highlighted *‘the actual risk associated with some device will be a joint function of how the use of that device interferes with driving and the circumstances under which drivers are willing to use it’.*

There has been some investigation into whether drivers delay their interactions with devices based on the current road environment and road demands. There is evidence to suggest that these factors have little impact on the timing of interactions, often leading to driver error, see Horrey and Lesch [3] and Lerner [2] for further details.

Studies finding conflicting evidence also exist. For example Horrey and Lesch [4] found that as rated demand of traffic scenarios increased participants’ willingness to engage decreased, suggesting the driving environment can have an effect on when and if drivers’ interact with non-driving tasks. Esbjörnsson et al [5] reported similar findings in an on road observation study as did Laurier [6] when looking at the timings of engagement with office work whilst driving.

Fastenmeier [7] as cited in Patten [8] (page 39) devised a way of classifying road demand based on the complexity of the road environment. A scenario was classified as high demand if both the vehicle handling and information processing resources were challenged (termed high/high). A scenario was classified as medium demand if the information processing resources were challenged but the vehicle handling ones were not (high/low) or, conversely, the information resources were presented with little challenge but a great deal of car control was required (low/high). Finally a scenario was deemed low demand if neither the information processing nor car handling resources were particularly challenged (low/low). This gives a relatively objective way to classify road demand experienced at any time by looking at the demands placed on the drivers' resources.

This study aimed to find whether or not drivers' willingness to engage with their phone was affected by the roadway environment. Furthermore, to the authors' knowledge, no studies have considered the extent to which the phone functionality intended to be used, e.g. placing a call compared to sending a text message, can affect willingness to engage. Therefore, this was also investigated in the current study.

2. METHOD

In a methodology similar to that of Horrey and Lesch [4] 20 participants (range: 23-47 years, mean: 32) all of whom had full UK driver's licenses and who, in a pre study questionnaire, reported using their phone at least occasionally whilst driving were recruited. They were shown (in a randomly selected order) 15 pre recorded video clips (each 8 seconds long) depicting different road scenarios, 5 were auto route based, 6 were main arterial road based and 4 were city driving environment based. Using Fastenmeier's [7] classifications (detailed above) the author subjectively rated the video clips based on the demand the road environment was perceived to place on the drivers' information processing and vehicle handling capabilities. This determined which of the 3 road demand classifications (high, mid or low demand) the clips fell under, resulting in there being 5 road scenarios in each demand classification (see table 1). Each video clip played for 5 seconds before a recorded voice said 'now'. At this point participants decided whether they would use their phone based on the road conditions experienced at that exact point in time. They gave their ratings using 3 point Likert scales, deciding whether they would be willing to place a call, answer a call, send a text or read a text as well as rating on a 5 point Likert scale how demanding they perceived the road environment to be. It was made clear that the participants were to imagine that it was an important phone call or text that they were making or receiving. Whilst making these decisions participants were also asked to think aloud and talk through any factors influencing their phone use decision; these thoughts were recorded on a dictaphone to allow further insight into the factors affecting phone interaction whilst driving to be obtained.

Table 1: Showing the road scenarios in each road demand classification and the mean perceived road demand as rated by participants on a 1-5 scale

High Demand	Mid Demand	Low Demand
Auto route coming on	Auto route medium traffic	Auto route empty
Leaving auto route	Main arterial stopped at roundabout	Main arterial fast flowing traffic
Auto route overtake	Main arterial left turn	Main arterial through green light
Main arterial road going around a roundabout	City environment slow moving traffic	Main arterial stationary red light
City environment turn right	City environment approaching stationary traffic	City environment fast flowing traffic
Participants' road demand rating: 4	Participants' road demand rating: 3	Participants' road demand rating: 2

A week later participants repeated the experiment, watching the same video clips (again in a random order) and using the same rating scales to ensure there was consistency with the answers given, and therefore that the ratings were not simply selected at random.

ANOVAs and post hoc tests were used to test for significant differences. The use of parametric tests being used on non parametric data was justified in a recent paper by Norman [9] and parametric tests were used in a similar study to the one presented in this paper by Lerner and Singer [10].

3. RESULTS

The participants rated (on a 1-5 scale) the demand they perceived for each road scenario. It was found the participants' ratings corresponded with the classifications assigned by the experimenters, as can be seen at the bottom of table 1.

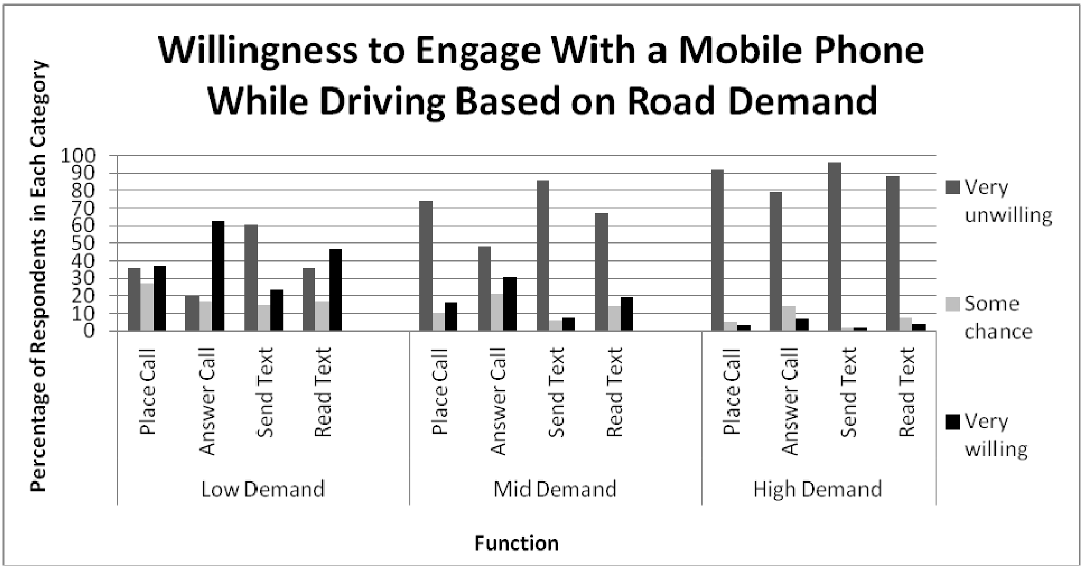

Figure 1: Showing drivers' willingness to use mobile phone functions based on road demand

Only 3 statistically significant differences were found between the first trial and the repeated measures trial one week later so all tests and analyses were run on the first week's data only.

3.1. Influence of Phone Function

As can be seen in Figure 1 the function intended to be used appeared to have an effect on willingness to engage, with sending a text having the lowest willingness rating in all environments and answering a call having the highest willingness rating in all environments. To test if the functions had a statistically significant effect on willingness to engage one way repeated measure ANOVAs were run between each of the functions' willingness to engage rating scores for the low, mid and high demand classifications separately.

It was found there was a significant effect for the type of function used in low road demand classification $F(1.9, 35.6) = 23.183$, $p<.001$, partial $\eta^2 = .55$ with Greenhouse-Geisser correction, showing participants were more likely to engage with some functions than others in a low road demand classification. In order to detect where the differences lay post hoc repeated measures t-tests were run with a Bonferroni correction making a p value of .008 or less required for significance. It was found that statistically significant differences were present between all functions at a $p<.001$ level apart from willingness to place a call and read a text message ($p=.340$) and answer a call and read a text message ($p=.019$) which were both non-significant differences.

It was further found there was also a significant effect for the function used in mid road demand classification $F(2.1, 39.1) = 23.013$, $p<.001$, partial $\eta^2 = .55$

with Greenhouse-Geisser correction, showing participants were more likely to engage with some functions than others in a mid road demand classification. Post hoc paired t-tests showed that statistically significant differences were present between all functions at a $p<.001$ level apart from for placing a call and reading a text message ($p=.090$) where there was no significant difference.

Similarly it was also found there was a significant effect of the type of function used in high road demand classification $F(1.6, 31.6) = 6.773$, $p<.005$, partial $\eta^2 = .26$ with Greenhouse-Geisser correction, showing participants were more likely to engage with some functions than others in a high road demand classification. After running the post hoc t-tests it was found that there was a statistically significant difference ($p<.005$) between placing a call and answering a call only, none of the further differences were found to be significant.

3.2. Influence of Road Demand

As well as testing to see if functionality affected willingness to engage, data on whether or not the road demand had an effect was also collected. As can be seen from Figure 1 the road demand classification also appeared to have an effect with the low demand classification being associated with a higher reported willingness to engage for placing a call, answer a call and reading a text than seen in the other two, higher, demand classifications. To test if these differences were significant one way ANOVAs were run on the willingness ratings for the same functionality between each demand.

For placing a call the roadway demand was found to have a significant effect $F(1.4, 27.3) = 73.142$, $p<.0001$, partial $\eta^2 =.79$ with Greenhouse-Geisser correction, showing the road demand could influence whether or not someone was willing to place a call. Post hoc paired t-tests were run with Bonferroni corrections to see where the differences lay. The Bonferroni correction meant that $p<0.0166$ was needed to be statistically significantly different. It was found that the difference between willingness to place a call in high demand and mid demand, high demand and low demand and mid demand and low demand classifications for placing a call were all significantly different ($p<.0001$).

For answering a call the roadway demand was found to have a significant effect $F(2, 38) = 92.666$, $p<.0001$, partial $\eta^2 =.83$, showing that road demand could influence whether or not someone was willing to answer a call. It was found that the difference between willingness to answer a call in high demand and mid demand, high demand and low demand and mid demand and low demand classifications were all significantly different with Bonferroni correction applied ($p<.0001$).

For sending a text message the roadway demand was found to have a significant effect $F(1.4, 27.4) = 24.305$, $p<.0001$, partial $\eta^2 =.56$ with Greenhouse-Geisser correction, showing the road demand could influence whether or not someone was willing to send a text message. It was found that the difference between willingness to send a text in high demand and low demand, and mid demand and low demand classifications were significantly different with Bonferroni correction applied ($p<.0001$). However, for sending a text in high demand and mid demand classifications the difference was not significant with Bonferroni correction applied ($p=.022$).

For reading a text message the roadway demand was found to have a significant effect $F(1.5, 28.3) = 47.895$, $p<.0001$, partial $\eta^2 =.72$, showing the road demand could influence whether or not someone was willing to read a text message. It was found that the difference between willingness to read a text in high demand and mid demand, high demand and low demand and mid demand and low demand classifications were all significantly different with Bonferroni correction applied ($p<.0001$).

4. DISCUSSION

A great many studies have already outlined the driving performance decrements experienced when using a mobile phone and driving. This paper instead aimed to explore the factors which can affect whether or not someone engages with their phone whilst driving in the first place, such as the functionality intended to be used and the demand of the road environment at the time of possible interaction. The results of the study supported Lerner's [2] findings that drivers' willingness to engage with a task whilst driving varies based on the task to be carried out, in this case whether the driver was required to answer a call, place a call, read a text or send a text. However, this study's results did not support Lerner's [2] further finding that drivers' '*willingness ...was rather insensitive to roadway characteristics*', instead finding higher ratings of willingness to engage for the low road demand classifications and lower willingness to engage for higher road demand classifications. This suggests the roadway did indeed also have an effect on drivers' willingness to engage.

The study used classifications proposed by Fastenmeier [7] in order to group road environments into high mid and low demand road classifications. The findings appear to support Fastenmeier's road demand classification criteria. The participants' roadway demand ratings supported those based on Fastenmeier's classifications, with the low demand classification corresponding to the lowest mean rating of perceived demand by the participants and the high demand classification having the highest perceived demand rating by the participants. Having an accurate way of classifying road scenarios based on defined criteria may be helpful to future studies where manipulation of road demand is required, though further testing of Fastenmeier's classifications are still required in order to fully validate them.

It was found that drivers were more willing to engage with their phones when faced with low demand road conditions than mid or high demand conditions, supporting Horrey and Lesch's [4] findings. This was true for nearly all phone functions, with willingness to engage in phone interaction decreasing significantly as the demand of the road increased for placing a call, answering a call and reading a text message, though there was no significant difference for sending a text in mid and high demand road scenarios. The lack of significant difference for sending a text in mid and high demand scenarios suggests as soon as the road environment becomes remotely challenging drivers were unwilling to send a text message, possibly suggesting this was perceived as the most demanding phone task. This was further reflected by sending a text message having the lowest willingness to engage results of any function in all 3 road demand classifications. The low demand classification was the only one where drivers reported being more willing than unwilling to use their phone, though only for answering a call and reading a text message. This suggests drivers modify their phone use behaviour depending on current road demands.

A further finding was that a drivers' willingness to engage with their phone could be impacted by the phone functionality intended to be used. It was found in all demand classifications that sending a text message was the least likely task to be engaged with and it was significantly less likely to be used than any other function in both the low demand and mid demand classifications. The only two functions which had significantly different willingness to engage ratings in all road demand classifications were placing a call and answering a call, with answering a call consistently having a higher willingness to engage rating. This suggests although both functions require speaking into the phone, answering a call was perceived as being far less demanding than placing a call. The 'think aloud' part of the study suggested this may be a result of answering a call only requiring the click of a button and then responding to the caller as opposed to having to search through a contacts list and choosing the desired contact when placing a call. Placing a call also involved more cognitive effort due to being required to initiate the conversation as opposed to just responding. Surprisingly, reading a text was the function with the second highest willingness to engage rating in all road demand classifications, though it was not significantly different to the third highest rated functionality of placing a call in any of the road demand classifications, suggesting these two tasks may be perceived to be similarly challenging.

In the high road demand classification there were only two functions which had significantly different willingness to engage ratings. This suggests in high road demand environments the functionality intended to be used had much less of an effect on willingness to engage. This may possibly support, and be explained by, Fuller's [7] model which suggests that drivers try to maintain a certain task difficulty level. Drivers were willing to interact with certain functions in low road demand environments as they had spare resources, so answering a call or reading a text would be possible whilst still maintaining the desired level of task difficulty. However, other functions, such as sending a text message, which may have been perceived as more demanding would not be attempted as this would have exceeded the desired task demand level. Similarly as the road demand increased, willingness to engage decreased for all functions, possibly as a result of the driver being much nearer to their desired task demand capacity and therefore interacting with most functions would have exceeded their desired level of task demand. Though this does not take into account the second part of Fuller's model, the driver's capability. This may be a topic for future investigation; to what extent does the driver's perceived capability affect willingness to engage with a secondary task whilst driving?

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DRIVERS' BEHAVIOUR, MOTIVATION AND ACCEPTANCE FOR IN-VEHICLE ECO-ASSISTANT SYSTEM DESIGN

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ABSTRACT: The purpose of this paper is to show the results of two studies carried out by Reial Automòbil Club de Catalunya (RACC) in the context of the eCoMove project [1]. eCoMove its a project within the Seventh Framework Programme (Theme 3 ICT – Information and Communication Technologies) that will create an integrated solution for road transport energy efficiency by developing systems and tools to help drivers sustainably eliminate unnecessary fuel consumption (and thus CO2 emissions), and to help road operators manage traffic in the most energy-efficient way. The consumer's opinion on additional driving comfort influences the buying decision and more and more drivers are aware of the increasing negative effect of traffic on the environment. Such motives play a growing role when developing new assistant systems [2]. For this reason two studies were carried out: "Driver behaviour and motivation" and "The eco - Human Machine Interface (ecoHMI) preliminary study". The first study was based on an online survey, with the participation of 15 European motoring associations and 5800 responses reached, and had the objective to evaluate the interest of the drivers on some specific applications that could allow them saving fuel and reducing emissions. The results show a notable interest on the eCoMove applications but there also some open points that should be considered for the implementation of such a systems basically related to the willingness to pay. On the other hand, the ecoHMI study was carried out through forty personal interviews. In this case the study was focused on the acceptance of use for the system in different situations and also the design and notification modalities preferred by drivers for the ecoHMI. Although most drivers are interested no the overall scope of the project, the time factor is still a barrier for users to use some applications for a daily commutes. In terms of design, the simplicity on the design and communication between the person and the HMI was the most valued characteristic.

1. DRIVER BEHAVIOUR AND MOTIVATION STUDY

1.1. Introduction

The goal of the study is to evaluate the acceptance of eCoMove driver assistant systems on a European level. The focus lies on three comparable features that the system is aiming for: positive environmental impact by saving fuel, system usefulness and willingness to pay. Its expected that users who participate in the survey will be interested in this type of support systems to improve driving efficiency, so usefulness its expected to be highly rated. On the other hand, the willingness to pay its not so clear and its of great interest to note differences between different countries.

1.2. Methods

The study was conducted by an online survey in cooperation with 15 European motoring associations (members of EuroTest), and the number of responses reached was 5800. The survey presents 8 potential eCoMove applications using illustrations and the participants were asked to rate different statements that cover the three features of interest. Each application (scenario) was rated according to several perceptual items; these items were selected according to similar user acceptance studies [3] and were adapted to the questionnaire focus. The study considers the technology acceptance as a function of "ease of use" and the "usefulness". In this case, two aspects extended the approach: the environmental impact and the willingness to pay. The questionnaire was divided in three main parts:

- *Socio-demographic and vehicle information*: the answers given in this part defined which questions the respondent would receive in order to distinguish between a private vehicle driver perspective and a business driver.

- *eCoMove Application Scenarios*: 8 applications were described using the illustration of a scenario. The applications were: dynamic green routing (see fig.1) – the system uses real time information to provide the most efficient route; post trip analysis – after the journey the system provides some figures to the driver about his performance; green wave – this application provides recommendations to avoid unnecessary stops on a route with traffic lights; pre-trip planning – the system calculates the most efficient route that could not be the fastest or the shortest; motorway management – the application helps to improve the traffic management with vehicle to infrastructure communication; efficiency rewarding – the vehicle exchanges information with the traffic control centre and applies discounts to the most efficient drivers; and finally the post-trip analysis for commercial drivers – the employer is informed about the performance of each driver and could provide rewards.

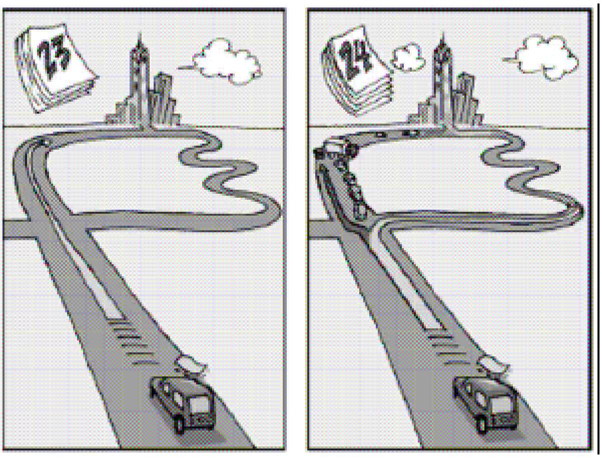

Figure 1: Dynamic Green Routing Applucation

- *Driving behaviour motives*: this part consisted of 10 questions each one representing a certain driving motive – object of utility, quest for low fuel consumption or social norm. The idea was to identify the respondent as one of three pre-defined driver types: time as main driving motive, environmentally conscious driving and perception of possibilities to change driving style into a more environmentally friendly one. This was made to find out which assistant systems are preferred by drivers who are motivated according to the factors.

1.3. Results

In the aggregate 5807 responses were collected (the estimation beforehand was 5000) around Europe. Each country had is own target and a projection factor (target number divided by actual number) was introduced to weight each case according to the national sample size. The participants rated the factors between (1) – strongly agree – and (5) – strongly disagree. The far majority of respondents were private vehicle drivers (91.1%). Only a share of 6.3% describe themselves as business drivers and 2.7% said they do not drive any kind of vehicle. Four out of five respondents were male (78.2%) which raises the question if women feel less addressed by the topic of eco driving than men. Two thirds of respondents (66.1%) are drivers in city environment, the highest share of city drivers is found in Eastern Europe (78.3%) and the lowest in the Alp Region (53.6%). Almost every second European driver drives regularly on highways/motorways (43.1%). Persons owning a car use it for most of their activities carried out like shopping (89.3%), visiting friends and family (88.8%), vacation (80.6%), leisure (78.7%) and fetching children (30.9%). Interestingly the trip purposes with the lowest relevance were work trips (27.0%).

1.3.1. Acceptance of use

The study showed that drivers around Europe do not per se oppose the idea of providing information to cooperative information systems. The results showed that most applications do not use too much personal information from the driver point of view - mean of 1.45 between strongly agree (1) and strongly disagree (5). An exception was an application in which the driving record in terms of “econess” results in parking lot discounting in urban areas (mean 2.38). The perception here was much less positive so clearly a limit is reached if the driver feels monitored through the recording of her or his driving habits.

1.3.2. Usefulness

The application's usefulness was determined - among other factors - by the perceived usefulness (mean 2.12) and it's ability to make driving more comfortable. The first factor for higher comfort is the perceived decrease of stress while driving (mean 2.16). None of the scenarios seemed to restrict driver's freedom, which is positive since the monitoring of drivers was assumed to create this impression among respondents. One important result was the awareness of the possibility to improve driving skills using eCoMove applications (mean 2.20). Especially the scenarios referring to ecoPostTrip received a positive feedback, less though among business drivers. The savings in fuel motivates the private car driver, which could be a rather simple feature of ecoHMI. When considering such applications for business drivers a strong incentive for changing one's skills should be needed. If someone does not benefit of such service personally the acceptance will be low so the challenge will be to develop such systems for the group of commercial drivers.

1.3.3. Environmental impact

The overall aim of eCoMove solutions is to reduce traffic emissions and the study shows that eCoMove applications could achieve this goal from the user perspective. The reduction of emissions is possible if the traffic flow will be smooth and drivers feel that the cooperative system can achieve this (mean 2.13). Improved driving skills will also contribute to reduce traffic emissions. The fuel saving effect is reasonable to be visualized since it motivates to drive environmental friendly and with less consumption. The results on the fuel saving impact of the post trip application support this recommendation.

1.3.4. Payment

The acceptance for payment will be another major challenge. The study showed that willingness to pay for such a system is quite low (mean 3.23). It is clear that a statement is difficult based on the illustration and its explanation. No high acceptance was expected but it was rather surprising that no application received any better ratings than others. The conclusion is that users are not yet convinced about the innovation and it will require efforts to achieve a good cost-benefit ratio, which will be perceived as such by users. The objective is to create incentives in a way that a normal driver is convinced about the added value of eCoMove solutions and ready to pay for them and the post-trip analysis could be important in this task.

1.3.5. Regional comparison

A large variation can be observed on the willingness to pay for the eCoMove applications. Whereas Eastern Europeans rather agree on a payment (mean 2.8), German respondents disagree (mean 4.0). The mean values vary less on the environmental impact or the perceived usefulness. In average both items were strongly agreed on. Southern Europeans rate the usefulness the highest (mean 1.7) and Eastern European the environmental impact (mean 2.0).

2. ECOHMI PRELIMINARY STUDY

2.1. Introduction

The second study was developed to identify the needs and expectations of end users as regards the ecoHMI and to assess the acceptability of some early designs provided by the manufacturers involved in eCoMove. Besides presenting some sketches, also the aim is to have a more global view of users related to the preferred communicaition and notification modes so different channels and designs were evaluated. Other studies [4] note that simple, effective and appropriately placed visual information must be available to the driver as part of a well designed HMI. At the same time, some scenarios were presented in order to asses the acceptability of use for such a system in particular situations, where maybe the time factor could prevail. It was expected that, though the persons interviewed had a certain interest of ecodriving systems since they presented as volunteers, the time factor could have higher weight than the driving efficiency in concrete situations.

2.2. Methods

The study consisted on face to face interviews with 60 participants and the main concepts evaluated on the study were: preferred notification mode, acceptance of use, evaluation of prototypes and interest on post-trip analysis.

The interview consisted of three parts. In the first part demographic characteristics were collected which also dealt with the familiarity with navigation devices and the "green driving behaviour". The second part covered question concerning preferences of the end users as favoured sensory channels or locations for ecoSmartDriving related recommendations and the different options were presented using visual materials. In part three participants were asked to comment on five design approaches and to rate them in relation to comprehension, support, attractiveness and overall preference.

2.3. Results

The analysis of the results was divided into two parts, quantitative and qualitative, because the study combined open interview questions also with ratings. Of the sixty participants, 39 were male and 21 were female and the average age was 44 years (min: 25 years, max: 73 years). Fifteen percent of the participants drove currently an automatic car but all drivers are familiar with gear shifting. The typical purpose for using a navigation device is routing to a destination (stated by 80 % of the participants) and the search for a point of interest (45 %). A minority of ten percent of the participants turns on the navigation device on every trip. Half of the participants indicated to show a "green driving behaviour" very frequently or always. The other half said they show that behaviour occasionally or frequently except for one participant who assessed himself to show "green driving behaviour" only very rarely.

2.3.1. Preferred notification mode

The visual channel, which is best-known modality by drivers, is also liked best for all types of recommendations (47 %); followed by the acoustic modality (32 %). It's also important to note that two out of three users would like to combine at least two modalities. When the recommendation is valid for a longer time period (e.g. optimum speed on a highway) just one modality is considered to be sufficient.

In this section we also focused on the visual channel and which is the preferred location where the system will display the information and recommendations. Taking into account that users consider the issue safety vital, they selected the locations with less danger because the driver do not need to look away from the road. This means that the instrument cluster (63 %) and head-up display (24 %) were the most rated options.

2.3.2. Acceptance of use

To assess the level of acceptance for such a system, we focused on two scenarios based on the eco-routing application. In the first one, users need to enter their destination to enable the system to provide the most efficient route. It has to be considered that for daily commutes the drives are not used to enter his destination and use a navigation device because they already know the alternatives routes. The results show that most users (88.3 %) agree that for weekend or leisure trips it is acceptable but for daily situation data entry would not be easily accepted. Many reasons were given: lack of alternatives in the usual route, short distances, profound knowledge of the route and possible alternatives, but the factor that prevails is time. In the second scenario the user was asked to indicate which of the three available routes will choose (see table 1) taking into account that is a Saturday morning and we are considering a leisure trip:

Name	Starting time	Arrival time	Consumption
Route 1	9:15	10:00	100%
Route 2	9:35	10:10	90%
Route 3	9:15	10:15	80%

Table 1: Alternative routes

In this scenario 68 % of the participants preferred the (time-wise) longest route 3, with most fuel saving. Still some subjects (about 17 %) opted for the standard route (the earliest arrival). Finally the least appreciated option (15 %) consisted of a delayed departure time of 20 minutes in exchange for a 10 % fuel reduction and shorter travel time. Another variation of the former scenario was to provide the same route options while located at home instead of in the car. Then the figures had changed:

Name	preferred while located in the car	preferred while located at home
Route 1	17%	5%
Route 2	15%	57%
Route 3	68%	38%

Table 2: Route preference by location availability

The formerly least appreciated option was like best, followed by the fueloptimized route. The standard route was clearly ranked lowest in this case so the availability of the information off-board its highly appreciate.

2.3.3. Prototypes evaluation

In this section some ecoHMI sketches were presented for two ecorecommendations: speed and gear change.

The most appreciate feature is the simplicity on the designs. Particularly for speed recommendations more than 90 % of the users prefers to have this information integrated in the cockpit due the fact that the information that are currently receiving its allocated there. Some design options present different colours to indicate if the user is driving at an eco-adequate speed or not, and ion this cases the use of the red colour was refused for most of participants and considered that only green should be used to indicate the optimal values.

Also the simplest designs for the gear change recommendation sketches where selected by more than 60 % of participants. The designs that also indicate the current run were more appreciated (73 % of respondents) than the others.

Finally, it was notable that some sketches have received low ratings when using arrows because they can be confused with turn signal indications.

2.3.4 Post-trip analysis

In this part the drivers select which are the most interesting features that post-trip could provide – i.e. comparing your performance with the optimal one, with other drivers or with older performance related to the same route. The vast majority of the participants (78 %) were interested in consumption data presented in a quantitative way rather than a global and qualitative evaluation. Concerning fuel consumption, a value that compares the current average fuel consumption with the calculated optimal one was of high interest for the average of participants due to its educational character whereas comparing with other drivers (social comparision) which was low rated for most of users.

The usefulness of this feature is closely related to the availability in an external format as was pointed in chapter 2.3.2.

3. DISCUSSION

The participants interviewed within these studies expressed their interest in the eCoMove overall concept and, in general, exposed that they would highly appreciate having such applications and services on their next car purchase. We found that the main motivation is the fuel saving, with the reduction of CO2 emissions in a second place, even thought the time factor has priority particularly on daily commuting.

Willingness to pay for such a system would be highly conditioned by the price so the stress should be made in highlighting the expected benefits in fuel saving – i.e. initial cost of system acquisition should be amortized during vehicle life. At this point post-trip tools may have a key role if it's able to translate the benefits of ecodriving to direct savings in euros.

The study also showed that the users consider that the eCoMove system does not use excessive private data but the necessity of having the capability to disable it was also raised for most participants.

As regards de ecoHMI designs the users mostly favour for the visual channel – located at cockpit or HUD – and the simplicity on the designs.

Finally, users showed a high interest on the off-board availability of information – i.e. route options on the pre-trip or post-trip analysis – and also could help to increase the acceptability of use for such applications that optimize the efficiency to the detriment of time.

All these conclusions were used as an input for other partners involved in the development of the final eCoMove solution.

4. REFERENCES

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