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Human Centred Design for ITS Decomobil Deliverable 5.2

Lucile Mendoza, Annie Pauzie, Ralf Risser, Manuel Oberlader, Fabien Moreau, Sophie Janin

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Review

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Abbreviations

Abbreviation	Meaning
SC	Scientific Committee
OC	Organising Committee

1. Introduction

The widespread deployment of in-vehicle driver information systems and the emergence of advanced driver assistance systems are profoundly transforming road transport. Through these Intelligent Transport Systems (ITS), a range of services is offered to the driver with the objective of supporting the driving task and improving the travel safety.

Furthermore, innovative ICT functions which are aimed at supporting a cleaner and safer multimodal mobility are deployed, thereby targeting drivers through eco-driving as well as travellers through improved information access. These developments raise numerous issues in terms of their acceptability and usability by a diversified population, and their effects and impact on user's behaviour and attitudes. This context encourages a Human Centred Design approach, in which ITS functionalities are designed according to users needs rather than being driven by technological capabilities.

Due to the non-existence of a specific conference focused on these themes, the HUMANIST NoE decided in 2008 to set up a European conference on Human Centred Design for Intelligent Transport Systems.

The aim was to gather the community of Human Factors researchers, to offer an overview of the current developments and future trends and to create an area for discussions and debates on with regard to these topics. The first conference was held on 3 and 4 April 2008 in Lyon, France. It was successful with 120 participants not only from Europe but also from Japan, Australia, Canada and the USA. (<http://www.conference.noehumanist.org/>)

The second European conference on Human Centred Design for Intelligent Transport Systems was held in Berlin on 29 and 30 April 2010. (<http://www.conference2010.humanist-vce.eu/>) and the third, organised in the frame of DECOMOBIL project was held in Valencia, Spain on 14 and 15 June 2012 (<http://conference2012.humanist-vce.eu>).

The present conference was held in Vienna, Austria, on 5 and 6 June 2014.

2. Scientific & Organising committees

The conference was organised by a Scientific Committee (SC) who defined all of its strategic matters including the conference scope, the call for papers content and the conference programme, and an Organising Committee (OC) for logistics.

The Scientific Committee was defined in March 2013 and is composed of:

- Ralf Risser (FACTUM, AT), President
- Annie Pauzié (IFSTTAR, FR)
- Corinne Brusque (IFSTTAR, FR)
- Alan Stevens (TRL, UK)
- Roland Schindelm (BASt, DE)
- Anabela Simoes (ADI-ISG, PT)
- Angelos Bekiaris (CERTH-HIT, GR)
- Stella Nikolaou (CERTH-HIT, GR)
- Pedro Valero Mora (INTRAS, ES)
- Josef Krems (TUC, DE)
- José Manuel Menendez (UPM, ES)
- Emil Drapela (CDV, CZ)
- Maria Alonso (CIDAUT, ES)
- Andrew Morris (Loughborough University, UK)
- Marcus Schmitz (WIVW, DE)
- Rob Eenink (SWOV, NL)
- Truls Vaa (TOI, NO)
- Lena Nilsson (VTI, SE)
- Pirkko Rämä (VTT, FI)

The Organisation Committee was defined in March 2013 and composed of:

- Ralf Risser (IFSTTAR, AT)
- Annie Pauzié (IFSTTAR, AT)
- Corinne Brusque (IFSTTAR, FR)
- Lucile Murier-Mendoza (HUMANIST VCE, FR)

3. Place of the conference



The conference place was selected on 27 May 2013, during the HUMANIST VCE General Assembly held in Munich, Germany, and was based on the proposal received from the DECOMOBIL Austrian Third Party FACTUM.

The conference was therefore held at the Federal Ministry for Transport, Innovation and Technology which is situated in the heart of Vienna. The Festsaal Bundesamtsgebäude was selected for its ideal size so as to accommodate all the conference participants.



4. Conference scope

An internal discussion of the organisers of the conference (DECOMOBIL) was held prior to the conference. This led to the decision that the subjects of the present conference, which were central themes to the previous conferences, would be modified. Indeed, this was supported by the fact that the research priorities had evolved during the 2 years period between the 2 conferences and thus an update of the proposed themes was required.

A reflection was therefore conducted which led to the following list of topics being proposed to the conference participants:

1/ Human Factors

- ITS user services
- Intelligent user interface
- User experience & sustainability
- Human error
- Tools to analyse human factors
- Distraction, attention, emotion & workload
- Neuro sciences in ergonomics
- Diversity and specificity of road user groups

- Drivers/riders needs and acceptance of assistance functions

2/ HMI & Design

- Effects of in-vehicle systems on driver performance
- Human centred design
- Cooperative systems acceptability and usability
- Acceptability of electro-mobility
- Smart mobility
- Automation and trust
- Intelligent vehicles
- Human Machine Interaction
- Effects of ITS on driver behaviour and interaction with the systems
- Field Operational Tests and Naturalistic Driving Studies
- Generic user interfaced for assistance systems

3/ Safety

- Safety & Mobility
- Safety of nomadic & mobile services
- In-vehicle devices and driving safety
- ITS to support VRU's safety

4/ Ecomobility

- Social networks for ecomobility
- Training for ecomobility
- Tools and methodologies for driver/rider ecodriving/riding training
- Green ITS to meet new driver needs
- Green driving/riding

5/ Methodologies

- Tools and methodologies for safety and usability assessment
- Modelling of drivers'/riders' behaviour for ITS design

5. Call for papers

The conference Call for Papers was launched on 5 November 2013. At this stage, the deadline for acceptance of extended abstracts (2 pages in length) was 25 January 2014 and the notification of papers acceptance was planned for 21 February 2014.

Abstracts were submitted via the conference specific website platform. Each received abstract was then automatically added to the abstracts database with a copy being sent to the conference organisers.

See call for papers in appendix 1.

6. Abstracts selection and paper review processes

The abstract selection process consisted of the President of the Scientific Committee, along with the help of the Organising Committee, reviewing all abstracts and deciding if they were suitable for the conference. In this phase, a total of 43 abstracts were selected for either lectures or poster presentation.

At the end of this process, each author has been asked to send his/her complete paper for the 28 March 2012 – a template for complete paper was provided (*see appendix 2*).

After receiving all complete papers from the authors, the Scientific Committee members were asked to review all papers following the conference review frame (*see the review frame in appendix 3*). All comments from the reviewers were expected for 15 April 2014 in order to be transmitted to the authors by 1st May at the latest. All final papers including reviewers' comments were then expected and received for 15 May 2014.

7. Conference programme

7.1. General programme

The conference programme was designed to take place over the course of 2 days as per the following scheme:

5 June 2014	
9.15	Welcome
9.30	Opening session Doing better driving research: suggestions from a reviewer, Paul Green, University of Michigan, Transportation Research Institute, USA
10.00	Session 1: HMI Design
12.00	Coffee break
12.15	Session 2: Vulnerable Road Users
13.15	Lunch in poster sessions room
13.15	Poster session
14.15	Special session 1: Senior driver needs in driving aids
15.15	Coffee break
15.30	Session 3: Field Operational Tests

17.10	Special session 2: Undertaking the potential of ITS
18.10	Horizontal session: Safety across transport modes
19.45	Dinner

6 June 2014	
8.30	Session 4: Advanced Driving Automated Systems
10.30	Coffee break
11.00	Session 5: E-vehicles
12.00	Lunch
13.15	Session 6: Methodologies
14.55	Coffee break
15.15	Session 7: Modelling & planning
17.00	Closing session

See complete programme in appendix 4.

7.2. Lectures

Thirty-four papers were retained for lectures and distributed among 8 sessions on the following themes:

- **Session 1:** HMI design, chaired by Peter Burns from University of Ottawa (Canada)
- **Session 2:** Vulnerable Road users, chaired by Heikki Kanner from VTT (Finland)
- **Session 3:** Field Operational Tests, chaired by Michael Regan from University of New South Wales (Australia)
- **Session 4:** Advanced automated & continuous monitoring driving systems, chaired by Paul Green from University of Michigan (USA)
- **Session 5:** E-vehicles, chaired by Annie Pauzié from IFSTTAR, (France)
- **Session 6:** Methodologies, chaired by Josef Krems from TUC (Germany)
- **Session 7:** Modelling & planning, chaired by Lucile Mendoza from HUMANIST (France)
- **Horizontal session:** Safety across transport modes, chaired by Evangelos Bekiaris from CERTH-HIT (Greece)



Fig.1: Some pictures of the lectures

7.3. Posters

Nine papers were retained for the poster presentation. This session was held on 5th June, in the same room as the lunch break, allowing participants and presenters to easily exchange views on the posters subjects.



Fig.2: Some pictures of the posters

7.4. Special sessions

Two special sessions were planned during the conference.

The first selected subject was on Senior Driver Needs in Driving Aids. The Session was chaired by Bjorn Peters from VTI (Sweden) and aimed at addressing the background activities, the current initiatives and the future priorities of Senior Driver Needs in European research. Special focus was placed on the need for safety and comfort as well as expectations concerning driving assistance. A comparison was made between French and Swedish drivers during discussions with the lecturers and the audience.

The following lectures were presented:

- **Older drivers' needs for safety and comfort systems in their cars – a focus group study among Swedish drivers** by Bjorn Peters – VTI
- **Older drivers' needs and expectations concerning car driving assistance – a focus group study among French drivers** by Thierry Bellet - IFSTTAR

The second selected subject was on taking advantage of the potential of ITS to improve road user interaction. The session was chaired by Ralf Risser from FACTUM (Austria) and aimed at addressing the potentials of ITS of improving the road user interaction. Special emphasis was given to pedestrians and two-wheeler riders. Four presentations were presented in order to open the discussions between the lecturers and the audience.

The following lectures were presented:

- **Pedestrian crossing** by Nicole van Nes – SWOV
- **Communication between car drivers and cyclists and the potential role of ITS** by Elisabeth Füssl – FACTUM
- **ITS and comfort safety** by Ralf Risser – FACTUM
- **Can navigation systems for pedestrians have negative effects?** by Daniel Bell – FACTUM



Fig.3: Some pictures of the special sessions

8. List of participants

Eighty-nine participants were present during the conference.

first name	last name	company	Count
Eva	Aigner-Breuss	KFV Austrian Road Safety Board	AT
Michael	Aleksa	AIT Austrian Institute of Technology GmbH	NN
Mildred	Alfons		AT
Maria	Alonso	CIDAUT	ES
Nur Khairiel	Anuar	CRANFIELD UNIVERSITY	GB
Erfan	Aria		AT
Jose	Balsa Barreiro		NN
Evangelos	Bekiaris	CERTH-HIT	GR
Daniel	Bell	Factum Chaloupka & Risser OG	AT
Thierry	Bellet	IFSTTAR	FR
Corinne	Brusque	IFSTTAR	FR
Franziska	Bühler	TUC	DE
Peter	Burns	University of Ottawa	CA
Fang	Chen	Chalmers	NN
Frédéric	Clouard	Continental Automotive France SAS	FR
João Pedro	Da Silva Morais		PT
Lian	Duan		SE
Chloé	Eyssartier	CEREMA	FR
Thomas	Franke	TU Chemnitz	DE
Elisabeth	Füssl	Factum Chaloupka & Risser OG	NN
EVA	GARCIA	CTAG, CENTRO TECNOLOGICO AUTOMOCION GALI	ES
Marko	Golnar		SI
Paul	Green	University of Michigan	US
Graham	Hancox	University of Loughborough	GB
Juliane	Haupt	Factum Chaloupka & Risser OG	AT
Yannick	JACOB	ParisTech	NN
Sophie	Jeannin	IFSTTAR	FR
Susanne	Kaiser	Austrian Road Safety Board	AT
Heikki	Kanner	VTT	FI
Aoife	Kervick	NOI	IE
Stephanie	Knasmüller	GMX	AT
Marlene	Koch		NN
Josef	Krems	TUC	DE
Maria	Kreußlein	TUC	DE
Matina	Loukea	CERTH-HIT	GR
Bjørn	Lund	Norwegian Public Roads Administration	NO
Jean-Pierre	Médevielle	HUMANIST VCE	FR
Lucile	Mendoza	HUMANIST VCE	FR
José Manuel	Menendez	UPM	ES
Florian	Michaeler		AT
Vera	Mimic		AT
ANERUDHA	Mondal	TU Wien	AT
Fabien	Moreau	IFSTTAR	FR
Andrew	Morris	University of Loughborough	GB
Anna	Müller	TU Wien	AT

Isabel	Neumann	TUC	NN
Aleksander	Pagon		SI
Annie	Pauzié	IFSTTAR	FR
Maria de Fátima	Pereira da Silva		PT
Björn	Peters	VTI	SE
Ingrid	Pettersson	Chalmers University of Technology	SE
Raissa	POKAM MEGUIA		FR
Mirjam	Pot		NN
Nadine	Rauh	TUC	DE
Michael	Regan	University of New South Wales	AU
Dale	Richards	Coventry University	GB
Ralf	Risser	Factum Chaloupka & Risser OG	NN
Magaly	Romão	USP	BR
Dominik	RUTSCHMANN		AT
Nuria	Sanchez	UPM	ES
Cheree Anne	Schepp		DE
Roland	Schindhelm	BAST	DE
Marcus	Schmitz	WIVW	DE
Joachim	Seidl	Germany	DE
Alisa	Sestan	TU Wien	AT
João Pedro	Silva Morais	Escola Superior de Educação de Coimbra	PT
Sara	Silvagni	Deep Blue srl	NN
Peter	Silverans	BIVV-IBSR	BE
Diana	Silvestru	TU Wien	AT
Anabela	Simoes	ADI-ISG	NN
Niklas	Strand	VTI	SE
Hana	Ticha		NN
Katrien	Torfs	BIVV	BE
Maria	Trantow	Technische Universiät Chemnitz	DE
Christine	Turetschek	AIT Mobility/DTS	AT
Truls	Vaa	TOI	NN
Pedro	Valero-Mora	Universitat de Valencia	ES
Wouter	Van den Berghe	BIVV-IBSR	BE
Arie Paul	van den Beukel	University of Twente	NL
Nicole	van Nes	SWOV	NL
Andras	Varhelyi	Lund University	NN
Min Juan	Wang	Chalmers	NN
Alistair	Weare	TRL	GB
Julia	Werneke	German Aerospace Center	DE
Harald	Widroither	Fraunhofer IAO	DE
Sebastian	Will	WIVW	DE
Lisa	Wintner	University of Innsbruck	AT
Petr	Zámečník	CDV	NN
Hermann	Knoflacher	TU Wien	AT

9. Conference Proceedings

Papers presented during the conference will be compiled in an e-book called “European conference on Human Centred Design for Intelligent Transport Systems – Proceedings”.

This e-book will be provided with the following ISBN number: 978-2-9531712-3-5 and the following barcode:



The e-book will be available on the conference website and disseminated on free e-books platforms. Free copies will also be available at the HUMANIST Secretariat and may be sent on request to interested individuals.

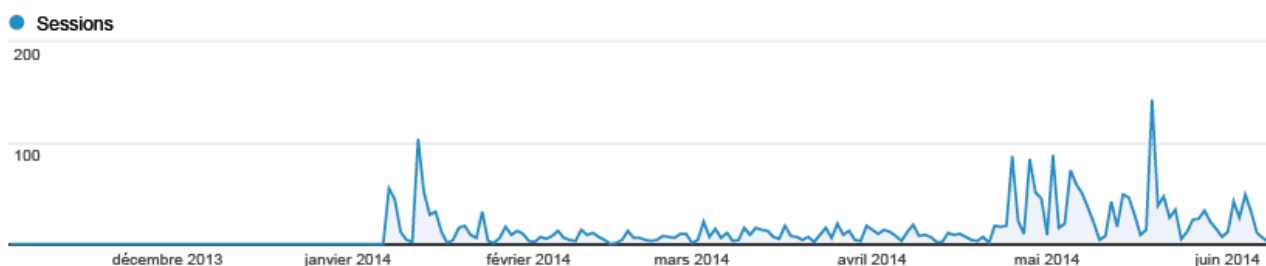
Moreover, electronic proceedings have also been added to the conference website (<http://conference2014.humanist-vce.eu>), providing electronic pdf copies of the conference papers and special sessions presentations. In addition, copies of the presentations (approved by the lecturers) will be available by August 2014.

See complete proceedings in appendix 5.

10. Conference website

A specific website (<http://conference2014.humanist-vce.eu>) was developed in order to present the conference and to provide the main information such as deadlines, directions, hotels suggestions, contact details and instructions for online paper submission. It was developed before the launching of the call for papers.

A statistic tool was implemented in order to track the number of visitors to the website. The results of the statistics are as shown in the following tables from the launching of the Call for Papers and the date of the conference:





Pays/Territoire		Sessions	% Sessions
1.	France	519	19,29 %
2.	Austria	368	13,68 %
3.	Germany	330	12,26 %
4.	United Kingdom	318	11,82 %
5.	United States	117	4,35 %
6.	Belgium	105	3,90 %
7.	Sweden	104	3,86 %
8.	Spain	90	3,34 %
9.	Italy	89	3,31 %
10.	Netherlands	66	2,45 %

11. Conclusions

A general conclusion was drawn by the Honourable President of HUMANIST, Jean-Pierre Médevieille during the closing session: “Thank you for the invitation, while many of our leaders of States are on the Normandy beaches. Thanks also go to the European Commission, which was main sponsor throughout the DECOMOBIL project. Thank you to the BMVIT that welcomed the conference, the Scientific Committee, our local organizer FACTUM, Ralf and Christine and their team, Annie and Lucile who worked with the Scientific Committee to support and frame the reviewing process and the framing of this conference, and for their support to the logistics. This conference shall be followed by an official and public DECOMOBIL deliverable. I think that the standards of this conference have been kept towards the success through plenary sessions, partners and special sessions. Almost 100 attendants from Europe or other worldwide countries were present.”

A very critical key note speech was given by Paul Green, and many interactions with authors have been a real leverage of the quality of this conference in addition to the excellence of presentations or posters.

On the content side, I took note of:

- Continuation of past trends of ITS and Human Factors, Human Centred Design, mobility

- Evolution and birth of new trends including eco-mobility and e-mobility, and new technological development coming from the Internet or Future Internet including social networks, or new scientific outputs.

I want to pinpoint some of the main issues raised:

- The enlargement of the concept of Naturalistic Driving Studies to VRU, cycling, e-bike, PTW and pedestrian through adapted methodologies and critical scenarios development
- The quality control and reliability of methodologies going till the uptaking phase
- The needs to extend human factors issues to cooperative ITS, and the various levels of automation till the full automation
- The “tensions” between cognitive ability or acceptability and “driving performance” to cope with interaction, safety, security, acceptability and acceptance
- The importance to take a multiuser and multimodal approach of ITS and interaction, this implies to have a more holistic approach even for the dedicated ITS services.

On the scientific side:

- Needs for adaptation or creation of adequate methodologies is critical for the future
- Needs for measurement guidelines or standards developments
- Needs for new concept such as HIS or Technology Adoption Models
- Needs to use big data and do it adequately
- And needs to participate to the clarification of definitions and other related issues

In all, for HUMANIST and DECOMOBIL partners sustaining its scientific orientations through the various Task Forces as well as our Marie Curie ITN daughters. Last but not least, there is a need to continue this series of bi-annual conferences on Human Centred Design for ITS: it is important not only for HUMANIST members but for all the Human Factors/ITS relevant community in Academia and Industry.

Please take note of the last DECOMOBIL workshop on 8 September 2014 in Lisbon, on the theme of Human Centred Design for safety critical systems.

See you in 2016 and have a good return trip”

Other conclusions

Participants of the conference were very satisfied with the location, time frame and scientific programme. Positive remarks were made about the programme content, and more specifically, the presence of international speakers, such as Paul Green, and reviewers such as Peter Burns and Michael Regan was highly appreciated by the audience, as they gave a world opening?? (wider/extended range or so?) to their respective sessions. The many discussions following the presentations demonstrated the interest of the participants in the conference contents and high lightened the relevance of the selected topics.

12. Appendices

Appendix 1: Call for papers

Appendix 2: template for complete paper

Appendix 3: Review frame

Appendix 4: Complete programme

Appendix 5: Complete proceedings



Topics

Registration

European Conference

on Human Centred Design for Intelligent Transport Systems

Vienna
Austria

June 5th - 6th, 2014

Ecomobility

ITS

Design

Human
Factors

Transport

Research



Submissions can be made under the following topics:

Human Factors

- ITS User services
- Intelligent user interface
- User experience & sustainability
- Human error
- Tools to analyse human factors
- Distraction, attention, emotion & workload
- Neuro sciences in ergonomics
- Diversity and specificity of road user groups
- Drivers needs and acceptance of assistance functions

HMI & Design

- Effects of in-vehicle systems on driver performance
- Human Centred Design
- Cooperative systems acceptability and usability
- Acceptability of electromobility
- Smart mobility
- Automation & trust
- Intelligent vehicles
- Human Machine Interaction
- Effects of ITS on driver behaviour and interaction with the systems
- Field Operationnal Tests and Naturalistic Driving Studies
- Generic User Interfaces for assistance systems

Safety

- Safety & Mobility
- Safety of nomadic & mobile services
- In-vehicle devices & driving safety
- ITS to support VRU's safety

Ecomobility

- Social networks for ecomobility
- Training for ecomobility
- Tools and methodologies for driver/rider eco-driving training
- Green ITS to meet new driver needs
- Green driving/riding

Methodologies

- Tools and methodologies for safety and usability assessment
- Modelling of drivers'/riders' behaviour for ITS design

Registration fees for participants have been set:

- at 250 € for authors and audience registration
- Free for EC representatives, students (upon presentation of student card) & DECOMOBIL partners

This includes:

- Conference participation
- Conference proceedings
- Morning and afternoon refreshments
- Lunches and dinner

Registration & paper submission is available through the conference website:

<http://conference2014.humanist-vce.eu>

Email contact:

lucile.mendoza@humanist-vce.eu

Organised by



With the support of



Conference scope

The widespread deployment of in-vehicle driver information systems and the emergence of advanced driver assistance systems are profoundly transforming road transport.

Through these Intelligent Transport Systems, a range of services is offered to the driver with the objective of facilitating the driving task and improving travel safety.

Nevertheless, these developments raise numerous questions about acceptance and possible effects and their impact on drivers' behaviour and attitudes.

All this encourages Human Centred Design approach, in which Intelligent Transport Systems are designed according to driver needs and are not driven by technological capabilities.

For this reason, the HUMANIST Virtual Centre of Excellence, in the frame of the DECOMOBIL project (Support action to contribute to the preparation of future community research programme in user centred Design for ECO-multimodal MOBILity - <http://decomobil.humanist-vce.eu>) is organising a conference on this topic.

During the conference, the following scientific topics related to Human Centred Design for Intelligent Transport Systems will be addressed:

- Human Factors
- HMI & Design
- Safety
- Ecomobility
- Methodologies

Call for papers

All lecture and poster presenters are required to submit an extended abstract (2 pages in length). Papers that have been published previously may not be submitted. Deadline for abstracts is set at November 29th, 2013.

Authors will be notified of the acceptance of their proposal by December 16th, 2013.

Final papers must be submitted by January 31th, 2014 to be published in the proceedings that will be distributed during the conference. Selected authors will later be invited to publish an extended version of their paper as part of a special issue in IET Intelligent Transport Systems Journal.

A section of the conference website is dedicated to guidelines for authors.

Website:

<http://conference2014.humanist-vce.eu>

Scientific committee

Ralf Risser (FACTUM, AT), President
Annie Pauzié (IFSTTAR, FR)
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Rob Eenink (SWOV, NL)
Truls Vaa (TOI, NO)
Lena Nilsson (VTI, SE)
Pirkko Rämä (VTT, FI)

Organisation committee

Ralf Risser (FACTUM), Annie Pauzié & Corinne Brusque (IFSTTAR), Lucile Mendoza (HUMANIST, FR)

Significant dates



Place



The conference will be held in Vienna, Austria at the:

Federal Ministry for Transport, Innovation and Technology
Festsaal Bundesamtsgebäude

Radetzkystrasse 2
A-1030 Vienna, Austria

More information at:
<http://www.bmvit.gv.at/en/ministerium/radetzky.html>

bmvit

Bundesministerium
für Verkehr,
Innovation und Technologie

TITLE OF THE PAPER – Arial 14 Bold - centred

Authors – Arial 10 - centred

ABSTRACT: Arial 10 – Justified – Margin 2.5

Please use the format and instructions provided on this sheet in preparing your paper for the European Conference on Human Centred Design for Intelligent Transport Systems. All lecture and poster presenters are requested to submit papers in English from 5 to 8 pages in length. The proceedings will be distributed to participants at the time of the conference. At the request of the proceeding printer that will be in charge of the document layout, papers have to be submitted as a Word as well as a pdf document.

Papers should be divided into clearly defined and numbered sections.

Subsections should be numbered 1.1 (then 1.1.1, 1.1.2), 1.2, etc.

Heading styles are as demonstrated below.

1 HEADING 1 is Arial 12 pts, capital letters, bold, left aligned, spacing before 12 pt, spacing after 6 pts

1.1 Heading 2 is Arial 12pts, bold, Italic, left aligned, spacing before 6pts, spacing after 6pts

1.1.1 Heading 3 is Arial 10 pts, bold, left aligned, spacing before 6 pts, spacing after 6 pts

Papers should be typed in Arial font, size 10pts, justified, followed by a 6pts space and presented in single column format and with 1.5 line spacing. Only paper size 16x24 cm is allowed – the paper size is automatically defined in the present document. Top margin should be 1.7 cm, bottom margin should be 0.95 cm, left margin should be 1.9 cm and right margin should be 2.03 cm – margins are automatically defined in the present document. Page numbers will be inserted automatically in the pages.

Table captions should be inserted above the table (10pts, bold, centred, spacing before 6pts, spacing after 6pts). There should not be a period at the end of captions. Number tables consecutively in Arabic numerals. Table text may be in a smaller font, if desired (e.g. 9pts). See example below.

Fig. xx Arial 10 – Bold – centred below the figure

Figure captions should be inserted below the figure (10pts, bold, centred, spacing before 6pts, spacing after 6pts). There should not be a period at the end of captions. Number figures consecutively in Arabic numerals.

Line drawings and bitmaps may be used as figures. Inherent Word drawings are unsuitable, unless converted to bitmaps. Inserted figures must not be formatted as floating with text (Word figure options). Most suitably a figure should be one of a bmp, jpg or gif file with a resolution of 300dpi.

The proceedings will be printed in black and white. Therefore, colour figures cannot be accepted. See example below.

Table xx: Arial 10 – Bold – centred - above the table

Equations: Please centre equations and number them consecutively in Arabic numerals enclosed in parentheses at far right.

$$x = \sum_{i=0}^n y_i \quad (1)$$

Acronyms and abbreviations should be clearly defined on their first occurrence in the text by writing the term out in full and following it with the abbreviation in round brackets.

Acknowledgments should appear as a separate section between the Conclusions and References sections.

References:

Responsibility for the accuracy of bibliographic citations lies entirely with the authors. Use the Vancouver (numerical) system for references. You should number your references sequentially through the text, and each reference should be individually numbered and enclosed in square brackets (e.g. [1]). Please ensure that all references in the Reference list are cited in the text and vice versa.

Examples of the ways in which references should be cited are given below:

Journal article

Smith, T., and Jones, M.: 'The title of the paper', IEE Proc. Syst. Biol., 2005, 1, (4), pp. 1–7

Conference paper

Jones, L., and Brown, D.: 'The title of the conference paper'. Proc. Int. Conf. Systems Biology, Stockholm, Sweden, May 2006, pp. 1–7

Book, book chapter and manual

Hodges, A., and Smith, N.: 'The title of the book chapter', in Brown, S. (Ed.): 'Handbook of Systems Biology' (IEE Press, 2004, 1st edn.), pp. 1–7

Harrison, E.A., and Abbott, C.: 'The title of the book' (XYZ Press, 2005, 2nd edn. 2006)

Thesis

Abbott, N.L.: 'The title of the thesis'. PhD thesis, XYZ University, 2005

Standard

BS1234: 'The title of the standard', 2006

Website

<http://www.theiet.org>, accessed April 2006



**European Conference
on Human Centred Design
for Intelligent Transport Systems**

**5 & 6 June 2014
Vienna, Austria**

Review of submitted papers

Paper description	
Title of the paper	
Names of the authors	
Main scientific topic of the paper	<input type="checkbox"/> HMI Design <input type="checkbox"/> Vulnerable Road Users <input type="checkbox"/> Field Operational Tests <input type="checkbox"/> Advanced Driving Automated Systems <input type="checkbox"/> E-Vehicles <input type="checkbox"/> Methodologies <input type="checkbox"/> Modelling and planning
Type of paper	Oral presentation <input type="checkbox"/> Poster <input type="checkbox"/>

Reviewer description	
Reviewer number	Reviewer 1 <input type="checkbox"/> Reviewer 2 <input type="checkbox"/>
Review type	Initial review <input type="checkbox"/> Review after revisions <input type="checkbox"/>
Name of the reviewer (confidential information)	
Expected date for the review	

Initial review	
Result of the review	
Accepted without revisions	<input type="checkbox"/>
Minor revisions to be made	<input type="checkbox"/>
Major revisions to be made	<input type="checkbox"/>
Comments of the reviewer that will be transmitted to the authors:	
Confidential comments of the reviewer to the scientific committee (if any):	
Recommendations of the reviewer	
Session	<input type="checkbox"/> HMI Design <input type="checkbox"/> Vulnerable Road Users <input type="checkbox"/> Field Operational Tests <input type="checkbox"/> Advanced Driving Automated Systems <input type="checkbox"/> E-Vehicles <input type="checkbox"/> Methodologies <input type="checkbox"/> Modelling and planning



European Conference

on Human Centred Design
for Intelligent Transport Systems

Vienna, Austria
5 & 6 June 2014

Programme

Scientific conference

Human Machine Interaction

Human Factors

Intelligent Transport Systems

Ecomobility

FOT and Naturalistic Driving Studies

Acceptability of electromobility

Safety of nomadic and mobile devices

Tools and methodologies for safety and usability

Design

Diversity and specificity of road user groups



Conference Timetable

5th of June

9.15	Welcome reception
9.30	Opening session
10.00	Session 1 - HMI Design
12.00	Coffee Break
12.15	Session 2 - Vulnerable Road Users
13.15	Lunch
14.15	Special Session 1 - Senior drivers needs in driving aids
15.15	Break
15.30	Session 3 - Field Operational Tests
17.10	Special Session 2 - Undertaking the potential of ITS
18.10	
	19.45 Dinner

6th of June

8.30	Session 4 - Advanced Driving Automated Systems
10.30	Coffee break
11.00	Session 5 - E-Vehicles
12.00	Lunch
13.15	Session 6 - Methodologies
14.55	Coffee break
15.15	Session 7 - Modelling & Planning
17.00	Closing session

Welcome session

Day 1, 9.15

HUMANIST Horizon 2020 Vision

Evangelos Bekiaris, HUMANIST President, CERTH-HIT, Greece

Opening session

Day 1, 9.30

Doing better driving research: Suggestions from a reviewer

Paul Green, University of Michigan, Transportation Research Institute, USA

HMI Design

Session chaired by Peter Burns, University of Ottawa

Session 1

Day 1, 10.00

Development and evaluation of a driver coaching function for electric vehicles

Monika Jagiellowicz, Michael Hanig & Marcus Schmitz (Würzburg Institute for Traffic Sciences)

To be or no to be an eco-driver? Analysis of motivation & resistances towards eco-driving

Myriam Hugot (IFSTTAR)

Mindfulness, distraction and performance in a driving simulator

Pedro Valero-Mora, Ignacio Pareja, Diana Pons, Marc Sanchez, Silvana A Montes & Ruben Ledesma (Universitat de Mar del Plata)

Design for system awareness; towards developing interface solutions for the transitions between automated driving and human control

Arie Paul van den Beukel & Masha van der Voort (University of Twente)

Human centred design of a mobile phone alert application for drivers

Annie Pauzié (IFSTTAR)

A wayfinding and road safety of alternative road access design solutions

Nur Khairiel Anuar, Romano Pagliari & Richard Moxon (Cranfield University)

Vulnerable Road Users

Session chaired by Heikki Kanner, VTT

Session 2

Day 1, 12.15

Will joy from e-bikes be threatened by new risks? Analysis of safety-critical events of e-bikes based on naturalistic cycling data

Julia Werneke, Marco Dozza & Michael Mackenzie (University of Technology, Department of Applied Mechanics, Division of Vehicle Safety, Accident Prevention Group)

Workload assessment for motorcycles riders

Sebastian Will & Eike A Schmidt (Würzburg Institute for Traffic Sciences)

Vulnerable Road User needs towards ITS

Daniel Bell (FACTUM)

Field Operational Tests

Session chaired by Michael Regan University of New South Wales

Session 3

Day 1, 15.30

Quality control (QC) procedure for naturalistic driving data using Geographic Information System (GIS)

José Balsa-Barreiro, Pedro Valero-Mora, Ignacio Pajera-Montoro, Mar Sanchez Garcia (University of Valencia, INTRAS)

ITS cooperative services and human factors - the FOTsis project experience

Jorge Alfonso, Nuria Sanchez, Aniceto Zaraoza & José Manuel Menendez (Universidad Politecnica de Madrid)

Displaying infrastructure based information in the car - results from Austria's FOT on cooperative I2V services

Dr Walter Aigner & Dr Wolfgang Schildorfer (HiTec)

A comparison of planned distracting behaviour among professional drivers and their colleagues

Claudia Wege & Trent Victor (Volvo cars)

Evaluation of Navigation Systems related to road safety

Claus Aichinger, Eva Aigner-Breuss, Michael Aleksa, Susanne Kaiser, Anna Müller & Katharina Russwurm (AIT, KFV)

Safety accross transport modes

Session chaired by Evangelos Bekiaris, CERTH-HIT

Day 1, 18.10

Exploiting safety results accross transportation modes: the EXCROSS project

Iraklis Lazakis, Osman Turan, (Dpt of Naval Architecture, Ocean and Marine Engineering – NAOME, University of Strathclyde, UK), Sara Silvagni, Simone Pozzi (Deep Blue Research and Consulting, Rome, Italy)

Advanced Automated & Continuous Monitoring Driving Systems

Session chaired by Paul Green

Session 4

Day 2, 8.30

Testing novel structural model of young driver willingness to uptake phone application driver monitor

Aoife Kervik (NOI)

In-field evaluation of the effects of Continuous Driver Support on driver behaviour

Andras Varhelyi, Anna Persson (Department of Technology and Society), Clemens Kaufmann (FACTUM)

To delegate or not to delegate: a Human Factors perspective of autonomous driving

Dr Dale Richards (Coventry University)

Drivers' attitudes towards driver assistance systems

Juliane Haupt (FACTUM)

Acceptability of driving and equipped vehicle with drive recorder: the impact of the social context

Chloé Eyssartier (CEREMA)

Acceptability of Speed Limiters

Corinne Brusque (IFSTTAR)

E-vehicles

Session chaired by Annie Pauzié, IFSTTAR

Session 5

Day 2, 11.00

Eco-driving strategies in electric vehicle use: what do drivers get to know over time?

Isabel Neumann, Thomas Franke, Franziska Bühler, Peter Cocron & Josef Krems (Technical University Chemnitz)

User experience with electric vehicles while driving in a critical range situation - a qualitative approach

Nadine Rauh, Thomas Franke & Josef Krems (Technical University Chemnitz)

The range comfort zone of electric vehicle users - concept and assessment

Thomas Franke, Madlen Günther, Maria Trantow, Nadine Rauh, Josef Krems (Technical University Chemnitz)

Methodologies

Session chaired by Josef Krems, Technical University Chemnitz

Session 6

Day 2, 13.15

Evaluation of the tactile detection response task (TDRT) in a laboratory test using a surrogate driving set up

Roland Schindhelm & Eike Schmidt (BAST)

Considering the potential of phone application driver monitor for young people

Aoife Kerwik (NOI)

Measures of usability for in-vehicle technology

Alistair Weare & Alan Stevens (TRL)

Setting the stage for self-driving cars: a method for exploration of future autonomous driving experiences

Ingrid Pettersson (Chalmers University of Technology, Design and Human Factors & Volvo cars Corporation)

Improved safety surface access at low cost airports: preferences by low cost passengers for pedestrian facilities at Kuala Lumpur International Airport, Malaysia

Rohafiz Sabar (University Utara Malaysia & Nur Khairiel Anuar (Cranfield University))

Modelling & planning

Session chaired by Lucile Mendoza, HUMANIST VCE

Session 7

Day 2, 15.15

Levels of passengers' flow in the membership function levels for a train's coach. Case Study: Panama metro line 1

Aranzazu Berbey, Rony Caballero, Victor Sanchez & Fransco Calvo (Panama)

Differences and discrepancies between product and process modelling in transport

Hermann Knoflacher (TU Vienna)

Cooperative Services and HMI for optimising mobility in non-road and multimodal transport

Nuria Sanchez, Jorge Alfonso, José Manuel Menendez (Universidad Politecnica de Madrid)

Intelligent urban structures - Intelligent human behaviour

Hermann Knoflacher (Institute of Transportation)

The Future of Mobility: the time to engage is now

Guy Fraker (USA)

Posters

Day 1, 13.15

Evaluating multimodal mobility-on-demand systems: Questions and Methods

Dorothea Langer, André Dettmann, Josef Krems, Angelika Bullinger (Technische Universität Chemnitz)

Wheel hub motor failures and their impact on the driver

M. Kreusslein, P. Cocron, I Neumann, M Pereira, B Augusto, D Wanner, J Krems (Technische Universität Chemnitz)

When automation fails

Niklas Strand

Drivers reasoning about future automated driving - discussions with focus groups

Arne Nabo, Anna Anund (VTI)

SAFeway2SCHOOL european project

Anna Anund (VTI)

Am I in the blind spot? - Investigating motorcycle riders' skills

Sebastian Will, Marcus Schmitz, Christian Mark (WIVW)

HMI for non-road & multimodal transport

José Manuel Menendez (UPM)

Smart cities

Myriam Neaimeh (University of Newcastle)

Human centred design for ecomobility: the DECOMOBIL project

Lucile Mendoza (HUMANIST VCE), Annie Pauzié (IFSTTAR)

Senior drivers needs in driving aids

Session chaired by Bjorn Peters, VTI

Special Session 1

Day 1, 14.15

Older drivers' needs for safety and comfort systems in their cars - a focus group study among swedish drivers

Christina Stave, Bjorn Peters, Tania Willstrand, Thomas Broberg (VTI)

Older drivers' needs and expectations concerning car driving assistance - a focus group study among French drivers

Thierry Bellet, Jean- christophe Paris, Claude Marin-Lamellet (IFSTTAR)

Comparison between French and Swedish drivers & discussions

Undertaking the potential of ITS to improve road user interaction

Session chaired by Ralf Risser, FACTUM

Special Session 2

Day 1, 17.10

Discussion session on the following themes:

Pedestrian crossing - *Nicole van Nes (SWOV)*, **Communication between car drivers and cyclists and the potential role of ITS** - *Elisabeth Füssl (FACTUM)*, **ITS comfort and safety** - *Ralf Risser (FACTUM)*, **Can navigation systems for pedestrians have negative effects?** - *Daniel Bell (FACTUM)*

Closing session

Day 2, 17.00

Closing of the conference

Jean-Pierre Médevielle (Honorable President of HUMANIST VCE, TRB Emeritus)

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Humanist

For information:

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Venue:

Federal Ministry for Transport,
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Registration:

Registration fees for participants:

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- Participation in the conference
- Conference proceedings
- Refreshments
- Lunches and gala dinner on 5th of June

Special issue publication



IET Intelligent Transport Systems, a peer-reviewed academic journal from the Institution of Engineering and Technology (IET) is delighted to announce its collaboration with the European Conference on Human Centred Design for Intelligent Transport System to produce a Special Issue of suitably expanded papers from this event.

Authors of conference papers that are considered suitable for expansion for consideration in the 2014 (Human Centred Design) Special Issue will receive a formal invitation to submit.

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Doing Better Driving Research: Suggestions from a Reviewer

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ABSTRACT:

This paper describes 11 guidelines to improve publications describing human factors studies of driving. These guidelines include: writing as a native speaker; allocating most pages to new material; allocating half of the abstract text to results; stating the research issues as who, what, when, where, why, and how questions; providing numerical predictions for outcomes; providing images of what subjects saw; providing interaction and dual dependent measure plots; balancing the results between practical and statistical significance; and formatting the references as required. Most importantly, the author suggests that publications be required to (1) use the definitions for measures and statistics in SAE Recommended Practice J2944 so that studies can be compared and (2) list relevant standards and guidelines as keywords to help translate the research reported into practice.

1. INTRODUCTION

Recently, the author has shifted his publication focus from reporting individual experiments to overarching publications to improve the field of human factors, and in particular, driving research. Publications include (1) a history of automotive human factors [1], which should be useful to those new to driving research and graduate students, (2) a writing guide for undergraduate students [2], (3) recommendations on how to quickly develop course materials [3], written for new faculty but useful to many others, (4) an SAE Recommended Practice defining driving performance measures [4], and (5) a summary of driving performance measures, presented at the most recent Automotive User Interface conference [5].

In that spirit, one overarching question is how publications on human factors and driving can be improved. Several publications provide statistics on why manuscripts are rejected [6 - 8] for journals concerning the social sciences, education, and medicine, but not engineering. The reasons why vary with the field.

This publication provides 11 guidelines to improve human factors (engineering) publications concerning driving based on the author's experience as a reviewer of journal articles (e.g., from *Human Factors*, *Applied Ergonomics*), conference papers, and student manuscripts. Selected papers from the 2010 Humanist conference (the most recent offering online) provide examples of following (and not following) the guidelines.

2. THE GUIDELINES

2.1 **Guideline 1: Make sure the manuscript is written as if the author was a native speaker.**

It almost goes without saying that a manuscript should be easy to read and understand, and not have grammatical or spelling errors, even if the manuscript is not written in the manuscript author's native language. Approximately 5% of the manuscripts recently reviewed are so badly written they are returned without any comments, other than suggesting the submitter seek the help of a technical editor. This is a troublesome situation as Microsoft Word, when set to English as the default language, flags repeated words, incorrect use of plurals, sentence fragments, and violations of the that-which rule. For additional guidance, the classic source is Strunk and White [9], though Plainlanguage.gov and related web sites are helpful. Further, even the best authors benefit from a review of their manuscripts by an experienced technical editor.

2.2 **Guideline 2: Allocate the most pages to what you have done.**

Most journals and conferences limit manuscripts to five to eight pages. When planning a manuscript, create a page budget (e.g., Table 1) to avoid wasting time writing and then cutting excessively lengthy sections. Emphasize what was learned and what is new, not the literature. If the introduction of a manuscript exceeds 25% of the page count, rejection is highly likely. The literature is not the story (unless the manuscript is a literature review).

Table 1: Suggested Page Allocation for a Five-Page Manuscript

Topic	Pages
title, author, affiliations, abstract	1/3 – 1/2
introduction	1
method	1 (or less)
results	1-1/2 (or more)
conclusions and discussion	1/2
references	1/2

Poor page allocation is primarily a problem for manuscripts, not publications such as those from the 2010 Humanist Conference. In fact, there are several thorough but brief literature reviews (e.g., [10]), whose brevity facilitates the desired page allocation.

2.3 **Guideline 3: List relevant standards, guidelines, policies, and procedures as keywords.**

Human factors research publications often do not make the connection between research and practice, which is a major problem. This connection is important to practitioners, who, for example, are estimated to be more than 80% of the members of the Human Factors and Ergonomics Society. One way to make the connection for practitioners is to list relevant standards and guidelines as keywords. In fact, the author believes that a standards keyword line should be required for journals and conferences such as this one.

Here is how it will work. If someone was reporting research on forward collision warnings, he or she should list SAE J2400 [11] and ISO Standard 15623 [12] in the standards-related keyword entry. Even better would be if the manuscript authors had read those standards before they conducted their research, and their conclusions provided the new text for those standards based on the research conducted. This would benefit (1) researchers (whose research gets into practice), (2) standards writers (who, when searching Google for their standard by its number, would find new research to include), and (3) practitioners (who will learn of applicable standards). Approximately half of human factors research is basic (but very worthy) research, so for those publications, there may be no connection. Nonetheless, the author feels very strongly that this listing should be required because it connects research to practice.

Implementing such a requirement will take some effort. The scope statements of most standards are inadequate, and after purchasing many standards whose titles seemed relevant, one finds that only a few are actually relevant. More complete and readily accessed information on standards, guidelines, and other requirements documents is needed. For instance, the author has published lists of standards related to driver interfaces with summaries of them in several places [13 - 15]. There is also a webinar on the Human Factors and Ergonomics Society web site, a benefit to members, providing an overview of human factors standards [16]. Furthermore, for the U.S., other potentially relevant documents include the NHTSA visual-Manual Distraction Guidelines, state laws (concerning cell phone use driver licensing), handbooks produced by the states and the National Safety Council on safe driving, guidelines for road design in the American

Association of State Highway and Transportation Officials (AASHTO) green book [17], guidance for sign, signal, and marking design in the Manual of Uniform Traffic Control Devices (MUTCD) handbook [18], and rules for hours of service of truck drivers (to avoid fatigue) from the Federal Motor Carrier Safety Administration. Certainly, there are similar rules, laws, and guidelines elsewhere. Papers at the 2010 Humanist conference did cite standards, primarily ISO standards, but some papers could have done more (e.g., [19]).

2.4 Guideline 4: At least half of the words in the abstract should concern the results and include numeric data.

As expressed by Baue [20], “writing a good abstract is not abstract writing.” A good abstract summarizes what was done, with about half of the abstract being results, so the reader can decide if they should read the entire paper. To comply with word limitations for abstracts, do not repeat the title in the first sentence, or describe the measures and conditions. Emphasize numeric data related to the procedure (e.g., the number of subjects) and driver performance (e.g. “The mean response time during the day was 1100 ms and at night was 50% greater”). If there is no substance in the abstract, then the publication probably lacks substance as well. Many abstracts in the 2010 Humanist Conference did not meet this content guideline.

2.5 Guideline 5: Present the research issues as 3-6 questions using the words who, what, when, where, why, and how.

A good introduction should say what the problem is, why it is important, and for publications, identify the relevant literature and what one should expect to find. Humanist Conference publications often refer to goals to identify the issues to be addressed, and are better than most publications in describing them. A more direct approach is to state the issues as who, what, when, where, why, and how questions. “What is the relative frequency of a driver being labeled inattentive versus attentive? ... What is the relative ... crash risk of eyes off the forward roadway?” [21].

Furthermore, as a corollary, verify that every question is also addressed in the results and in the conclusions. Subheadings for each question can help assure such.

2.6 Guideline 6: Provide numeric predictions of experiment outcomes.

Too often, authors just describe tests that were done with some discussion of how theories could explain the outcomes, explanations that appear tacked on in hindsight. Text such as, “Using so and so’s method, the mean task time with a unique tone as feedback should be 100 ms less than when no tone is provided” is desired. Methods such as GOMS [22] and SAE J2365 [23, 24] can be used to estimate task times, and there are many other methods to estimate driver performance. The lack of predictions makes research on human factors and driving look weak. The lack of predictions is not acceptable for other fields of science and engineering, and should not be acceptable here, as well. Admittedly, there are often times when so little is known about a topic that predictions cannot be made. Nonetheless, such predictions are uncommon in Humanist Conference publications.

2.7 Guideline 7: Show pictures or drawings of what subjects saw.

A picture is worth 1000 words. If a visual interface was examined, show example screens and label them (e.g., character sizes, lighting levels) to save text.

If subjects drove on a particular road, show example road scenes. Most Americans, even driving researchers, are unlikely to know what a particular motorway near London is like to drive. Similarly, few Europeans, Japanese, Koreans, Chinese, or others will have any sense of what Interstate 94 west of Ann Arbor is like. Most Americans would be clueless as well.

The screens subjects saw are already in computer format, and road scenes are available from video recordings and Google street view. If not, one can use a cell phone camera to record the desired images.

2.8 Guideline 8: Define dependent measures using SAE J2944 [4] for driving performance measures and SAE J2396 [25] and ISO 15008 [26] for glance related measures.

For the last seven years, the author, with considerable help from Gary Rupp, has been writing an SAE Recommended Practice (J2944) to define driving performance measures and statistics [4]. This effort was stimulated by an extensive literature review [27], which showed that many measures had 10 or more names and were only defined 10-15% of the time. The current version of J2944 is more than 170 pages long with 300 references. For each measure and statistic there is a definition, guidance on the use of the measure or statistics based on the literature, in some cases sample data from naturalistic driving, and a specification for how the terms should be cited. When creating definitions, the approach was to include all likely alternatives (options), so as to encourage referencing J2944. Thus, as shown in Table 2, many terms have more than two alternative definitions; with a recommendation being provided where there was a consensus.

Table 2. Selected Terms Having Operational Definitions in SAE J2944 [4]

Term (options)	Comments
response time	15 terms ... until accelerator moved, ... until brake lights on, ... until maximum jerk while accelerating, etc. with 2 or 3 options for each one
longitudinal measures	distance and time for each, see Figure 1; also range
time to collision (2)	plus minimum time to..., adjusted time to..., time exposed time to..., time integrated time to..., inverse time to...
required deceleration	
coherence	plus gain, phase angle, time delay
steering...	reaction time, movement time, response time, reversals (2 options)
lateral position (3)	
lane departure (11)	plus number of., duration, magnitude, time integrated magnitude
time to line crossing (3)	plus minimum ..., inverse ...
lane change (5)	plus number of ..., duration of..., severity, urgency
roadway departure (3)	plus number, duration of..., magnitude of... , pavement departure, time integrated magnitude.

As an example of why J2944 is needed, highway engineers have studied highway capacity for almost a century, defining headway as the time from when one vehicle passes until the next one passes. Human factors researchers studying crash avoidance are interested in the space between vehicles, which they mistakenly and routinely call headway, not gap, its correct name. If the lead vehicle is a tractor-trailer, then the difference between the two measures, the error, is the length of that vehicle, approximately 55 feet (16.7 m).

However, the current situation is even more complicated (Figure 1). Some driving simulators that provide "headway" as an output measure, use it as the distance from the center of gravity of one vehicle to another (which makes perfect sense for vehicle dynamics calculations). Other simulators use the spatial/geometric center as the reference. If the users of these simulators are asked what they are measuring, they will say "headway," but refer to it as the distance between vehicles (gap), when in fact it is a third measure.

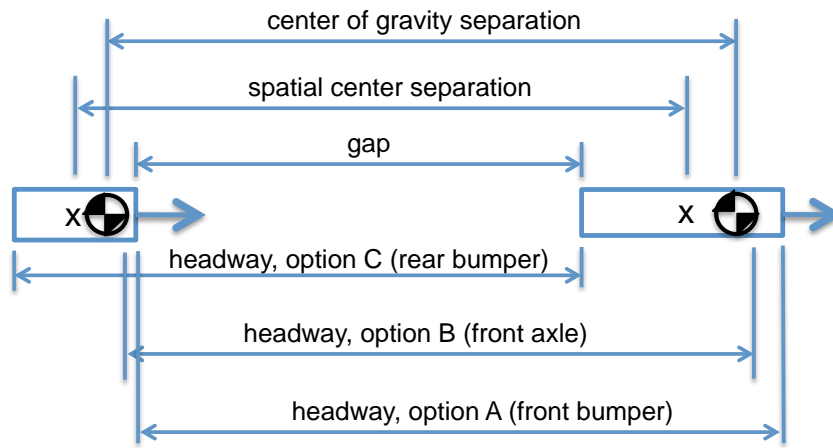


Figure 1: Vehicle Longitudinal Measures from SAE J2944 [4]

2.9 Guideline 9: Use interaction plots for independent measures and dual dependent measures instead of single variable plots.

A good publication provides a complete representation of the results. Often, one will see one figure showing the effect of age (just two bars, young and old), a second figure showing the effect of gender (again, just two bars), and a third figure with the interaction. Interaction plots, even when some factors are not significant, give a more complete representation of the results and require less space.

Similarly, in many driving studies, multiple dependent measures are collected, but they are examined individually, providing a nonintegrated picture. The reader is much better informed by figures that combine likely pairs of dependent measures, such as standard deviation gap and standard deviation of lane position. Figure 2 shows an example of steering angle and throttle angle from the SAVE-IT project. The two ellipses represent $p=0.90$ and $p=0.95$ if steering angle and throttle angle were from a joint normal distribution.

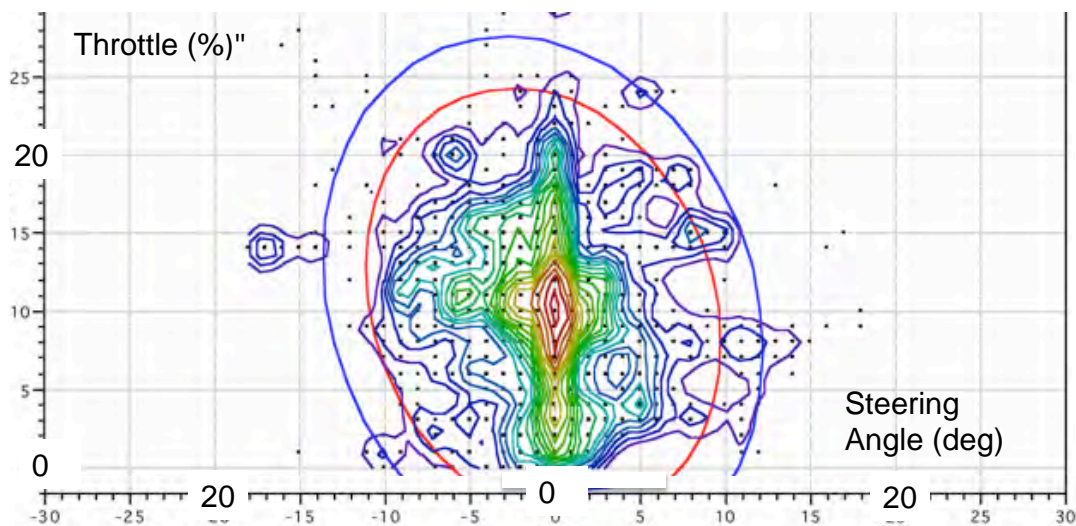


Figure 2: Bivariate Measures: Steering Angle vs. Throttle Angle for Freeways [28]

2.10 Guideline 10: Focus the analysis on regression analysis and means, not on ANOVA and statistical details of significance.

In psychology, a field that is a foundation for human factors, ANOVA is traditionally used to describe performance differences. However, human factors research is often conducted to predict performance, so regression analysis, a related method, is more appropriate. Furthermore, when regression equations are reported, the percentage of variance accounted for is also provided, which is useful information. For example, Whitehurst [29] describes a study of the factors affecting reading gauges (Table 3). In real designs, there are always compromises, but this table indicates that scale number progression should not be compromised as it accounts for the most variability in performance.

Table 3: Percent of Variance Accounted for by Various Design Factors from Whitehurst [29]

Factor	% Variance	Factor	% Variance
Numerical progression	38	Pointer design	0
Interpolation	9	Scale number location	0
Scale unit length	4	2-way interactions	5
Scale orientation	1	Subjects	17
Marker width	0	Residual	25
Clutter	0	Total	100

After statistical significance has been established, a publication should focus on mean differences or effect sizes. Do the results pass the “so-what test?” “There was a statistically significant difference between men and women (men were 3% less) for the rainy – nighttime condition, when subjects were tired.” ... “So what?”

There are many times when exhaustive reporting of statistical significance, listing the degrees of freedom, F value, significant level, eta value, and other statistics for one measure after another, including those that are not statistically significant, gets in the way of understanding what was found. Place those details in a table or in an appendix, or omit them. Those that are more statistically savvy than the author may disagree.

2.11 Guideline 11: Make sure the references are complete and follow the required format.

Problems in complying with this guideline occur when the manuscript is not written in the native language of the manuscript author. Manuscript authors follow the appropriate basic style, either the Harvard (author, year) style favored by psychological, educational, and many human factors publications, or the Vancouver (number reference style) favored by IEEE [30]. However, manuscript authors appear to ignore the specific format required (American Psychological Association, Modern Language Association, American Medical Association, University of Chicago, etc., <http://www2.liu.edu/cwis/cwp/library/workshop/citation.htm>). As with poor grammar, reviewers do not like spending time on such low-level corrections -- formatting references. Particularly troublesome is where references are formatted inconsistently, (e.g., some titles are in quotes and some are not, some journal names and book titles are underlined and some are italicized, author names are provided in multiple ways). Bibliographic software (e.g., Endnote) can easily resolve these problems.

3. CONCLUSIONS

This paper lists 11 guidelines to improve the ease of use and usefulness, and the overall quality of human factors publications on driving. Some of these guidelines are quite straightforward, such as writing as a native speaker, allocating page content to new material, checking reference formats, and providing pictures of stimuli and roads. Five guidelines, two of which are linked, are particularly important.

First, many papers, especially by novice authors (e.g., students) fail to clearly identify what the question or questions to be addressed are (for example, using the words who, what, when, where, why, and how). Further, even experienced authors often do not provide quantitative predictions of the expected outcomes.

Second, the focus on analysis needs to shift towards balancing the statistical and practical significance by emphasizing regression analysis and by reporting mean differences. What really matters, and by how much?

Third, much more needs to be done to translate research into practice. One mechanism is to add an entry --- relevant standards, guidelines, policies, and procedures -- below the existing keyword entry at the beginning of most papers.

Fourth, the author also strongly advocates that papers reporting driving studies must comply with SAE J2944, or provide definitions of equivalent detail.

Following these guidelines will improve the quality of research concerning human factors and driving. Most publications provide sufficient descriptions of the test method and proper tests of statistical significance. However, many publications fall short in terms of replicability and applicability, and as a consequence, are viewed by researchers in other fields of science and engineering, as not as good as they should be. These guidelines provide the direction needed to improve the quality of research on the human factors of driving.

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AIRPORT ROAD ACCESS DESIGN SOLUTIONS: A CONCEPTUAL STUDY OF WAYFINDING SYSTEMS

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ABSTRACT

The growth of the airport in the world will have a significant impact on future road access design. Pressure by drivers for simplifying of airport wayfinding has led to the inclusion of basic road access design so as to reduce the cost. An effective of wayfinding is directly linked to the reduction in drivers' travelling cost and number of road accidents. Drivers prefer an effective airport wayfinding system in airport areas to navigate easily. This has raised an aim to investigate ways in which airport road access design can be improved, through a conceptual study of both wayfinding design and signage information systems. It leads to the exploration of the new field of the study in order to propose appropriate guidelines and solutions on airport navigation with an emphasis on simplifying the wayfinding provision design in a future.

Keywords: Wayfinding; Signage design; Driver behaviour; Navigation system

1 INTRODUCTION

Wayfinding is an important activity that people do throughout their entire lives as they navigate from one place to another. Lynch (1960) stated that the wayfinding is the progressive process which used by people to arrive at the destination successfully. Charpman and Grant (2002) stated that wayfinding helps people to identify their location, next destination, and to choose the best route to the intended destination. Montello and Sas (2006) agreed that wayfinding occurs when people need to travel from one place to another on the intended route and direction without having accidents or getting delayed and reach the destination successfully. It is also important to distinguish the

destination upon arrival and reversing the process to find the way back. In this paper, drivers' wayfinding is defined as a process in which people make a decision (choose) to navigate using information support systems (clues) such as maps, lighting, sight lines, and signage, and arrive at the destination (results) successfully.

The lack of wayfinding provision in airport areas has discouraged the interests of drivers and much effort has not been directed towards understanding the concepts and its practicality (Darken and Sibert, 1996; Burns, 1998; Montello and Sas, 2006). An ineffective number of signage has been constructed around airport areas which distracts the wayfinding. Harding (2012) stated that many airports have not established the concept of 'simple', functional and less is more' on airport navigation system. Therefore, the airport has less attractive and competitive than neighbourhood airports [Airport Cooperative Research Program (ACRP), 2011; Alhussein, 2011]. In many cases, drivers experience most difficulties to understand a complete wayfinding process which stimulates a distraction while driving (Bhise et al., 1973; May et al., 2005). The distraction from inadequacy of signage (i.e. too much advertising signage) in airport road access areas could increase confusion of drivers and road accident (Mitchell, 2010; Wener et al., 1983).

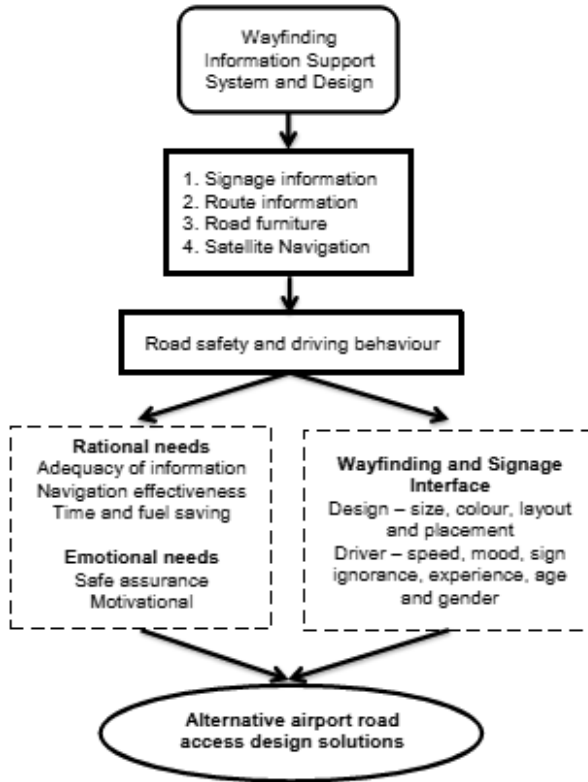
From the literature search, it was realised that the cost of airport facilities (including wayfinding) regularly appeared in airport studies as a benchmark for measuring industry performance (Graham, 2003; Corlett et al., 1972). The lessons learnt from the literature search were quite surprising and the need to fill a knowledge gap (examining the effects on the wayfinding and road safety) appeared to be necessary (Carsten and Tate, 2005; O'Neill, 1991). As a remedy to counter this problem, efforts to investigate the effect between wayfinding, road safety and drivers' expectation are crucial.

2 SETTING OF THE SCENE

Wayfinding is a natural skill which drivers used common-sense knowledge of geographic space. Drivers need adequate information to continue their travelling. A good signage aids drivers' navigate easily (Butler et al, 1993).

Figure 1 shows the conceptual framework as the result of a literature review of wayfinding provision.

Figure 1: Drivers' wayfinding process (Author, 2014)



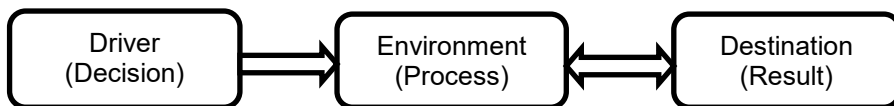
2.1 Wayfinding and Signage Information System

A straightforward design has been adopted in the structure of wayfinding design. Simplifying wayfinding provision will eliminate the effort in delivering an aesthetic value of signage as the aim is to reduce investment cost. Signage provides a directional guidance, reassure drivers about intended location, sites of local services, speed limit and warn of upcoming changes or hazards. Findlay and Southwell (2004) stated that wayfinding is involved a variety of driver's strategies and sources of information afforded by the landscape of which signs are a key component, often supplemented by paper maps and word of mouth. Signage information of wayfinding represents a form of social control to limit people movements and behaviour

(Dann, 2003, cited in Findlay and Southwell, 2004). According to Transport Scotland (2013), the wayfinding principles are suggested as below:

- a. Fewest possible signs of the smallest adequate size in the clearest and simplest form.
- b. Clarity of the signs information, fonts, backdrops and colours.
- c. Increasing the number of signs can cause more vagueness and confusion without solving the problem.

Figure 2: Drivers' wayfinding process (Author, 2014)



Wayfinding is useful for making a quick decision due to complex road access design. Figure 2 shows drivers' wayfinding process.

- i. Driver (Route decision)
Complete information concerning decision alternative ways of road access is available and feasible to drivers.
- ii. Environment (process)
Drivers use alternative surrounding objects (i.e. wayfinding, signs and landmark) and processes into valuable information. At this point, drivers develop alternative shorter distance in which presentation of right information is crucial.
- iii. Destination (Result)
Drivers eliminates an excess in travelling based on amount of information received which includes the financial cost (i.e. fuel costs and tolls) and the opportunity cost (i.e. time spent travelling) on their journey.

Drivers use two immediate elements of wayfinding; choices and clues. Choices are related to instance decision points in wayfinding (Raubal and Egenhofer, 1998). Decision points (also refer as choice points) are the points where drivers need to make a quick decision using available information (i.e. exit from highway and split between roads leading to terminal and parking). The choices give opportunity to drivers to decide two or more alternative way

on road access. Driver tends to use a clue to make estimation on road architecture. Clues include any signs and physical architecture along the road. Mitchell (2010) agreed signage should be specific, designed and placed in accordance with national standard in which advantages to drivers in terms of locate, read and understand them within a timeframe. According to ACRP (2011), the signage needs to be conspicuous, legible, brief, understandable, and located a sufficient distance from the choice point to allow enough time to detect, read and make a decision. Table 1 explains the signage information indicator components.

Table 1: Signage information indicator (Source: Transport Scotland, 2013)

Indicator	Issues
Traffic direction	The flexibility of signage indicates a number and size in certain circumstances on road access design.
Safety	Too much signage discourages drivers' complacency which contributes to accident risk. A detailed evaluation to ensure that only minimum wayfinding provision has been proposed.
Adequacy of information	Pressures by business, road users and tourism agencies for information signs alongside roads allocation. The effectiveness of existing signs, or related signage information is necessary.

2.2 Impact of Navigation System

Navigation is defined as an integrated system which involves traditional and modern wayfinding elements. These elements turn to effective wayfinding if up-to-date information is loaded sufficiently. The navigation system (i.e. satellite navigation) conveys route guidance to the driver using both visual and audio display, respectively. The research found that the recorded navigation directions produced shortest routes (in terms of distance and time), and resulted in the fewest navigational errors. Parkes (1993) stated

that the vocal directions (i.e. left, right, straight on) may be more demanding than pictorial symbolic information (i.e. arrows) as to be interpreted in a particular context. Parkes argued that vocal directions are superior. The effect of visual and auditory modality received most attention in previous research due to its relative contribution to normal safe driving behaviour.

In order to increase road safety, the adaption of both traditional (i.e. paper maps) and an electronic navigation system has been recommended. Streeter et al. (1985) agreed that several traditional navigation methods (i.e. paper maps, recorded vocal directions, customized route maps and a combination of the latter two) aids drivers' in their journey. Burnett (2000) stated that the electronic navigation system display position affected the frequency of glances to the display and number of navigational errors, such that a low position resulted in less glances and more navigational errors. Bhise and Rockwell (1973) supported that the duration of glances towards road traffic signs were almost twice as long in low density traffic as in high density traffic.

Satellite Navigation system (Sat Nav) has changed the traditional wayfinding processes in which real-time of wayfinding navigation can be introduced. Sat Nav user tends to drive slowly and in some circumstances they probably stop driving completely, particularly when approaching junctions. Although this may appear to be safety behavioural adaptation, speed reductions occurred without consideration of traffic regulations has been notified. Driving in an unfamiliar area engaged in 50% fewer cases of unsuitable driving behaviour than those using conventional navigation methods [Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO), 2007]. TNO agreed that drivers faced unfamiliar areas; journey distances and durations were shorter for those using electronic navigation systems than those using conventional navigation methods. In many cases, drivers have difficulties to follow the Sat Nav system due to fewer obstacle (i.e. too concentrate on signage and focus on road) which caused to stress, delay and potentially unsafe road behaviour such as late lane changes or attempting to read paper or screen maps while driving (May, Ross and Bayer, 2005).

3 CONCLUSIONS

The research provides worthwhile concepts for the design of efficient

wayfinding provision. The results contribute to the following areas:

1. Better understanding and improvement of airport wayfinding information support systems for airport road access design solutions.
2. Integration of traditional (i.e. signage and paper map) and modern (i.e. Sat. Nav) wayfinding to enhance the interaction on sign information.

The research will be beneficial to develop an adequate wayfinding provision in which able to increase a quality of drivers' navigation in airport areas. The research contributes for a safe navigational system to be adopted by parties involved (i.e. drivers, airport authorities and road planners). Furthermore, there are two areas that can benefits to the society. A better linkage and transportation of wayfinding information system connects parts of transit systems to each other, one design to another, and activities and places (i.e. signage). Secondly, the road access to the airport can be improved as it will complete a wayfinding information process to the destination successfully.

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DRIVER'S SITUATION AWARENESS DURING SUPERVISION OF AUTOMATED CONTROL – Comparison between SART and SAGAT measurement techniques

Arie P. van den Beukel, Mascha C. van der Voort

ABSTRACT: Systems enabling to drive automatically are being introduced on the market. When using this technology, drivers are in need for interfaces which support them with supervision of the automated control. Assessment of Situation Awareness (SA) which drivers are able to gain while using such interfaces, is important. Based on comparison between SART and SAGAT measurement techniques within a simulator study, the test set-up presented in this paper suggests to be successful in providing a coherent test-bed with relevant situations to assess the level of SA drivers gain when involved in supervision of automated control and while using different types of feedback.

1 INTRODUCTION

Automotive industry has started implementation of automated driving for the consumer market through introduction of driver assistance which allow both lateral and longitudinal system control during specific situations within existing infrastructure (e.g. motorway cruising). The systems introduced are based on semi-automation meaning that automation is only possible when specific boundary conditions are being met, like detection of road lines and driving on motorways. This requires human (driver) readiness to act as a back-up in case automation fails or exceeds her boundary limits. The role of the driver therefore changes from actively operating the vehicle to supervising the system during automation. However, performing supervisory tasks is related to low vigilance, causing e.g. slower reaction times and misinterpretation when intervention is needed [1]. Carefully designed driver-interfaces are therefore needed to support drivers in their additional role to supervise the automation. During this development, a difficulty is to assess the contribution potential interfaces have in supporting drivers with their supervisory task. Although it is commonly recognised by researchers that measurement of Situation Awareness (SA) is relevant to assess driver's

ability to take back control, there is limited consensus on the appropriate technique to measure SA. Two techniques are most common: SART (a self-assessment method) and SAGAT (a probe-taking method). The reliability and validity of both techniques are subject to discussion [2]. Also an earlier experiment by the author intended to measure SA in circumstances relevant for semi-automated driving (i.e. taking back control) showed contrary results between SART and SAGAT [3]. Although most existing studies show results in favour of SAGAT, by e.g. showing better face validity [2], the result of the author's earlier experiment indicated that SAGAT was producing false scores. Therefore, the goal of this research is to renew the test set-up, update the scenarios and evaluate whether these changes help in establishing a more coherent framework for SA-assessment when using both SART and SAGAT techniques for the assessment of interfaces which support supervision of automated control.

2 MEASURING SITUATION AWARENESS

Endsley defines Situation Awareness as the “perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future” [4]. This definition is well accepted within the research community [2]. However, ambiguity exists on how to measure SA. Two rating techniques are most popular: SAGAT and SART.

The Situation Awareness Global Assessment Technique (SAGAT) involves the administration of queries during ‘freezes’ in a simulation. The queries relate to probes and need to be tailored to represent 3 levels of SA, in line with Endsley's definition, i.e.: level 1 Perception, level 2 Comprehension and level 3 Projection. An example of a level 2 question is: “What vehicle's manoeuvre is currently (i.e.: during ‘freeze’) causing a dangerous situation?”. Applying SAGAT requires intensive preparations. Nonetheless, the objectivity of this technique, while using predefined probes which are representative for the relevant elements to comprise Situation Awareness, is its main advantage.

The Situation Awareness Rating Technique (SART), on the other hand,

involves self-assessment of SA by participants based on standardized queries and is typically administered post-trial [5]. The technique accounts for individual differences in attention and available cognitive resources to achieve SA: the standardized questions encompass three groups: (1) "Demand", referring to variability and complexity of a situation; (2) "Supply", referring to applied cognitive resources and (3) "Understanding; referring to quantity and quality of understood information. After taking cumulative group scores, a total score is calculated according to $SA-SART = U - (D - S)$.

Validation studies have only found moderate correlation between sub-scores of SA, i.e.: between SAGAT level 1 and overall SART [5] and between SAGAT level 1 and SART-Supply [2]. According to Salmon [2] no studies have reported significant correlation between overall scores of both methods, leading to the conclusion that the SAGAT and SART are actually assessing different aspects of SA. SAGAT, essentially measures the extent to which a participant is aware of pre-defined elements in the environment and their understanding of these elements. SART, on the other hand, provides a measure of how generally aware participants perceive themselves to be without referring to specific elements within the environment. Several studies have shown significant correlation between overall SAGAT scores and overall performance whereas SART did not show this relation [2],[6]. Therefore SAGAT is regarded the more reliable technique for assessing SA. As explained in the introduction, a previous study of the author, showed contrary result. Due to the test set-up it was presumed that SAGAT produced false scores. Therefore we decided to compare again both techniques within a renewed set-up.

3 RELEVANT DRIVING SITUATIONS TO TEST SA

The presumed false scores within the previous study are most likely due to the test set-up, involving quite many relatively short trials with limited variation in the accompanying driving situations, making the experiment to be

like a reaction test based on impulsive reactions without much cognitive throughput. Moreover, the time duration between probe occurrence and probe taking seemed to have caused misunderstanding to what situation in time the probes were referring. Therefore we wanted to renew the situations. Based on system boundaries we therefore defined six scenarios, which differed in hazardous and critical situations. The hazardous situations required attention, without direct necessity of intervention. A hazardous situation could develop into a critical situation which would require the driver to intervene. System boundaries for semi-automated driving depend on available technology (e.g. performance of sensors and algorithms) and on choices in system design (e.g. defining a boundary speed). Within this study the concept of congestion assistance is taken as a reference: the system operates only with a maximum speed of 50 km/h, if lines are being recognised, if a target vehicle is being recognised and if driving on a motorway without roadwork. In line with these system boundaries, we have defined three critical scenarios which involve accident avoidance. These scenarios are:

- **Emergency Brake (EB)** - While driving automatically, the target vehicle makes an emergency brake and comes too close, violating minimum distances. This causes the system to warn and requires the driver to take over control. Without intervention a collision would occur.
- **Merge Out (MO)** - While driving automatically, the target vehicle merges out to the left lane. As there is no new target vehicle on the own lane, the ego vehicle terminates automation and requires the driver to take over control. Without intervention the ego vehicle would drift out of lane with the danger to collide with neighbour vehicles.
- **Cut-in (CI)** - Just before an exit and while driving automatically, a vehicle from the left lane cuts in closely in an attempt to take the exit. With this manoeuvre the vehicle comes too close, violating minimum distances. This causes the system to warn and requires the driver to take over control. As the cut-in vehicle continues to brake, reluctance to intervene would lead to collision.

As we want to assess support drivers are provided with to execute their supervisory task, we also included three rudimentary interface-types which differed in their way to offer feedback. The characteristics of these feedback-types are: Type A provides only audible feedback. The system's detection of

an hazardous situation was announced by an alerting one-tone sound, while a critical situation used an alarming 3-tone sound (both exceeding the simulated engine and road roar with about 12 kHz). Type B provides in addition to the same audible feedback a simple textual feedback to indicate whether the audible warning is for a hazardous or critical event. Apart from the audible warning (which was again the same as for type A), type C also provide detailed visual feedback on system status, like successfulness of detecting a target vehicle. The belief was not that these types of feedback would be particularly good, but the intention was to serve as an input to have something to compare during measurements.



Fig. 1 Driving simulator used for the experiment

4 DRIVING SIMULATOR EXPERIMENT

4.1 Task and Simulator Environment

Participants were seated in a mocked-up vehicle, which was placed in a simulated motorway environment, as shown in figure 1. Every participant drove 6 test trials with different driving situations. Within each trial, participants drove automatically, but remained responsible for safe driving. Their main task was to supervise system operations and to intervene when required. As described in the previous section, an interface supported the drivers with their supervisory tasks, by either requesting extra attention (so

called 'soft warning') or requesting intervention (so called 'hard warning' for critical situations). In order to include realistic circumstances, participants had functionality at their disposal from a smartphone and were invited to read mails and review a calendar. As participants remained responsible for safe driving, they were advised to divide their attention appropriately. Judgement whether it would be necessary to intervene, was at the driver. Common automobile control interfaces, including a physical steering wheel and physical gas and brake pedals, allowed participants to take full control of the vehicle if necessary. Other vehicles drove in front and behind the simulated vehicle, as well as on the neighbouring lanes. All vehicles drove with time headways between 1 and 1,5s. at about 50km/h, as to simulate jammed traffic. Between experiments the position of the neighbouring vehicles was identical per situation to ensure that every participants got the same chance of resolving the situation.

4.2 Experimental Design

The independent variables for the experiment comprised of 'situation' and 'feedback'. 'Situation' was manipulated within subject: Each participant was confronted with three hazardous situations (which required extra attention) and three critical situations in which it was necessary to retrieve control (and avoid an accident). To make the situations non-predictable, the order between situations was arbitrary and also one condition was added in which no extra attention or take-over was required. 'Feedback' was manipulated between subjects and divided over the situations in order to have each feedback-type tested in every situation 8 times. The division of 'feedback' over the situations was randomized for each participant to avoid influence of carry-over effects. Shortly after a hazardous or critical situation occurred, the simulation was paused. Then, the screens were put blank and the experimenter subjected the participant to a SAGAT and SART questionnaire. The order of questionnaires was alternated between the trials. Each SAGAT questionnaire presented three questions based on probes tailored for the specific situation afore. An example is: what caused the system's request for extra attention? Depending on the situation, the correct answer would be "approaching end of motorway", "failure to detect roadlines", etc. After completing both questionnaires, a new trial started.

4.3 Participants and Procedure

24 persons were recruited and had at least one year of driving experience. Participants were either students or university personnel, their age ranged from 20 to 40 years old. Per participant the experiment lasted 1 hour with 15 minutes of instruction and training with the driving simulator and 6 times a 6-minutes trial. Per trial the automated driving lasted between 2,5 and 3 minutes until the simulation was paused to fill in the SA questionnaires. 3 Trials required take-over of control. The experiment was timed to ensure that simulation paused after the ability to retrieve control. The experimenter started each trial manually while the participant was directly driving automatically.

Table I: Comparison between SAGAT and SART scores per feedback-type and depended on situation

	SAGAT scores			SART scores		
	Feedback-type			Feedback-type		
Critical situations	A	B	C	A	B	C
1b; Emergency brake	1,86 ¹	1,75	2,00	4,83 ¹	5,10	<i>3,98</i>
2b; Merge-out	1,88	1,63	<i>1,38</i>	5,59	5,14	4,54
3b; Cut-in	2,00	2,50	2,25	4,50	3,79	4,58
Average all critical situations	1,91	1,96	<i>1,88</i>	4,98	4,68	<i>4,37</i>
Possible range low – high SA	0 (“low”) to 3 (“high”)			-5 (“low”) to 13 (“high”)		

¹) based on n=7, all other conditions n=8

Note: **highest scores** are highlighted in bold and lowest scores with italic and underlined font.

5 RESULTS

Depended on situation, table I shows a comparison between overall SAGAT and SART scores per feedback-type. According to both SAGAT and SART, feedback-type C scores lowest on average over all situations. SAGAT and SART scores differ in indicating the feedback-type with highest scores. According to SAGAT, type B scores highest on average. The highest average SAGAT score of “1,96” for type B indicates that 5 out of 8 participants were able to perceive, understand and predict future states of any situation correctly with feedback-type B. Over all, situation 3b (“Cut-in”)

with feedback type B enabled participants to gain highest Situation Awareness according to SAGAT. According to SART, type A scores highest on average. The minimum and maximum values were scored in different situations. This could be explained by the fact that SAGAT is an objective measure and SART a subjective measure, while differences between the critical situations are likely to cause SA perception in one situation to be comparatively lower or higher than in another situation. However, in this study the influence of situation on SA-scores is not included.

Table II: Comparison between subscores SAGAT-level 2 and subscores SART-U per feedback-type and depended on situation

Critical situations	SAGAT-level 2 scores			SART-U scores		
	Feedback-type			Feedback-type		
	A	B	C	A	B	C
1b; Emergency brake	0,86 ¹	1,00	<i>0,63</i>	3,90 ¹	4,29	<u>3,58</u>
2b; Merge-out	0,75	0,88	<i>0,63</i>	5,21	4,83	4,50
3b; Cut-in	0,75	0,88	0,75	4,08	4,54	4,46
Average all critical situations	0,79	0,92	<i>0,67</i>	4,40	4,56	<u>4,18</u>
Possible range low – high SA	0 (“low”) to 1 (“high”)			1 (“low”) to 7 (“high”)		

¹) based on n=7, all other conditions n=8

Note: **highest scores** are highlighted in bold and *lowest scores* with italic and underlined font.

Both SAGAT-level 2 and SART-U scores are referring to SA-level 2: Understanding.

Table II shows a comparison between the subscores SAGAT-level 2 and SART-U. This is important because both subscores refer to the second level of Situation Awareness, i.e. Understanding. With SART-U, participants were asked to give a self-assessment on (a) gained information, (b) quality of understood information and (c) familiarity with the situation. With SAGAT, probes were taken to measure whether the participant understood what aspect required attention in the situation, like approaching end of motorway, or a failure to detect road lines, etc. The results show that the subscores SAGAT-level 2 and SART-U succeed in indicating the same feedback-types with highest and lowest scores. According to both measurements, type B scores best. The highest SAGAT score of “0,92” for type B as average over all situations indicate that on average 7 out of 8 participants were able to understand any situation correctly with feedback type B. The perception of

correct understanding (based on SART) was relatively lower (score “4,56” in a range from 1 “low” to 7 “high”), but according to SART participants also perceived type B overall best.

6 CONCLUDING REMARKS

In comparison with the results from the earlier study [3], giving contrary outcomes of gained driver’s SA based on SART and SAGAT scores, the results from this study are encouraging as SART and SAGAT do not show conflicting results. Based on the used SA-measurement techniques, the proposed test set-up seem to be successful in discriminating between the quality with which feedback-types support drivers in their supervisory task. Therefore, we carefully conclude that this renewed set-up does succeed in providing a coherent test-bed with relevant situations to assess the level of SA drivers gain when involved in supervision of automated control and when retrieving control is needed. However, when comparing the results it has to be noted that both for SAGAT and for SART most scores do not differ significantly between conditions. Hence, further assessment with regard to significance and variance between the scores is needed. Moreover, differences in SART-scores between the conditions are low, especially when we acknowledge that these scores could theoretically range between “-5” (low SA) to “13” (high SA) with a median of “4”. Our testscores only ranged from “3,98” to “5,59”. Maybe this is due to the variety of questions involved in the SART questionnaire. Besides from ‘Understanding of the situation’, these questions also refer to ‘Supply of cognitive resources’ and ‘Demand of the situation’. It could be that the amount and variety of the questions work as a ‘damper’ on the scores. Furthermore, it is interesting to mention that it is against expectations that feedback-type C scored worst, while C offers the most ‘rich’ feedback with both audible and visual information and was therewith expected to offer more support in understanding the circumstances that caused a critical intervention. An explanation for this unexpected result could be that the extra information caused participants to be distracted and therefore less concentrated on the actual traffic situation outside the vehicle.

Concluding that the division of lowest and highest scores were not according to expectations, underlines the necessity to further develop appropriate interfaces for supervisory control of automated driving and underlines the importance of thoroughly testing interfaces in representative situations before making decisions on implementation. For the latter, the results of this research give an important contribution, while providing solutions for assessment of involved levels of Situation Awareness.

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Human Centred Design of a smart phone alert application for drivers

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Abstract

Smart phone applications developed to support driving task could be powerful tools to contribute to drivers' safety, eco-mobility and comfort, by allowing real time and quick widespread of critical road information, using geo-location and social networking. Furthermore, downloading smart phone applications is easily accessible at low cost for the drivers. Nevertheless, several issues such as distraction linked to the use of smart phone while driving and reliability of the transmitted information might be critical. In this framework, a survey has been conducted in order to evaluate drivers' usability and acceptability of a collaborative mobile service related to critical road events alert. This analysis showed that drivers are more confident in information displayed by the mobile service than any other sources of road alerts such as radio and variable message signs. Furthermore, senior drivers were motivated to use the mobile service, with a main concern dealing with road safety, and senior participation to the social network in order to generate information to the community was important even if their mileage was lower than younger drivers. Only few drivers recognized some interference with the driving task while using the application. Real road experiments would need to be conducted to evaluate positive versus negative impact of mobile services use while driving.

Keywords: driver safety, traffic information, human factors, mobile transport service, driver generated content, social network in transport, design, acceptability, usability, alert information.

Introduction

At the end of 2011, there were about 6 billion mobile subscriptions, estimates "The International Telecommunication Union" [1], which corresponds to 87 percent of the world population that would be concerned. Within this context, the worldwide smartphone market grew 54.7% year over year in the fourth quarter of 2011 [2]. In relation to this deployment of smartphone, there is a corresponding increase access to sophisticated services such as internet and geo-location [3](Figure 1).

Indeed, over 300,000 mobile applications have been developed in the last three years, with 10.9 billion times downloads; and demand for download mobile applications is expected to peak in 2013. Japanese consumers are still more advanced in mobile behavior, using mobile Web, applications and email more than US or Europeans [4].

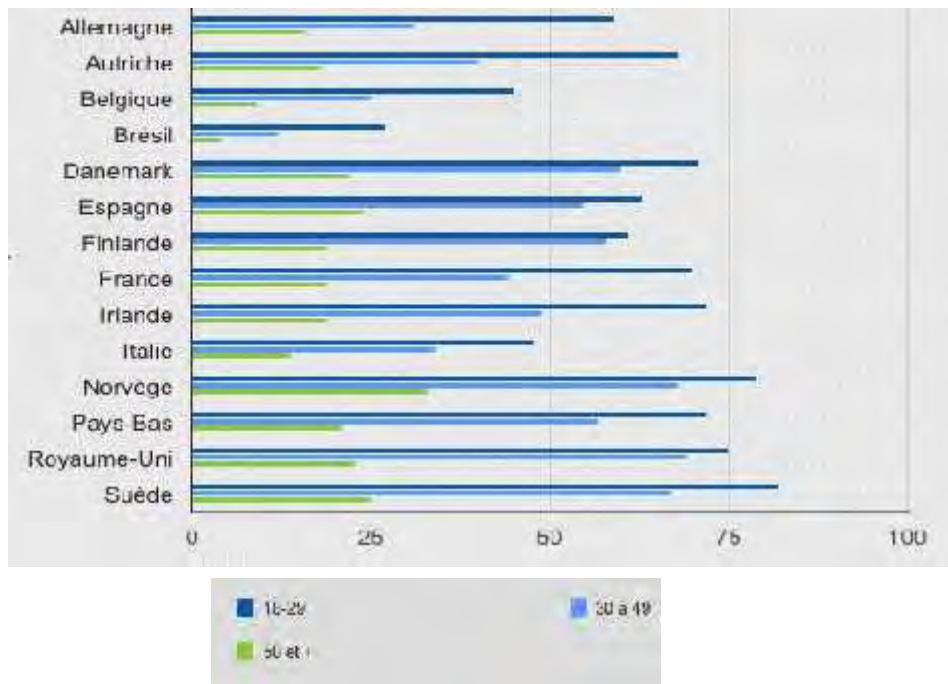


Figure 1: Smart phone audience by age group in 2012.

In this framework, distraction related to the use of mobile phone while driving has been seriously studied as it can induce an important decrement in road safety. Indeed, even when it is a hand free device, which intends to reduce or eliminate the distraction arising from manual operation, the mobile phone conversation impacts on situation awareness and performance. It has been shown for young and senior drivers [5] as well as for experienced and novice ones [6]. Even if novice drivers committed generally more driving infractions in terms of speeding, collisions, pedestrians struck, stop signs missed, and centerline and road edge crossings, and were less aware than their experienced counterparts, however, the two groups suffered similar decrements in performance due to cognitive distraction while speaking on the hand free mobile phone. An other experiment on real road using hands-free devices confirmed these results, showing that drivers changed their visual behavior due to cognitive load [7]. Changes in visual behavior were most apparent; when looking outside of the vehicle, drivers spent more time looking centrally ahead and spent less time looking to the areas in the periphery. Drivers also reduced their visual monitoring of the instruments and mirrors, with some drivers abandoning these tasks entirely. Furthermore, when approaching and driving through intersections, drivers made less inspection glance to traffic lights and their scanning of intersection areas to the right was also reduced. Vehicle control was also affected; during the most difficult cognitive tasks, there were more occurrences of hard braking.

So, driver distraction induced by conversation on mobile phone, even hand-free, has been clearly demonstrated by several experiments among diversified drivers population and various driving contexts. But conversation is an activity disconnected to the driving task, and has to be conducted by the driver in addition to the control of his/her driving task, inducing then a high potentiality of interference.

The issue of distraction is more complex to evaluate when considering smart phone applications devoted to support the driving task, that could both bring useful information to facilitate the driving task and create distraction and interference linked to the requirement for the driver to manage this information.

Among these mobile applications, some of them are aiming at increasing drivers' comfort, eco-mobility [8], ridesharing [9] and safety. Scopes of these applications can be real time feedback to the drivers related to their fuel consumption, but also anticipation about road events (traffic and critical zones) and information about critical distance of the vehicle in front,

For example, some low cost smart phone applications allow giving information to the driver about the distance with the vehicle in front based upon the phone camera (Figure 2). Three levels of information are transmitted to the driver corresponding to the levels of criticality: green for safe, orange for careful, and red for danger.



Figure 2: Example of display for smartphone application informing the driver about the safety of the distance with the vehicle in front (on the picture, the color green symbolizes that the distance is safe).

Closely linked to the widespread of the smartphone use, there is a tremendous increase in social networking activities. The mobile media technology allows drivers and travelers to communicate and to collaborate in virtual communities and networks [10] (Figure 3).



Figure 3: Example of display for ride sharing smartphone application informing the driver about the location on real time of a pedestrian belonging to the community and asking for a ride. This application raises several issues in terms of distracting effect on the driver in addition to personal data privacy.

Networking is also used to make real time road events circulating among members of a community in a process that can be called “ *user-generated content* », where each member sends information to the others on a voluntary basis. These innovative applications could constitute an efficient and low cost tool to inform drivers about real time events happenings with positive impact on road safety. Indeed, there is a clear drivers' need to be quickly and

accurately informed about critical road events, traffic information and critical zones in order to anticipate, or even to avoid these events. Nevertheless, little is known about actual drivers' use and needs of these applications while driving, and little is known about trust and motivation of the drivers' social community to participate to this activity, neither about its actual efficiency.

Objective of the survey

An investigation has been conducted among drivers of a dedicated mobile service centrally managed based upon the principle of "driver-generated content" for road alert information, in order to understand usability and acceptability of this service. This service allows drivers to inform the members of the community about location and type (accidents, roadwork, obstacle, etc...) of critical road events. Community participation is on a voluntary basis principle for the driver with an easy access to the buttons allowing communicating information in real time to the network via the service management system whenever the driver detects critical event on the road, with touches on tactile screen available anytime on the main screen of the system. A survey using internet media has been launch in cooperation with the service provider to investigate several issues linked to the use of this service. This survey was composed by a set of 141 questions, covering various issues such as users' profile, frequency and context of use of the service, understanding of functionalities and interfaces design, evaluation of the type of buttons the driver would use to inform about road events such as obstacle on the road, accident, icy road illustrated by photos, trust in the information displayed by the service. Several questions were dedicated to the social network level of participation to the community, motivation regarding this participation, potential interference and annoyance while driving when informing or validating information for the community, current number of stars symbolizing driver's reliability, trust in the other network members.

Most of the questions were closed-ended, some of them were open in order to better understand reasons and motivations regarding answers. Filling the survey required about 20 minutes. The announcement of the survey has been sent by mail to about 20 000 drivers using the smartphone service and selected according to two criteria: an annual subscription to this service and more than 6 months of experience. A total of 988 of these drivers filled in completely the survey.

Results

Drivers are using the mobile service very often, mostly several times per week or every day, with 42,3% on motorway, 38% on national/departmental roads and 19,65% in urban area. The service is considered as being the more comfortable to use in motorway context for 85% of respondents and in urban area for only 1%.

The main essential reason for using this application was "to keep points of the driving license" (87%), knowing that, in France, each violation to road code leads to demerit points withdrawn from the 12 original driving license points, and over speeding in a dangerous zone can result to points loss, with 1 demerit point for over speeding under 20 km/h of the speed limit and 2 demerit points for over speeding between 20 to 30 km/h over the speed limit. Being informed in advance about these zones allowed drivers to adopt the right speed.

The other reasons to use the service, far less priority, were "reliability of the information coming from the community" (45%), "size of the community" (44%) and "road safety issue" (44%), in comparison with other issues such as "system easy to use" (28%), "friends recommended the service" (18%), "innovative technology" (15%) and "to belong to the community" (13%).

Generally speaking, efficiency of the social network and reliability of the alert information is closely linked to the size of the community, with the requirement that at least one member has

the opportunity to identify a critical road event and the willingness to inform the network about it, for a given area at a given time. In this framework, it is understandable that the choice of this type of service is based upon the item “size of the community”. What is interesting is that an analysis of responses according to 3 main age groups (18 to 30 years old, 31 to 60 years old and more than 61 years old, splitting made with a clear objective to contrast generational culture typical of each group), revealed that the senior group is not that much aware about the importance of the “size of the community” and that their main objective in using this service is rather linked to “road safety” (Figure 4).

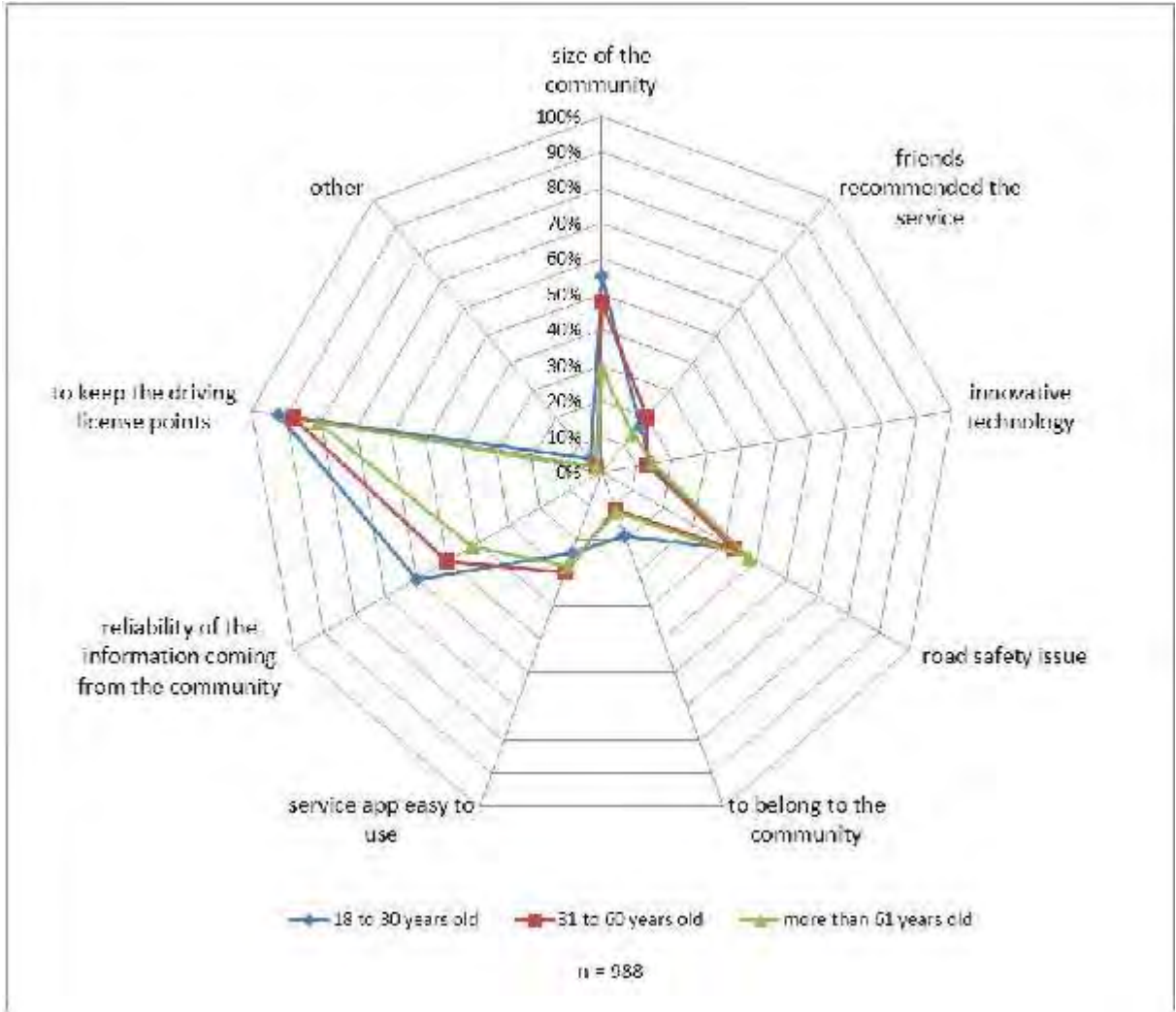


Figure 4: Reasons for using the mobile service by age groups

Furthermore, “belonging to the community” per se is not a major motivation for the sample of drivers, obviously less important than “road safety” and “system easy to use”; the younger group is the more concerned by the item linked to community belonging.

The impact of the community activity allowing road alert reliability would not be clearly perceived by the seniors. Then, not surprisingly, the level of participation to the community decreases as the drivers’ age increases, with a “systematic participation” of about 83% for the young drivers and 52% for the drivers over 61 years old (Figure 5). It can be noted that seniors’ participation is still quite high.

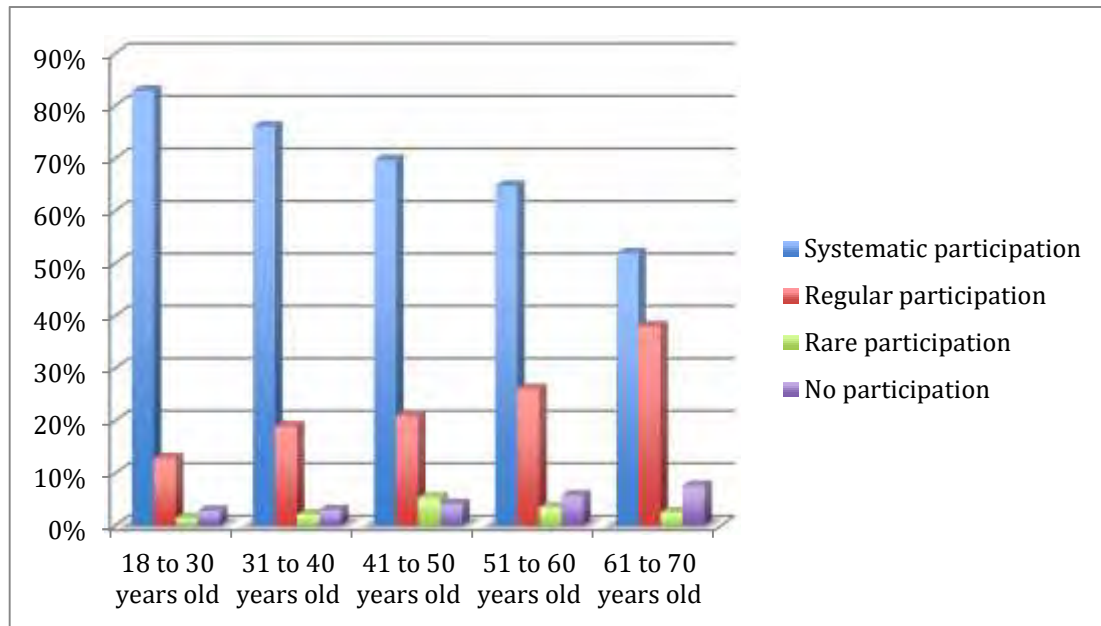


Figure 5: Participation to the community by drivers' age

The main reasons to participate to the community is the willingness to have a good functioning of the system for 68%, and, to a lower extent, by solidarity with the community for 29%. "Gaining stars" or "playing with the service" are very marginal reasons.

Negative impact of this participation to the driving activity is rated "weakly disturbing" for about 50% of the drivers, "a little disturbing" for 44%, "disturbing" for 6% and nobody found it "very disturbing", with similar findings whatever the drivers' age. This result is very important taking into account road safety concern. It is clear that drivers chose if they want to inform the community about an event and when, being then in full control of the interaction with the device, and able to manage any interference with the driving task. Nevertheless, these results are based upon subjective comments and impact of using the system on the driving task would deserve to be evaluated in real road context by recording drivers' behavior, in order to confirm this low level of interference.

Concerning drivers' ranking, half of them did not know their own number of stars, commenting that they were not too much interested to participate to a "competition with award", but nevertheless, they considered it is important to be informed about stars of drivers ahead in order to evaluate the reliability of the information ("very important" for 47%, and "important" for 42%).

Regarding drivers' interest to be ranked, 43% are willing to gain stars while 43% did not understand what is the purpose of stars or did not know the exact process to get them. In this last case, surprisingly, an important amount of drivers did not manage to make a clear link between having stars and being considered as reliable in the community.

For the group of drivers aware about the stars meaning and purpose, most of them are really motivated to participate and to be well ranked to guarantee the good functioning of the system, "more stars, more reliable information, more confidence of the community".

Indeed, confidence in the social network is a crucial issue for a driver community generating content. Taking into account the important ratio of drivers unaware about the logic and the issue linked to get stars, it seems that this process would deserve more pedagogy toward the drivers to increase motivation of participation.

Road alerts displayed by the service are considered as reliable “most of the time” by 86% for “danger zones” corresponding to critical constant zones, and by 73% for “disruption zones” corresponding to temporary critical zones.

Information coming from the community is considered more reliable than the one coming from the variable message sign and from the radio (figure 6).

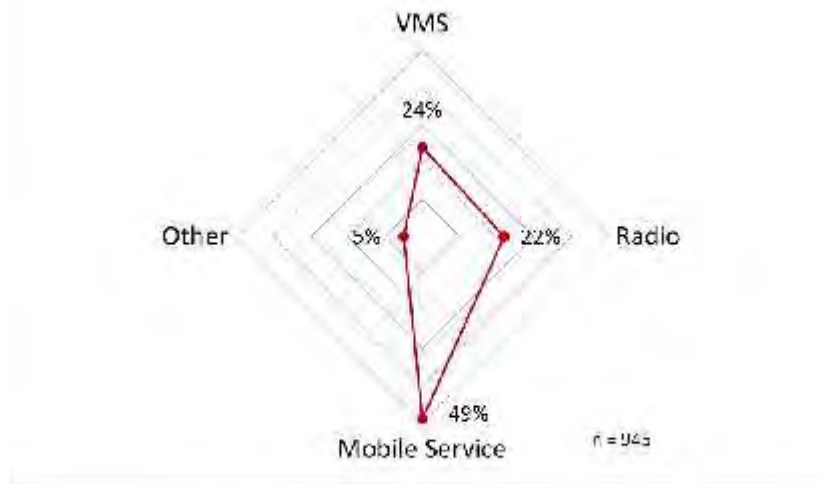


Figure 6: Drivers' evaluation of reliability for the road alert information by sources of information

In the same vein, a recent research demonstrated how information on weather warnings coming from social network was efficient to make drivers changing behaviour [11]. In this study, weather warnings information disseminated through network was a powerful tool to convince driver to change decisions such as route planning and trip cancellation. The overall opinion of the service was very positive, especially when compared to other sources of traffic weather information and alerts.

Generally speaking, mobile devices are primarily used for personal communication, while traditional road information channels such as VMS, and including radio, are more impersonal and research shows that people remember better information that affects them personally [12].

Conclusions

Relying on social networking to improve real time communication among drivers could be a powerful tool to contribute to safety and comfort, by allowing quick widespread of critical road information through “driver-generated content”. This communication process, based upon application downloaded on smartphone, is easily accessible with usually low cost. Nevertheless, several issues such as distraction for the driver and reliability of the transmitted information with resulting level of drivers' trust might be critical.

The investigation conducted to gather data on a service aiming at informing drivers about dangerous and critical zones in real time showed that mobile services can be considered as a good candidate to display critical road information to drivers, with positive results in terms of acceptability and motivation of use, even by seniors drivers who did not have the same generational culture than young ones regarding social networking but seems to be motivated to participate as other researches already showed [13]. Nevertheless, further investigations on drivers' visual strategy, cognitive load and performance while using these services through

experiments on real road will allow identifying potential negative consequences in terms of road safety linked to the use of these supportive applications while driving.

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DEVELOPMENT AND EVALUATION OF A DRIVER COACHING FUNCTION FOR ELECTRIC VEHICLES

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ABSTRACT:

Several different driver coaching approaches exist that aim at supporting eco-friendly driving. Most of these approaches have been designed for vehicles with combustion engines and could therefore not be simply adapted to fully electric vehicles (FEV) as of the different vehicle architecture. The paper at hand outlines a driver coaching function that has been developed especially for FEVs. It aims at improving an efficient driving style and thus should support the driver optimising energy consumption and remaining range. The coaching function provides specific visual real-time feedback via a head-up display addressing several different aspects of the driver behaviour. A driver coaching study has then been conducted to evaluate the coaching concept and to compare it with two further common coaching approaches. The study results show a significant improvement of energy efficiency as well as the usefulness and high acceptance of the specific driver coaching function. On the basis of these results, the paper also discusses the possibility of implementing an active forced-feedback pedal as a reasonable feedback channel for driver coaching.

1 INTRODUCTION

Considering the relatively low range of electric vehicles compared to vehicles with combustion engine and the associated range anxiety (see e.g. [1]), eco-driving is becoming an important approach by which means range may be extended. Several different driver coaching approaches exist that aim at supporting eco-friendly driving [2-4]. These coaching approaches differ mainly regarding feedback time (real-time vs. post trip) and regarding their functionality (general feedback vs. context specific feedback). However, most of these approaches have been designed for vehicles with combustion engines and could therefore not be simply adapted to fully electric vehicles (FEV) as of the different vehicle architecture (e.g. regenerative braking).

The paper at hand outlines a driver coaching function that has been developed especially for FEVs and aims at improving an efficient driving style and thus extending remaining range. The coaching function provides specific real-time feedback as previous research has shown that immediate feedback has significant impact on the driving style when linked to the particular situation [4, 5]. The coaching function addresses six aspects: hard acceleration, exceeding speed limits, speed behaviour while cornering, deceleration towards lower speed limits, speed behaviour at hilltops and downhill sections, and car following.

In order to evaluate the driver coaching concept, a driving simulator study has been conducted, in which the coaching concept has been compared with two further common coaching approaches: (1) a verbal instruction prior to the drive which explains how to drive efficiently with electric vehicles, and (2) an unspecific feedback in real-time during the whole drive.

2 METHOD





2.1 Research question

By means of the driver coaching study the following research questions are about to be investigated: a) which impact has specific real-time coaching on energy consumption, b) how much do drivers benefit from specific coaching compared to unspecific coaching or to sole verbal instruction, c) how far does the specific real-time coaching change the driving behavior, and d) how acceptable is specific driver coaching?

2.2 Driver coaching variants

The first of the three coaching variants (VER) makes use of verbal instructions prior to the drive (see Table 1, left). In the second variant (COA) the driver also gets the verbal instructions. In addition, he receives situation specific real-time advices via the head-up display (see Table 1, right). These advices correspond with the verbal instructions. In the third variant (SKA), the verbal instructions are also given prior to the drive. In addition, the driver obtains via the head-up display a consumption scale with a pointer indicating whether he drives more or less efficient than a reference driver.

Table 1: Verbal instruction and corresponding real-time coaching advices.

Verbal instruction	Specific advice
Omit hard accelerating	
Do not exceed the current legal speed limit	
Keep constant speed while negotiating a curve	
Decelerate by means of the electric brake Try to omit hydraulic braking by means of anticipatory driving	REKUP!
Sail over hilltops / sail when driving downhill in order to gain speed	SAIL!
Keep a sufficient distance to leading vehicles in order to omit velocity fluctuations.	

2.3 Study design

The study was conceptualized as a 3x2 experimental design with randomized distribution of participants to one of three experimental conditions (i.e. VER, COA, SKA). The first factor is a between-subject factor with three levels comprising the three types of coaching. The second factor is a within-subject factor with two levels comprising the repetition of the test run (baseline vs. experimental run).

2.4 Description of the simulation environment

For the coaching study, a static driving simulator with an electric vehicle and consumption model was used. The driver's view is realized by means of three flat screens (42" diagonal each) enabling a view of 180°. The head-up display was integrated into the bottom part of the mid plasma screen indicating the vehicle's speed and a) the coaching advices or b) the consumption scale. The vehicle was equipped with a combined pedal solution (one-way pedal solution), which has implemented the electric brake on the accelerator pedal (i.e. releasing the accelerator pedal leads at some point to the onset of the electric brake) [cp. 6]. The maximum electric brake force realizes -1.7 m/s^2 .

2.5 Test track

The test track was designed in a way that allows experiencing all driving situations which may be critical regarding energy efficiency and are addressed by means of the driver coaching (i.e. inclines, declines, sharp curves, car following situations, several changes of speed limit, intersections with stop signs, and intersections with traffic lights). It has a total length of 15 kilometres and could be driven through in about 15 minutes.

2.6 Test procedure

Each testing trial took approx. 90 minutes. Participants were explained that the study is investigating specific functionalities of electric vehicles. In a short driving trial the participant could get familiar with the electric vehicle model, the static simulator, and the combined pedal solution.

In the following, all drivers performed the baseline drive with the instruction to apply their natural driving style. At this point, participants are not aware that the upcoming test runs are about efficient driving. According to the experimental group, the drivers obtained either the verbal instruction only or additional specific or unspecific real-time advices. After the experimental drive participants obtained a questionnaire on acceptance and workload.

2.7 Participants

All participants (N=30) were trained and experienced drivers from the test driver panel of the WIVW. The sample included 16 women and 14 men. Mean age was $M=33$ ($sd=14$) years.

3 RESULTS

3.1 Energy consumption

First of all, no significant difference in energy consumption could be found in the baseline drive comparing the three experimental groups ($F(2,29)=0.013$; $p=.987$).

Secondly, the average energy consumption could be significantly reduced from 1.77 kWh in the baseline to 1.30 kWh in the COA condition, $t(9) = 4.76$, $p < .001$. Drivers in the SKA condition benefited comparably from the

unspecific coaching, $t(9) = 7.17$, $p < .001$. Drivers in the VER condition saved 22 % by means of the verbal instruction, $t(9) = 9.31$, $p < .001$.

Thirdly, there is no significant effect on the consumption between the experimental conditions, $F(2, 29) = 1.83$, $p = .180$. The mean consumption in the conditions COA and SKA tends to be lower than in the VER condition (see Figure 1).

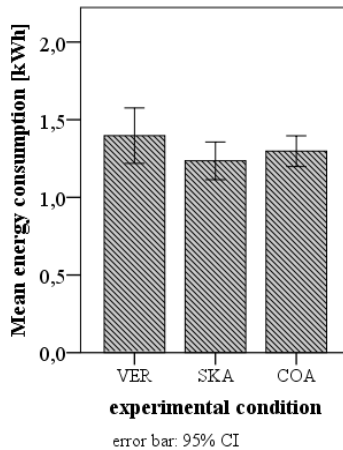


Figure 1: Mean consumption for the three experimental coaching conditions in the second drive.

3.2 Driving behaviour

Concerning the driving behavior, there is a significant effect of the experimental condition on the two parameters a) velocity, $F(2, 29) = 3.94$, $p = .032$, and b) positive acceleration, $F(2, 29) = 5.85$, $p = .008$. As can be seen in Figure 2 (left) mean velocity is lowest for the COA condition and highest for the VER condition (COA vs. SKA: $t(27) = -1.00$, $p = .330$; COA vs. VER: $t(27) = -2.77$, $p = .010$; SKA vs. VER: $t(27) = -1.78$, $p = .087$). Mean positive acceleration is significantly higher in VER compared to COA and SKA (COA vs. SKA: $t(27) = 0.43$, $p = .674$; COA vs. VER: $t(27) = 3.15$, $p = .004$; SKA vs. VER: $t(27) = 2.73$, $p = .011$) (see Figure 2 right).

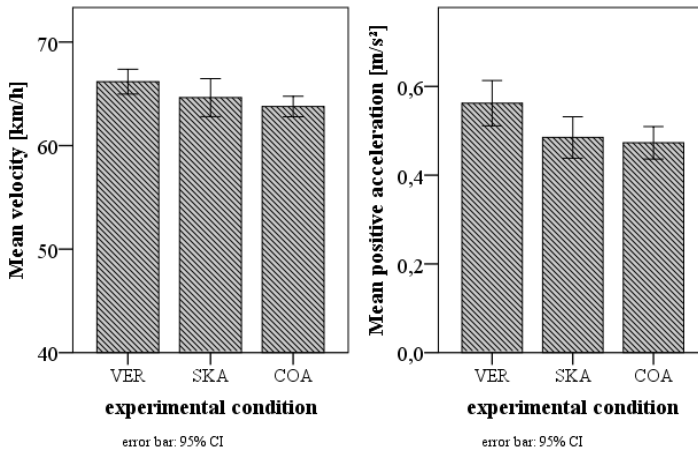


Figure 2: Mean velocity (left) and mean positive acceleration (right) for each experimental condition.

No differences could be found with regard to deceleration by means of electric braking, $F(2, 29) = 2.86$, $p = .075$, although this parameter tends to be lowest with COA (see Figure 3 left). This tendency fits with the results on sailing, where also no significant total effect of the experimental condition could be found, $F(2, 29) = 2.46$, $p = .105$, but in COA least time tends to be spent with sailing as can be seen in Figure 3 (right).

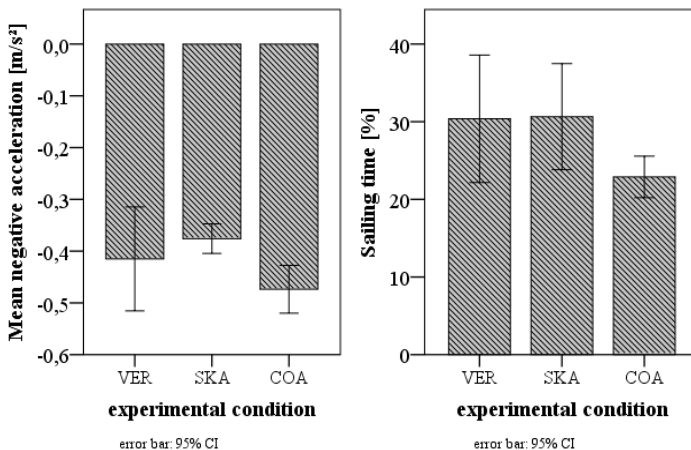


Figure 3: Mean negative acceleration (left) and mean percentage of sailing time (right) for each experimental condition.

For parameters as usage of the hydraulic or electric brake (as a percentage

of total time) no differences were found between the three groups for the experimental drive.

3.3 Acceptance of specific real-time advices

Drivers assessed the specific coaching to be helpful in order to improve efficient driving and the advices were rated to be not frustrating, disturbing or distracting, but quite motivating and understandable. Most criticism was expressed concerning the very restrictive velocity advice and the accuracy of the recuperation advice as participants sometimes reached the according velocity too early or too late.

4 DISCUSSION

The study results show a significant improvement of energy efficiency by means of the driver coaching function. All three approaches could significantly decrease the energy consumption compared to the baseline drive, with significantly lower savings for the verbal instruction. Specific and unspecific feedback could gain comparable savings.

The coaching advises (in addition to the verbal instruction) had a high impact on driving behaviour (especially compared the verbal instruction only). This results in lower average velocity, lower acceleration, higher deceleration by means of electric braking, and less sailing time. Further, the specific driver coaching shows a high usefulness and acceptance. However, the recuperation advices have to be optimized and the advice "exceeding speed limit" has to be individually adjustable in order to further increase acceptance.

As a summary, the specific real-time coaching is recommended due to the guidance towards specific efficient driving behaviour patterns and due to the possibility of advice-free driving, which reduces distraction. Continuing studies should investigate whether it is possible to further reduce distraction and workload by means of the implementation of an active accelerator pedal into the driver coaching function. In doing so, some icons may be removed from the visual channel or some advices could be applied even more precisely, as for example the recuperation advice. The added benefit of an active accelerator pedal should be investigated in further studies.

Acknowledgment: The study was conducted in the frame of the eFuture project [7] that was partially funded by the European Commission under FP7.

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Mindfulness, distraction and performance in a driving simulator

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Abstract

The following paper will explore the link between mindfulness measured as an individual trait and a number of variables of driving performance in the SIMUVEG driving simulator. 67 subjects of ages between 18 and 24 filled up the MAAS, ARDES and ARCES questionnaires and were evaluated in two driving performance measures, namely, time to line-crossing and mean speed. The results shown no correlation between the performance measures and the mindfulness measures, and low but significant correlations with the measures of distraction. These results are relevant to the assessment of distraction driving as a personal trait of some drivers.

Introduction

Driving is a complex process that involves several perceptual and motor subtasks. Three subtasks that are usually mentioned as relevant for keeping control of the vehicle: keeping longitudinal control—for example, controlling speed—, keeping lateral control—for maintaining the car in the road's lane- and avoiding obstacles. Driving is regarded as a rather easy task, where most of the time drivers can successfully carry out these three tasks effortlessly without suffering incidents.

Failures in control of the vehicles have been associated with driver inattention. As Noi states (1), "(...)from a traffic safety viewpoint, it may be pragmatic to define 'inattention' simply as a lack of awareness of critical information". Critical information would be what is required for driving in an acceptably safe context and for avoiding situations that may turn out to be the origin of an accident. Causes for inattention can be external such as those occurring on the road or carrying secondary tasks while driving, or internal, such as fatigue, alcohol, or the own stable traits of the driver. As mentioned by Ledesma et al. (2), individual traits have been researched less than other possible sources for inattention and it would be interesting to know if people who are prone to distraction in everyday life, have also this tendency in driving.

A personality trait that brings an interesting promise is mindfulness. Research on and applications of mindfulness have grown up exponentially in the last decade. It has been related with enhanced well-being, health, creativity, performance and attention among other variables (3). Mindfulness refers to attending the experience on purpose and non-judgmentally. There are not a universally accepted definitions of mindfulness but the elements that are often in them refer to “being aware and pay attention to the present moment”. Mindfulness can be fostered via explicit activities such as meditation or in everyday activities such as eating or, of course, driving.

Hanan et al. (4) have suggested that mindfulness may play a role in predicting speeding behaviour. So, after reviewing the concept of mindfulness and highlight its potential importance applied to driving, they use the operationalization of Brown y Ryan (5) of this concept as the most applicable in this field.

Brown y Ryan (5) regard mindfulness as a more or less stable trait of personality referred to the capacity of being attentive and focus in the present moment. In order to operationalize this concept, they built the Mindfulness Awareness Attention Scale (MAAS). MAAS provides a unifactorial view of mindfulness that emphasizes as its most central aspect the attention/awareness to the present moment, which can be of key importance for driving. MAAS is a simple scale that provides a single score per subject. This scale can be used even if the subject has not experience on meditation. There are two versions of the MAAS, one evaluating mindfulness as a trait, and other measuring this variable with regard to a specific state of the individuals.

On the other hand, Ledesma et al. (2) provide scales for measuring distraction in driving-ARDES, the Attention Related Driving Errores Scale. Ardes has been found to correlate significantly with the ARCES (6) scale, which measures cognitive errors in general, not tied to a specific situation.

This paper explores the power of the attentional and mindfulness scales previously mentioned for predicting performance of drivers in two of the key aspects outlined in the first part of this introduction: longitudinal and lateral control. Speed, one of the variables related with longitudinal control, has been already connected with mindfulness by (4). However, lateral control seems to be a variable that might correlate with it, as it requires a continuous control than can be enhanced if more attention is given to the present moment. Other important subtask of driving, avoiding obstacles, will not be considered in this paper.

The performance variables will be evaluated in a driving simulator as an approximation to real life situations. In short, in the empirical part of this paper, the subjects answered to the scales previously mentioned and they drove in a driving simulator. We expect that the scores in the scales will correlate with the performance measures taken in the driving simulator.

DESCRIPTION OF THE STUDY

In this study, subjects filled up a number of questionnaires related with mindfulness and distraction—described in the measurements section—and drove for approximately 20 ms. in the SIMUVEG (7) driving simulator. No special instructions were given to the subjects except for driving as they would do normally in situations such as the ones displayed in the simulator.

Half of the subjects filled up the questionnaires before driving and the other half did it after in order to control for the effect of being measured on their behavior behind the steering wheel.

Participants

72 subject participated in the study although 5 of them had to be discarded because of incomplete data. All the participants were required to have a valid driving license. The subjects were recruited using students enrolled in a course on research. Students in the course contacted with other students not in the course and brought them to the driving simulator facilities. The mean age of the students was 22 with a range of 19 to 27. They have had their driving licenses for an average of 3.22 years with a maximum of 8 years. 35 were female and 32 were male.

The subjects were in a healthy condition and they were encouraged to wear correcting lenses or equivalent if needed. None experienced severe symptoms of simulator sickness but in some cases described low levels of discomfort that were not sufficient to prevent them from going on with the experiment.

Test Materials and Equipment

The high-fidelity driving simulator SIMUVEG (see Figure 1) was used for this experiment. This is a fixed platform simulator with three screens of a size 6x1, 5m, which guarantees that participants have their field of view completely covered under normal conditions. Three XGA projectors with 2000 lumens display 3D images in real time created using in-house developed software (8) running in a standard computer that is connected to a sensorized car - a Renault Twingo with sensors in the steering wheel, brake, throttle and so forth. The car features manual transmission, a rear view mirror and two side view mirrors. Finally, the audio system of the driving simulator reproduces 3D audio and Doppler effects.

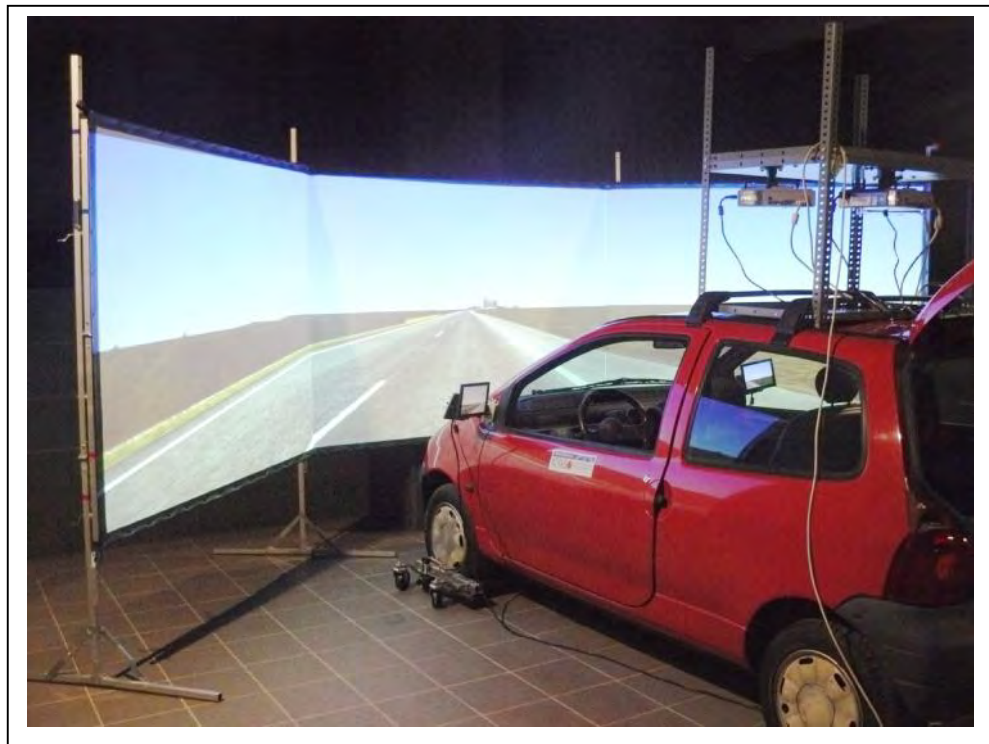


Figure 1 Driving Simulator SIMUVEG

There are two SIMUVEG scenarios, namely, a low traffic highway part designed to get the drivers acquainted with the basics of driving in the simulator, and a two-way rural road part with several traffic conflicts such as a truck stopped on the verge of the lane, a tailing car, curves, etc. The first part (4,5 km of 18 km) is regarded as training and is not included in our analysis. The training track takes place on the same rural road as the experimental track and, by driving through it, drivers get used to the operations of the car such as steering, braking, speeding, and so forth.

Measurements

The measurements taken in this experiment were of three kinds: general questions about the subject, distraction and mindfulness self-rating scales and driving simulator performance measurements.

General questions

The subjects answered questions about their experience and habits of driving. These questions will not be subjected to analysis in this paper, though.

- How many years have you been driving?
- Frequency of use of the car (1=almost every day; 2=some days per week; 3=some days per month)
- Kilometers per week
- Have you ever gotten a transit ticket? (1=No; 2=Yes, once; 3=Yes, more than once)
- Have you ever had any significant distraction when driving?
- Do you use your mobile telephone while driving?

Distraction and mindfulness scales

The following scales were used for measuring distraction and mindfulness of the subjects in the study

- MAAS: The Mindful-Attention Awareness Scale (5) has 15 items that evaluate general awareness and attention to current events and experiences. All items are negatively worded (e.g., "I find it difficult to stay focused on what's happening in the present") and were reversed for the analysis. In this study, MASS items were answered based on a 5-point scale, from *almost never* (1) to *almost always* (5). Notice that we chose not to reverse the results in the scale as it is usually carried out in other studies, so the scores in our test reflects mindlessness rather than mindfulness.
- MAAS State: This scale takes five items from the MAAS scale that are evaluated respect to most immediate present. Thus differs from the MAAS in which this scale refers to what it happens in general to the respondent. We also did not reverse the scores in this test.
- ARDES: The Attention-Related Driving Errors Scale (2), was used to assess driving attention-related errors. This scale comprises 26 items referring to non-intentional driving errors, resulting, in whole or in part, from attentional failures. Participants were asked to read each item and indicate on a 5-point scale the frequency with which the described situations happened to them, ranging from *never or almost never* (1) to *always or almost always* (5).
- ARCES: The Attention- Related Cognitive Errors Scale (6) is a 12-item scale describing everyday performance failures arising directly or primarily from brief failures of sustained attention. As an example, an item states "I have absent-mindedly placed

things in unintended locations (e.g., putting milk in the pantry or sugar in the fridge).” Similar to ARDES, participant’s task was to rate in a 5-point scale the frequency with which the described situations happened to them, ranging from *never or almost never* (1) to *always or almost always* (5).

Driving simulator performance

Driving simulators offer a number of measures potentially useful for evaluating performance (9). In this case, *Speed* was chosen as measure of longitudinal control and a variant of *Time to Line Crossing* (TLC) (10) described below was used for evaluating lateral control. Notice that, in a driving simulator, measures are evaluated continuously providing several values per second. As the data analysis here carried out is at subject level, it is necessary to summarize the values in some way. This process of data reduction is described below:

- *Mean speed (MS)*: In SIMUVEG this is evaluated as the average of maximum speeds computed every ten meters of driving. This value is very close but not equal to the simple average speed computed dividing the total distance driven by the total time used by each driver. It is assumed that low values in this measure are related to increased mental workload and that drivers often try to compensate increased workload by reducing speed (9).
- *Average of minimum TLCs (MTLC)*: This measure is based in the TLC used for measuring lateral control. Thus, minimum TLC value is calculated every ten meters as an indicator of maximum risk of driving off road along them. Then, an average for all the maximum values is calculated per subject. High values in this variable can be interpreted as associated with good lateral control whereas low values would imply repeated episodes of bad lateral control.

RESULTS

Descriptive results are shown in Table 1. Values are for 67 valid subjects. Notice the high value of asymmetry in the MTLC variable (2.391) and the moderate positive asymmetry values of the other variables.

	Min	Max	Mean	Std. Dev.	Asymmetry
MAAS.ST	6.00	19.00	10.98	3.12	.90
MAAS	21.00	56.00	35.04	8.36	.47
ARCES	16.00	50.00	28.14	7.83	.50
ARDES	19.00	50.00	30.95	6.79	.37
MS	61.17	105.69	82.05	9.68	.70
MTLC	3.69	51.20	12.55	8.95	2.39

Table 1: Descriptive Statistics for the variables in the study

Pearson and Spearman correlations were calculated among the variables. Small differences probably due to slightly curvilinear relations between the variables were found between the two types of correlations so it was decided to report only ordinal correlations. These are shown in Table 2 with significant correlations flagged with asterisks (*<0.05;**<0.01). The pattern of the correlations is rather simple with self-rating scales related with mindfulness and distraction displaying strong correlations among them and performance measures showing

moderate correlations (MS and MTLC) between them. The ARDES scores, on the other hand, correlated significantly with MS and MTLC, although these correlations were rather moderate. Finally, the ARCES score correlated significantly with MS—again, only moderately—but not with MTLC.

	ARDES	ARCES	MAAS	MAAS.ES	MS	MTLC
ARDES	1.00	.597**	.523**	.468**	.253*	-.320**
ARCES	.597**	1.00	.617**	.524**	.241*	-.166
MAAS	.523**	.617**	1.00	.740**	.165	-.078
MAAS.ST	.468**	.524**	.740**	1.00	.090	.002
MS	.253*	.241*	.165	.090	1.00	-.419**
MTLC	-.320**	-.166	-.078	.002	-.419**	1.00

Table 2: Spearman correlations among the variables in the study

CONCLUSIONS

Indeed, the idea of applying mindfulness to driving is very appealing. Contrary to the usual discussion of negative factors for driving—distraction, cognitive workload, perceptual complexity—mindfulness offers instead a positive message: more focus on the present circumstances will reduce the negative factors and improve driving. This hypothesis is very attractive if we consider that, in principle, mindfulness can be trained so that we could improve drivers' behavior using meditation or in other ways. This hypothesis has been already advanced by Hanan et al. (2010) applied to driving and a similar claim has also been made in other areas. If mindfulness demonstrated its potential, we might have a very valuable tool for improving driving and consequently reducing accidents.

Unfortunately, these claims have not drawn much support from our studio. As can be seen in the results, the correlations between the MAAS scores, the usual way of measuring mindfulness, and the two measures of performance while driving were not significant, whereas a questionnaire specifically related with distraction while driving—ARDES—did. On the other hand, a more general distraction measure, one referring to everyday activities displayed correlation with one of the measures—MS, Mean Speed—but not the other—MTLC. Therefore, this suggests that the specific measures of distraction in driving have potential for predicting some general aspect of driving performance but the more general measures such as the ARCES have somewhat less potential. Finally, general measures of mindfulness, either as a trait or as a state, are not associated with this two indicators of performance.

Despite the previous conclusions, we do not think that the whole matter is been settled yet. The current study has several limitations that make the conclusions reached in it preliminary only and consequently they could be modified in the future. These limitations affect mainly to the measures of driving performance taken, the effects of training, the sample limitations and the different effects on groups. We will discuss these limitations below:

In this study, we chose only two general parameters of driving performance related in one case with longitudinal control (MS) and in other with lateral control (MTLC). Although these

two parameters are essential for driving, how they are related with good driving is a matter open to discussion. Thus, with regard to speed, driving too fast or driving too slow may be both synonyms of bad driving, but it is unclear which the optimal value for speed is. This reasoning leads to consider non-linear relationships between the mindfulness and distraction measures and speed in a more detailed way than carried out here. Some hint of this type of relationship is evidenced in that ordinal correlations showed stronger effects than linear correlations suggesting a more complicated association between the variables than the one hypothesized here. Regarding MTLC, given the correlation found with MS, there is the possibility that its correlation is partially dependent of MS and consequently a model including it would be of interest.

Additionally, these two measures are both general measures of driving whereas it is arguable that the concepts here discussed are only of relevance in specific situations where the attention or focus in the present may make more difference. In short, avoidance of obstacles, as mentioned by (1) is another key component of driving, and we have simply not considered it here. Therefore, measures such as reaction to hazards or to conditions that require monitoring such as changes in speed limits would be more sensitive than the ones used here. Including subtasks as part of the experimental situation such as responding to a phone call or paying attention to an in-vehicle information system (11, 12) might be of interest here.

Also, in this study we have only measured the level of mindfulness and distraction of drivers and we have correlated it with the indicators. It would be also important to check if manipulation of these levels via training the drivers in mindfulness or perhaps in techniques for avoiding distraction would have an impact on performance. The results shown here hints that focusing on things that produce distraction during driving is possibly useful but this should have to be tested with a specific study.

Still, another limitation of this is that we used a convenience sample composed mainly of young people representative of the general population of drivers. It is possible that the effects here explored are not sufficiently strong to be shown with this sample but special groups such as drivers with a history of accidents, or cognitive or health problems (13) might benefit of compensating their deficits.

Finally, as usual with driving simulator studies, it is convenient to remark that findings in simulators must be confirmed using real life studies. In this case, naturalistic driving (14) might provide an ideal framework for studying this issue in combination with the methodology used here.

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Vulnerable Road User needs towards ITS

Daniel Bell

ABSTRACT:

Due to fast development of new technologies in the field of Intelligent Transport Systems (ITS) a number of new research topics arise, especially in view of vulnerable road users (VRUs). As most developments in the ITS sector are primarily targeting motorised transport with focus on safety and ecological aspects of transport, there is still a lack of both research and development considering VRUs not only as passive element. The VRUITS project, funded by the EC, aims at actively integrating the “human” element into the ITS approach.

Goal of the EC co-funded project VRUITS (Vulnerable Road Users and ITS) is to assess societal impacts of selected ITS, and provide recommendations for policy and industry regarding already available and future ITS in order to improve the safety and mobility of VRUs. Main focus of the VRUITS approach is to provide evidence-based practices on how VRU safety and mobility can be integrated in Intelligent Transport Systems and on how HMI designs can be adapted to meet the needs of VRUs. In addition these recommendations are tested in field trials to further improve and adapt these applications to actual vulnerable road user needs.

Based on focus group discussions and expert interviews, critical scenario analysis and a comprehensive ITS mapping process the basic research phase of the project focussed on:

1. Identification of critical situations for VRUs based on European accident data
2. Assessment of needs of VRUs towards ITS services and applications by integrating actual stakeholders in course of a qualitative research process
3. Identification and prioritisation of ITS which affect VRU safety as well as general mobility and comfort aspects

1 VUR needs and ITS

In order to integrate actual stakeholders into the research process and

assess current issues, needs and attitudes towards ITS representatives of different vulnerable road user groups have been involved in discussion rounds. In addition experts from tangent fields, infrastructure, traffic planning, ITS, policy, etc., were interviewed to gather insight in future developments, technology potential and issues in the fields of ITS and VRUs.

1.1 Focus Group Discussions with VRU groups

Based on a sample of overall 143 participants covering the following five VRU groups: adults, parents, adolescents, older road users, cyclists and PTWs (powered two-wheelers) from four partner countries (Spain, Finland, Austria, the Netherlands) 20 focus group discussions were conducted.

Based on the collected materials critical situations in traffic were identified to serve as a qualitative basis for the situations that could potentially be addressed by ITS solutions. These critical scenarios for VRUs are usually related to:

- High (car) speeds
- lack of respect of motorised traffic
- visibility/conspicuity
- Complexity and density of traffic
- Lack of communication between road users
- Weather conditions/maintenance of infrastructure

In general the participants of the different VRU groups discussed experiences on all levels of ITS including mobile applications, in-vehicle and infrastructure; with a high variety of known technologies (informing, intervening, warning) and high level of experiences among car drivers (BSD, ISA, GPS, Cruise Control, etc.). Actual experiences with various systems are generally very positive with hardly any statements regarding failing ITS.

One of the main goals of the discussion rounds was to identify the technology potential of ITS from the point of view of the different VRU groups. Most important benefits identified include:

- Increased visibility of VRUs (communication, warning, intervention)
- Increased overall traffic flow (automation)
- Economic (less fuel consumption) and ecological (less CO² emissions) aspects
- Increased comfort in traffic (information)

On the other hand participants were asked to identify potential hazards and

adverse effects of these emerging technologies on both the safety and general mobility of vulnerable road users. One of the main aspects identified by motorcyclists was loss of autonomy. Generally distraction (sounds, visuals, interaction), overreliance, or overconfidence technical reliability and potential negative effects on actual abilities (i.e.: decreasing spatial abilities/driving skills/reaction times) were mentioned in this regard.

1.2 Expert Interviews

In the course of 10 semi structured interviews with 10 European level experts from the fields of technology (including infrastructure, technology development and application), policy (structural aspects, legal issues, etc.) interest groups of vulnerable road users and infrastructure service providers additional qualitative input on both technological aspects as well as user-oriented aspects of ITS and traffic safety was gathered. Focus of discussion were VRU mobility needs, critical scenarios in traffic and technology potential of available and future technologies in the transport and mobility sector.

Safety issues identified in course of the expert interviews were very similar to those discussed by the different VRU groups:

- Visibility of VRUs
- Infrastructure design especially in view of actual space for VRUs in traffic
- Speed of motorised traffic
- Education, training and awareness of the different road user groups
- Lack of data on VRU specific accidents (single pedestrian, etc.) constitutes a significant barrier for ongoing developments of solutions specifically designed to address VRU safety.

In general the potential of ITS solutions to improve VRU safety and positively affect general mobility was assessed favourably. The potential of automation and direct support to reduce user errors, especially of novice drivers, older road users and children in traffic was identified as functions directly affecting

road safety. Traffic efficiency was another area where technological solutions could provide a source for improving traffic flow and fuel and CO² emissions overall improving traffic conditions. In view of motorised traffic, current systems are perceived to help compensate for distraction, fatigue etc. which are causing factors for high shares of VRU accidents. Overall ITS is seen as relevant technological factor to help improve independency of vulnerable road users by increasing comfort and decreasing uncertainty through information. A topic of potential future interest in the ITS sector was education and training via simulation and e-coaching solutions which could be especially relevant for motorised traffic, specifically for PTWs.

Beside these positive implications the interviewed experts also identified ITS hazards and current barriers to broad scale deployment. Main adverse effects were seen in distraction and risk assessment of ITS users, especially among car drivers. Attention to traffic and the corresponding requirements for HMI (human-machine interface) design will be important aspects not only for technological developments, but also for scientific evaluation. In addition there are still open questions when it comes to responsibility in case of system failure or misuse and privacy in connection with personalised data.

2 Critical scenarios in traffic

Based on available European accident data, most relevant critical scenarios for cyclists, pedestrians and PTWs were identified to serve as a basis for safety relevant situations to be potentially addressed by ITS solutions. The approach in the accident analysis started out by identifying databases providing access to either in-depth and macro data on actual circumstances of accidents involving VRUs. In addition existing project results and already identified scenarios were taken into account to select most relevant scenarios from a VRU perspective.

All of the analysed scenarios took both national databases, from Spain, Austria, the UK, Sweden and Finland, and CARE data into account leading to more than one scenario per mode in certain cases.

2.1 Pedestrian scenarios

Analysis of CARE data showed that accidents were most likely to occur when the pedestrian was crossing the road mid-block, actually in distance from a

junction. In addition the reported accidents occurred in fine weather with dry road conditions. In view of time of day results suggested most accidents involving pedestrians to occur between 12pm and 6pm.

In regards to the actual location where pedestrian accidents occurred accident data suggests that most accidents occur in urban areas on roads with speed limits below 50km/h. The majority of accidents involved collisions with passenger car as collision partner, which was not only confirmed by CARE data, but also national accident databases.

Issues regarding not identifiable parameters include information on vehicle characteristics, vehicle speed pre-collision and pedestrian actions prior to collision.

2.2 *Bicycle scenarios*

Accident data from CARE involving bicyclists suggested that the most common scenario was a passenger car and a bicyclist heading in the same direction with the motorised vehicle turning into the cyclist's path. Results from national accident databases showed another picture suggesting that the most common scenario was a vehicle pulling out into the path of the on-coming cyclist at an intersection.

As seen with pedestrian accidents the majority occurred in fine dry weather during daylight hours. Another similarity to pedestrian accidents involve the actual location, with most accidents occurring in urban areas at relatively on roads with relatively low speed limits of 50km/h.

2.3 *Motorcycle scenarios*

In view of most common motorcycle accidents there was also a discrepancy between the national databases and CARE data. In the CARE database the most common scenario involved a PTW being hit by a vehicle with both vehicles initially heading in the same direction and the car then turning across the path of the PTW. In national databases the most frequently observed accident scenarios involved motorised vehicles pulling out from intersections into the path of the PTW. In both cases the vehicle most

commonly involved in the PTW accident was a passenger car. As with pedestrians and cyclists most accidents occurred within urban environments with again most commonly occurring on roads with low speed limits. Accidents mostly happened during the summer months, with fine and dry weather conditions during daylight hours.

3 Prioritisation of ITS for VRUs

Based on available literature and accident scenarios and the results of the qualitative assessment of different VRU groups the most promising ITS solutions covering both safety and general mobility aspects were mapped. An initial set of 14 solutions aimed at pedestrians, 34 addressing cyclists, 28 motorcyclists, and 10 systems for motorised vehicles were identified as positively affecting VRU safety and mobility. In course of an expert workshop with stakeholders from different tangent fields the most relevant solutions were identified and considered for the impact assessment. Overall 20 systems were selected for the final inventory covering safety and mobility relevant functions for all considered VRU groups.

For each VRU group different applications were identified as having a positive effect on VRUs.

For pedestrians these solutions focus on the following aspects in traffic:

- Car speeds (i.e.: speed cameras and ISA)
- Visibility and detection (i.e.: tags for kids, in-vehicle pedestrian detection tools, automatic detection of pedestrians)
- Generally improving comfort and mobility (mobile phone tracking for transport planners, countdown signals, special users)

For bicyclist the systems identified as having the highest potential to support safety and mobility were on the one hand solutions that are aimed at detectability and conspicuity of the cyclist in traffic:

- Intersection safety
- Blind spot detection
- Bicycle green wave & pre-green for bikes

- Automatic bicycle identification

And systems that provide information relevant to cyclist and therefore increase comfort and mobility:

- Safe route planner and critical black spots in traffic
- Information on bike sharing
- Public transport vehicles where bicycles are allowed

For motorcyclists most of the identified solutions are related to other motorised traffic and hence focussing on increase detectability and conspicuity:

- Intelligent speed warning for motorcyclists
- Rider monitoring, to warn in case to rider is unattentive
- Intersection safety
- Cooperative systems allowing communication between vehicles and between vehicles and infrastructure

The final inventory to be used in course of the adaptation and development process of an assessment methodology for ITS addressing VRUs is not only covering safety, but also comfort and general mobility.

4 Conclusions

The results of the first tasks of the VRUITS project provided insight not only into critical scenarios and accident data of VRUs, pedestrians, cyclists and PTWs, but also integrated actual stakeholder needs and attitudes towards ITS into the approach. By applying focus group discussions, expert interviews and workshop methods in course of the basic research phase an inventory of the most promising ITS solutions for vulnerable road users was established to serve as basis for the assessment methodology and controlled field trials.

In view of safety relevant systems these need to cover the different scenarios

for the different road user groups. For pedestrians the key scenarios consistent in all used databases were mid-block accidents, remote from a junction. In view of cyclists safety needs the most relevant scenarios to potentially be addressed by ITS were not consistent in all available data sources but especially junctions and intersections where 'give-way' is required were relevant. These findings regarding motorcyclists correspond to results found for bicyclists.

In this regard systems with the highest potential to provide support in critical scenarios in traffic are aiming at reducing both car speeds, by providing information and support to the car drivers and reduce the complexity of high density traffic situations, especially at intersections. In addition solutions that increase visibility and conspicuity of vulnerable road users were identified as highly relevant for avoiding potential accidents. By providing additional information in traffic, for routing, parking etc., both efficiency and comfort of vulnerable road user can be supported in turn increasing general mobility of the affected road users. On the other hand potential adverse effects negatively impacting traffic safety were identified and will be considered in course of the impact assessment. Distraction, technical reliability as well as still existing standardisation issues need to be tackled in course of technical development.

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Workload assessment for motorcycle riders

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ABSTRACT:

Both German and European studies have shown that compared to other modes of transport accident rates and injury risk for Powered Two Wheelers (PTW) are particularly high. Efforts are taken to enhance safety and comfort for motorcycle riders e.g. through Advanced Rider Assistance Systems (ARAS) and On-Bike Information Systems (OBIS). Consequently, questions about distraction and rider workload arise and need to be addressed. A riding simulator study (n=14) was conducted in order to test the sensitivity of performance measures, subjective ratings as well as physiological measures to controlled variations in rider workload, while in a second study (n=15) these parameters were used in order to assess the effects of different secondary tasks. The secondary task of operating an OBIS led to the highest workload e.g. indicated by deteriorated lane keeping and increased subjective ratings compared to a simple visual, an auditory and no secondary task at all.

1 INTRODUCTION

The relative trend between the numbers of fatalities of motorcyclists compared to that of other road users within Europe is alarming. Whilst the percentage of fatally injured car drivers, moped riders or pedestrians declined over the years, there is a relative tendency for motorcycle riders to be even more involved in fatalities [1]. At the same time the riding patterns of motorcyclists within the EU changes towards high-mileage riding (more than 5,000 km per year) [1] and bigger touring bikes [2]. These kinds of motorcycles are more often equipped with Advanced Rider Assistance Systems (ARAS) like e.g. speed alert warning or blind spot monitoring and On-Bike Information Systems (OBIS) like e.g. navigation systems that should support riders and prevent accidents or mitigate injuries. Nevertheless, those

systems might also bear potential for distraction if attention is attracted by flashing lights or audio signals. This holds especially for OBIS as ARAS like e.g. Traction Control work unobtrusively most of the time. This paper describes a first empirical approach towards specification of the sensitivity of different workload measures to be applied for the assessment of rider information systems. The complete project report will be published soon [3]. Hereby, workload “...represents the cost incurred by a human operator to achieve a particular level of performance.” [4]. Therefore an approach towards workload description is proposed and the effects of different secondary tasks on workload were examined.

2 METHOD

2.1 *Riding simulator*

The simulator that was used for the study is equipped with a full-size motorcycle mockup type BMW R100S including all relevant devices and physical controls (Fig. 1).



Fig. 1 Riding simulator (left) and an exemplary track section (right)

The bike is rotatable fixed at its longitudinal axis. Shifting his weight the rider has the possibility to roll the motorcycle passively but there is no active motion of the mockup. The riding simulator includes simulation of longitudinal and lateral dynamics, sound simulation and image generation for urban, highway and rural scenarios (60 degrees field of view). The riding scenario control includes the definition of road geometry, influence on the appearance of the surrounding landscape and detailed control of other traffic participants. All components are based on WIVW driving simulation software SILAB. Furthermore, all parameters of the simulation as well as all accumulated data can be recorded. This includes e.g. inputs of the rider, physical quantities of

the vehicle dynamics simulation, characteristics of the road geometry or information about other traffic participants. Data from real motorcycle rides was used to validate the motorcycle simulator, especially focussing on the relationship of acceleration, brake pressure and pitch angle.

2.2 Test procedure

2.2.1 Study 1: workload description

The first study aimed to describe changes in workload induced by the following variations in strain:

- track difficulty (easy: track width 3.50 m, curve radii > 1000 m, little oncoming traffic, smooth slope vs. difficult: track width 2.75 m, curve radii between 150 and 800 m, dense oncoming traffic, obstacles, steep slope)
- riding instruction (“as safe as possible” vs. “as fast as possible without endangering anybody”)
- length of ride (short: 10 minutes vs. long: 60 minutes)

All participants completed four short rides on rural roads with all possible combinations of track difficulty and riding instruction. In addition they performed one long ride on the difficult track and the instruction to ride as fast as possible without endangering anybody on a separate day. Pulse rate was recorded while riding. After each ride participants were asked to fill in the NASA Task Load Index as a subjective measure of rider workload [4].

2.2.2 Study 2: effects of different secondary tasks

The second study analysed the effects of different types of secondary tasks. This is of high relevance as different OEMs and suppliers already offer a variety of ARAS or OBIS using e.g. a visual or acoustic human machine interface (HMI). A total of 15 riders rode on courses of varying difficulty (easy vs. difficult) under four different secondary task conditions: baseline without any secondary task, counting certain target words in an audio-book (acoustic), Peripheral Detection Task (visual, [5]) and operation of a user interface (navigating through system levels in a menu) via touchscreen simulating an on-board computer. The order of conditions was randomly assigned to each rider. After each ride participants were asked to fill in the

NASA Task Load Index.

2.3 Participants

All participants were recruited from the WIVW test driver panel. 14 riders participated in the first study, five to them were women. Mean age was 33 (sd= 11) years. The participants rode 3094 (sd= 3056) km on average the year before. 15 participants were recruited for the second study, two of them were women. Mean age was 36 (sd= 14) years. The participants rode 4045 (sd= 4274) km on average the year before. In both studies, two participants were experienced in using an on-bike navigation system.

3 RESULTS

3.1 Study 1: workload description

All three varied components of strain (track difficulty, riding instruction, length or ride) clearly influence the riders' performance. Riding data, subjective ratings and pulse rate were investigated to register workload. In this paper only the effects of varying track difficulty and riding instruction are reported. Experimental data were analysed with a repeated measures ANOVA using the four combinations of track difficulty and riding instruction as within factor. The significance level was set at .05.

As manipulation check one can see that different instructions lead to different mean velocities ($F_{3,11}= 83.67$, $p < .001$; Fig. 2 left). Riding "as safe as possible" leads to a lower mean velocity than the instruction to ride "as fast as possible without endangering anybody". This seems to be related to the lateral behaviour as the standard deviation of lateral position (SDLP) increases for the fast instruction on both track types ($F_{3,11}= 21.60$, $p < .001$; Fig. 2 right). There is no significant difference between the track difficulties.

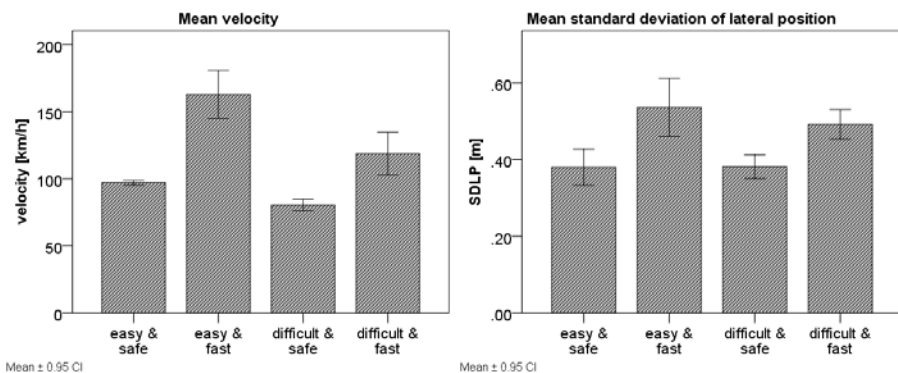


Fig. 2 Mean velocity (left) and standard deviation of lateral position (right) by track difficulty and riding instruction

Concerning the participants' subjective ratings the variation of track difficulty and riding instruction lead to different experienced workload ($F_{3,11}= 17.11$, $p < .001$; Fig. 3 left). Under the easy & safe condition riders report the lowest and under the difficult & fast condition the highest workload. No difference is found between easy & fast compared to difficult & safe.

The mean pulse mainly reflects changes in the riding instruction. Fast riding leads to a significantly higher pulse compared to safe riding ($F_{3,11}= 9.61$, $p = .002$; Fig. 3 right). The combination of driving safely on an easy track results in the lowest pulse values.

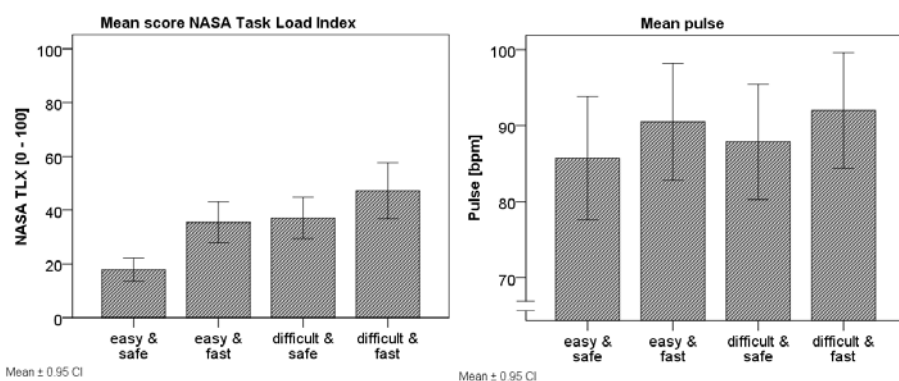


Fig. 3 Mean score on NASA Task Load Index (left) and pulse (right) by track difficulty and riding instruction

3.2 Study 2: effects of different secondary tasks

Experimental data were analysed with a repeated measures ANOVA using track difficulty and type of secondary task as within factors. The significance level was set at .05.

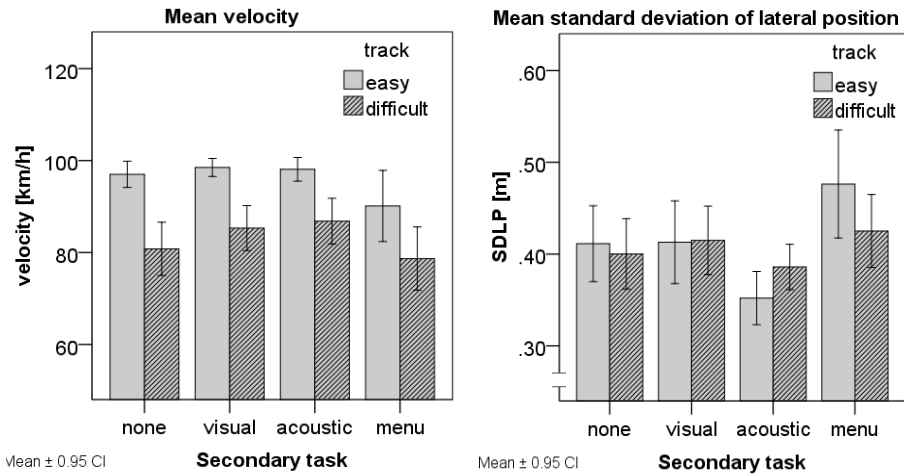


Fig. 4 Mean velocity (left) and standard deviation of lateral position (right) by track difficulty and type of secondary task

First of all, participants again ride faster on the easy track ($F_{1,12}=79.25$, $p<.001$; Fig. 4 left). In general, the different secondary tasks influence riding behaviour. Specifically, a difference between types of secondary task ($F_{3,10}=3.86$, $p=.045$) and a significant interaction between type of secondary task and track difficulty ($F_{3,10}=10.99$, $p=.002$) is found.

Further investigation reveals that participants ride slowest in the menu condition on both tracks. Furthermore, they ride significantly faster on the difficult track when performing a visual or acoustic secondary task compared to the menu operation. Concerning lane fidelity an effect of the secondary task can be seen as well ($F_{3,10}=6.62$, $p=.010$; Fig. 4 right). SDLP improves while operating an acoustic secondary task and deteriorates in the menu condition. Neither a main effect of track difficulty ($F_{1,12}=1.12$, $p=.310$) nor an interaction ($F_{3,10}=2.11$, $p=.163$) can be found.

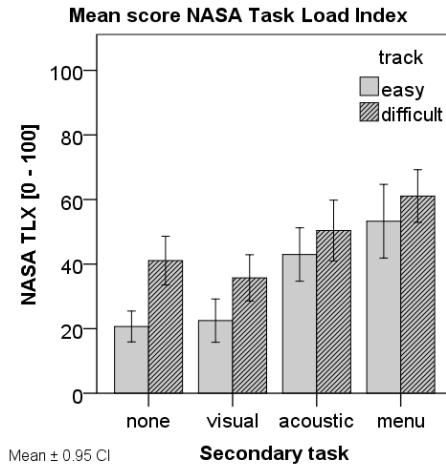


Fig. 5 Mean score on NASA Task Load Index by track difficulty and type of secondary task

There is a significant effect of track difficulty ($F_{1,12}= 29.14, p< .001$) as well as type of secondary task ($F_{3,10}= 36.31, p< .001$) and their interaction ($F_{3,10}= 8.81, p= .004$) for the subjective rating (Fig. 5). Participants report higher workload when riding on the difficult track. They experience less workload in the baseline condition as well as while operating the visual secondary task compared to the acoustic and menu condition. Additionally there is a significant difference between no secondary task and the acoustic condition for the NASA TLX score on the easy course, but not on the difficult track.

4 DISCUSSION

This paper presents options how to operationalize workload for motorcycle riders in a riding simulator setting and reports effects of different secondary tasks as a use case.

According to the riding instruction participants rode at different velocities indicating a successful variation of strain. This led to changes in lateral control, pulse and subjective measures indicating an increase in workload. The pulse measurement seemed to be mostly sensitive for the variation of

the instructed riding speed. Nevertheless, negative aspects like the installation under protective clothing, costs, and noisy values, led us to not further follow this approach. Besides the adaptation of mean velocity, the effect of different track difficulties could be seen in the participants' subjective ratings. The results of the NASA TLX indicated that riding on a difficult track leads to a higher level of experienced workload, possibly rising from the increased demand with regard to foresighted driving and the constant assessment of the own riding capacity. To conclude, track difficulty and riding instruction seem to be proper possibilities to influence rider behaviour or respectively rider strain resulting in changes in workload. On the other hand, a variation in the parameters mentioned above, under standardized conditions of track difficulty and riding instruction, could serve as workload indicators.

Therefore, this approach was used in the second study. The effects of different secondary tasks could be seen in the riders' lateral and longitudinal performance as well as subjective ratings. The standard deviation of the lateral position revealed an interesting finding: when being engaged in a visual or acoustic secondary task, SDLP did not significantly change compared to no engagement. It even decreased at first when having higher workload. Only if visual-manual distraction increased considerably (menu condition), SDLP increased significantly. One possible explanation is the active compensation of riders. They try to focus more on their riding performance as they know about the distraction. This coping mechanism is obviously limited. The riders reported less workload and felt safer on the easy course and e.g. worked on the menu task more often and for longer time periods. This could provide an indication of the need to support riders concerning the usage of bord computers or OBIS or even to lock specific functions while riding.

In sum, it was shown that workload of motorcycle riders is a promising and not yet sufficiently covered field of research. Motorcycle simulation appears as a good tool to investigate riders' workload within boundaries of normal vehicle dynamics, without endangering the participants. Further studies on this subject are urgently needed to substantiate the impact of information and assistance during motorcycle riding more closely and contribute to a higher level of safety for powered two wheelers.

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Displaying infrastructure-based information in the car – results from Austria's field operational test on cooperative I2V services

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ABSTRACT:

This research paper on the presentation and evaluation of mobile ITS services in vehicles covers a wide area of topics and includes a theoretical framework of user acceptance and at the same time first conclusions of the different aspects in the discussion section. Research on human machine interfaces has often been piggy-packed onto technology research activities as an add on both on European scale Field Operational Test's as well as with national testbeds and lighthouse projects. Public authorities want answers to crucial questions in terms of technical feasibility and scalability in the medium term time scale resolved, because this is the rationale for co-funding large scale research and development projects. At the same time user involvement and testing with users in real-world situations is expected; but often the challenges and short term dynamics of large-scale industry projects with competing technological approaches and yet emerging international harmonization and standardization have very limited degrees of freedom and design options for real world testing with end users. And the end user involvement relies on a series of limiting conditions from a technology point of view of the mobile devices including HMI design and layout topic. This paper presents results from one of these Field operational Test's – the Austrian Testfeld Telematik; with valuable user reactions during a large-scale demonstration involving several dozen cars during the ITS world conference in 2012, and from the necessary activities to enable a comparison of user generated mobile data from 65 drivers with different mobile devices under real world traffic situations on public roads.

1. Introduction

This paper presents a brief overview of different stakeholders' expectations into research approaches and research results on in-vehicle driver assistance services. Then we link our approach (in tracking drivers' acceptance of in-vehicle information on nomadic devices) to different

research traditions and corresponding research questions. We elaborate briefly on the extended technology acceptance model which we have used in 16 European Commission RTD projects for assessing driver acceptance and unveil some of our preparatory studies necessary to be able to perform the ITS service assessment. After first results, that have not been presented elsewhere we discuss implications and give an outlook into next steps.

The widespread deployment of in-vehicle driver information systems and the emergence of advanced driver assistance systems are profoundly transforming road transport. Through these Intelligent Transport Systems, a range of services is offered to the driver with the objective of facilitating the driving task and improving travel safety. Nevertheless, these developments raise questions about acceptance and possible effects and their impact on drivers' behaviour and attitudes. All this encourages a Human Centred Design approach, in which ITS are designed according to driver needs and are not driven by technological capabilities and available options. This issue is at the core of our paper, has been at the core of our project design challenge and is at the core of many similar research and development projects. For this reasons we are looking forward to discuss our lessons learnt with colleagues from other r&d areas and projects in a session at the conference in Vienna. We know that our research on using the extended technology acceptance model brings into the discussion the most widely used approach in assessing technology acceptance – even when this research tradition is only one of a vast diversity in European ITS evaluation method. This was one result in our study assignment of comparing European practices in ITS evaluation within the 2DECIDE project.

2 Different stakeholders' expectations into research approaches and research results

Research on human machine interfaces has often been piggy-packed onto technology research activities as an add on both on European scale Field Operational Test's as well as with national testbeds and lighthouse projects. Public authorities want answers to crucial questions in terms of technical feasibility and scalability resolved in the medium time scale of 3 to 5 years; because this is the rationale for co-funding large scale research and development projects and programs. At the same time user involvement and testing with users in real-world situations is expected; but often the

challenges and short term dynamics of large-scale industry projects with competing technological approaches and yet emerging international harmonization and standardization have severely reduced degrees of freedom and design options for real world testing with direct end user involvement.

The section lists different stakeholders' expectations into research approaches and research results on in-vehicle driver assistance services:

- External validity (project results are valid also for all cultural contexts in all European Union member states and sometimes even beyond). (c.f [1]).
- Clear answers to deployment decisions (c.f [2]).
- Robust results converging with results from similar ITS research
- Measurement quality / reliability (not just single item questions but sound measurement instruments – even if this easily reaches the limits of what users are ready to answer / administer.
- Academic career promotion or completion of PhD work
- Widespread use of mobile devices and smartphones by end users, which influences directly the expectations of the delivered ITS services, the used services and the experiences made, and therefore the overall acceptance by the users linked to it.

3 Project context determines research opportunities

From our experience in 16 similar European commission telematics (ICT) projects we present some of the lessons learnt how project context determines research opportunities. Our experience was validated within the study on ITS evaluation in Europe [10] (project 2DECIDE – ITS toolkit under EC's strategic activity 6.2 (ITS Action Plan)).

In the US (DoT / RITA) it has become good practice that evaluation groups are entirely independent from research and development groups. Contracts are given to experts on the condition that they use robust, comparable tools and frameworks. In Europe we have seen not only vast differences in research cultures (path dependency) into drivers' acceptance. We even find that many projects make reference to FESTA methodology or state of the art

in general terms without adhering to this state of the art within the "tailor-made" research approach of the single project.

Within the 2DECIDE project we analysed more than 400 ITS evaluation studies and found that convergence of methodologies or tools to be the rather rare exception. Comparability of data and results between different projects was not found.

4 Rather different research traditions and research questions

We link our approach (in tracking drivers' acceptance of in-vehicle information on nomadic devices) to different research traditions and single research questions. The issue at stake is nicely demonstrated in the conference programme in the aspects:

- Methodologies
- Human Factors
- HMI & Designs
- Safety
- Ecomobility

All these research branches seem to have their own good practice and their own tools for their single aspects of work. This increases the overall design challenge: Do you adhere to a specific research community or answer the general question of R&D result users: Are these mobile ITS services under analysis ready for deployment or not?

5 The extended technology acceptance model in user studies and transport research studies (TAM – Model)

We elaborate only briefly on the extended technology acceptance model which we have used in 16 European Commission RTD projects for assessing driver acceptance. The extended technology acceptance model has been used and described in hundreds of papers and projects (c.f [3]). Some sources see it as the most widely used model and tool. Our team has used this approach since 1997 in most of our user-related research. Basically the model sees driver acceptance defined by ease of use and perceived usefulness. The model consists of pre-drive questionnaires about user expectations combined with after drive questions about the user experiences and answers and changes between the two are compared

statistically. If these aspects of work are combined with short feedbacks to single services (realized as so called event triggered pop-up questions on a mobile device) than the overall picture of user reactions covers even more aspects and details of user acceptance.

6 Our preparatory studies

Mobility and driver context is rather different due to prior experience with assistance systems. Therefore we re-used lessons learnt from European Commission's flagship project COOPERS (on infrastructure to car cooperative services) [4] as well as results from 12 focus groups, participant observation, results from projects Telefot, Eurofot and Fot-Net. For the Field Operational Test (FoT) – TTA extensive work has been started in order to analyse the basic technical operating conditions for the selection and the characteristics for acceptable end user consumer devices from an evaluation point of view. The technical aspects are the correctness of background maps and views in the FoT geographic area as well as the positioning accuracy and set update frequency of the mobile device in the area in the south of Vienna. Please relate to [5] for further details of these aspects. This resulted first in a list of acceptable devices for participating users and secondly in a set of recommended user settings for devices used by participants of the FoT TTA.

7 First results of the FoT - TTA

A part from the selection of the suited mobile devices the Austrian Field Operational Test investigated necessary development steps for bringing cooperative infrastructure-to-vehicle (I2V) services to a deployment-ready stage; the simplified research question was: 'Do cooperative I2V services work already sufficiently well for the next deployment steps?'. Based on the FP6-IP COOPERS and the FESTA methodology the authors developed a multi-method, assessment methodology to identify early end-user acceptance indicators for the different cooperative services, and adapted this to various mobile devices of lead users

During the 2012 ITS world congress Vienna a common demonstration of the

TTA consortium and the Car- to-Car-Communication-Consortium (C2C-CC) showed first very promising results in setting-up end user services based on I2V technology. Services like 'in-vehicle-signage' or 'road-works warning' were shown on different end-user devices (smart phones, tablets, and in vehicle integrated devices from different manufacturers).

The assessment methodology of the FoT had to be adapted due to technical development changes as well as time constraints for the real-world testing period. A sample of 65 friendly users tested the TT services during a period of two months (October to November 2013). Collected user feedback consisted of:

- (1) A mobility behaviour questionnaire before starting the test drives,
- (2) An evaluation questionnaire after the test period as well as
- (3) Pop-up questions directly on the end-user device to be completed after every test ride and concerning the experienced services only.

All test drive data as well as GPS-tracks have been evaluated by an independent international evaluation group together with the sensor traffic counting on the ASFINAG network on the motorway A4. (University Graz: Prof. Fellendorf, University Munich: Prof. Busch etc).

First results show:

- (1) Cooperative services are valuable for most of the users;
 - (2) The shown services were mostly perceived as correct and in-time;
 - (3) 25% of the test users reduced their speed due to cooperative-services;(4)
- Most of the users are willing to use the services in future.

8 Limitations of these results

Limitations arise mainly from the trade-off between individual research traditions' good practices and deployment authorities' expectations. The main limitations are due to:

- Methodological issues especially for road safety aspects
- Measurement issues and comparability
- Complementing Simulation studies
- Distress and distraction measurement and Video data

9 Discussion

We have elaborated that an FoT with a variety of end user devices is feasible, but the effort to make user data related to ITS services comparable

for the assessment is very high. There is an indication that current in vehicle devices have an influence on driver behaviour.

According to the involved numbers of users in FoT's and the related sizes of user groups for the comparative assessment of results between projects the approach needs to be improved and intensified much beyond sharing data. The combinations of this direct assessment methods with traffic simulations of street segments and motorway corridors will be discussed in the workshop.

10 Outlook / next steps

All data as well as GPS-profiles of the test rides have been evaluated by an independent international evaluation group. We are looking forward to discussing our early results and lessons learnt with colleagues at the Humanist conference in Vienna.

11 Conclusions

It is quite obvious – there is room for improvement. We feel there should be an exchange on various research traditions beyond the sharing of data or a common basic principle like the FESTA handbook. The combinations of real user involvement with parallel simulations and calculations are necessary to determine scaling up of cooperative ITS solutions from local to (urban) context and corridor level. Somehow this confirms conclusions from several European initiatives [6], [7], [8], [9] that have tried to stimulate convergence in research and evaluation on intelligent transport. And the most important finding for future R&D projects and scientists related to user acceptance aspects: user are accustomed to state of the art mobile devices and GUI's, therefore do not present them anything below in R&D context's.

Acknowledgments

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Evaluation of Navigation Systems from a Road Safety Perspective

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ABSTRACT

Navigation systems play an essential role in today's traffic system. The increasing availability of navigation-related data changes driving behaviour and reduces routing time. Yet this development also bears risks for users, in terms of distraction or inattention. Empirical findings regarding the distracting effects of navigation systems are heterogenous. The research project ORTUNG aimed at shedding light on these divergent findings by observing drivers under real traffic conditions. In particular, the visual distraction of the use of navigation systems in comparison to traditional map-based navigation was examined by means of eye-tracking and the monitoring of driving dynamics. Differences in routing were also explored. Data analysis indicates increasing road safety when a navigation system is used in unfamiliar areas. Fewer gazes exceeding 2 seconds were found for users of the navigation system whereas map navigation leads to higher eyes-off-the-road time.

1 INTRODUCTION

In the last decade, navigation systems have become a popular and widespread user device in vehicles. Their variability and complexity has increased manifold in the past years. Their benefits are set against their possible distracting effects, which raise the probability of having an accident. Studies show that distraction could be the cause of up to 10 % of all accidents [1].

The increasing amount of research that is being conducted in the field of driver distraction has led to a variety of definitions. Young & Regan [2, p.380] suggest that distraction occurs "when a driver's attention is, voluntary or involuntary, diverted away from the driving task by an event or object to the extent that they are no longer able to perform the driving task adequately or safely".

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Previous research concerning distraction caused by navigation systems is somewhat heterogenous. The mode of use seems to play an important role: Manual data entry during driving takes up to 9 minutes and is more distracting than talking on a mobile phone or tuning a radio [3, 4]. Even selecting a predefined destination requires 10 to 12 looks at the screen and therefore often leads to inattention. Young [2] identified three aspects that reduce distraction: spoken instead of manual data entry, auditory instead of visual directions and step-by-step instead of overall instructions.

Research commissioned by one manufacturer [5] indicates a positive influence of navigation systems on road safety and the number of accidents, stress level, driver attention and performance. Knapper et al. [6] compared the use of navigation systems and paper-based maps and found no differences between the two test conditions. In contrast, other studies have revealed higher values for reaction time and mental workload [7] as well as lower driving performance [8] for the use of paper maps as opposed to electronic guidance systems.

The objectives of the ORTUNG study were to evaluate the distractive potential of navigation systems as well as to assess their benefits compared to map navigation in unfamiliar areas under natural driving conditions.

2 METHODOLOGY

In order to assess the potentially distracting effects of navigation devices, test drives with 57 participants were carried out in the period from May to August 2013 in and around Vienna, Austria. The test subjects were recruited based on gender, age and driving experience in order to represent the average driving population. Furthermore, unfamiliarity with the test route (38 km), which included all kinds of road types (urban/rural roads, motorways etc.) and information densities, was an important criterion in participant selection. A between-group design was chosen for the study. One group drove the test route using a navigation system (group 1), the other using a paper-based map (group 2). Allocation to one of these groups depended on the subject's own stated preference.

2.1 Test vehicle & sensor systems

Capturing both driver behaviour and visual distraction places a high demand

on the measurement system. Accordingly, the following sensor systems were employed in the test vehicle: a faceLAB (Seeing Machines) dash-mounted eye-tracking system, a 3-axial accelerometer, an inertial motion unit, a high precision positioning system as well as the vehicle's own CAN Bus system. The data obtained from these different systems were synchronized to provide a detailed description of both the driver and the vehicle.

2.2 Procedure

Subjects were given the task of navigating a route with five required stopovers. To this end, group 1 was supplied with an ordinary Garmin Nüvi navigation system with a predefined route. Proband navigating using a paper map (group 2) were provided with a road atlas and additional Google Maps printouts showing the exact positions of the predefined stopovers. The subjects in group 2 had to devise an appropriate route for themselves. After the test drives, the probands were asked to complete a questionnaire regarding perceived distraction and difficulties during the drive as well as their experience with and attitudes towards navigation systems.

2.3 Data analysis

Visual distraction was assessed for group 1 (navigation system) by means of eye-tracking. The eye-tracking system provided information about frequency and duration of gazes towards the navigation system. Two seconds are considered the maximum accepted duration for a gaze when interacting with in-vehicle telematics such as navigation devices. Gazes that exceed this critical limit are associated with reduced road safety [e.g. 9, 10]. To examine visual distraction for group 2 (map users), a video tool for semi-automatic event annotation was developed during the project (Fig. 1).



Fig. 1: Eye-tracking and navigation systems in test vehicle (left), data visualisation tool (right). Source: AIT.

3 RESULTS

3.1 Routing

As expected, differences were identified between the two test groups with regard to total driving time and total distance driven. The test subjects who were equipped with navigation systems predominantly followed the proposed route. This resulted in a 17% reduction in route length as well as a 23% reduction in overall driving time compared to the map-using group. While average speed during driving did not differ significantly, the number of standstills was twice as high for group 2 (map users). On average, the driving time for group 1 (navigation system) participants was about 50 minutes for a covered distance of 38 km whereas the members of group 2 spent an average of 65 minutes on the road and covered a distance of 46 km.

Focusing on the difference in route length and driving duration, it is worth noting that from a safety perspective navigation systems help reduce the risk of accident since drivers' exposures tend to be smaller.

3.2 Gaze behaviour

3.2.1 General conclusions

Referring to the overall test run time (including standstills) the comparison of the frequency of gazes at the navigation aid shows that test subjects in group 1 (navigation system) looked more frequently at the device (M=198 glances, SD=110) than subjects in group 2 (map) (M=140 glances, SD=108). However, gaze durations were shorter for group 1 (M=0.46 seconds, SD=0.14) than for group 2 (M=4.1 seconds, SD=2.7). When excluding the standstills, both groups spent the same relative amount of time looking at the navigation aid while the vehicles were in motion.

As a next step, gazes exceeding 2 seconds – which can be considered critical in terms of road safety – were analysed. 31% of these gazes of group 1 occurred while the vehicle was in motion whereas this was the case for 14% of the gazes for group 2. However, the total duration of all gazes exceeding 2 seconds when excluding standstills was much higher for group 2 (group 1: 44 seconds, group 2: 1093 seconds).

Considering the overall test run time (including standstills) all participants of group 2 (map) were found to have had at least one longer gaze at the

navigation aid whereas this was the case for only a quarter of the drivers in group 1 (navigation system).

3.2.2 Gazes in the context of speed

Fig. 2 combines driving speeds and gaze analysis: velocity values during long gazes (≥ 2 sec) are visualized using a violin- and boxplot. The larger range of values in terms of velocity in group 2 (map) is evident, suggesting that gazes at the map occur at even higher speeds, where possible accidents are usually more serious.

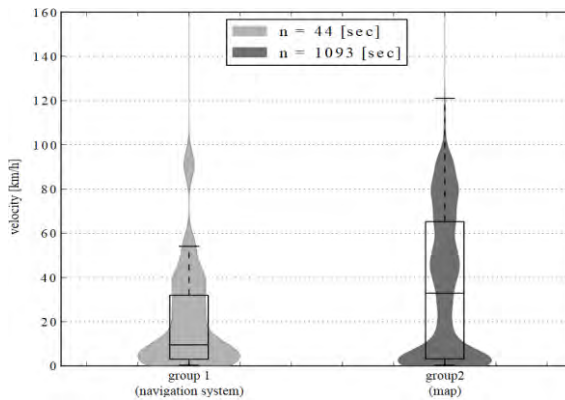


Fig. 2: Violin- and Boxplot of velocity values during gazes with duration ≥ 2 seconds.

3.2.3 Percent Road Centre analysis

In order to obtain a better understanding of possible differences in gaze patterns between the two groups the percent road centre (PRC) was calculated. The PRC is a performance indicator describing the fraction of gazes dedicated to the road centre. Following the methodology devised by Victor et al. [11] a density-based spatial clustering method was applied to the eye-tracking data to calibrate driver-specific ellipsoids defining central viewing areas (Fig. 3). By computing the fraction of gazing falling into these areas a PRC-like indicator was estimated.

The two populations were then compared with respect to certain driving situations such as points of decision along the route. Obviously, group 1 was automatically informed by the navigation system about exits and turns upon approaching a decision point whereas the other group had to solve the navigation task on their own by consulting road signs or the map. Therefore

the hypothesis was formulated that the PRC of group 2 (maps) is lower at points of decision compared to group 1 (Fig. 3). This hypothesis was verified as a Welch-test comparing the groups' PRC-values resulted in a p-value of 0.008. It should however be mentioned that the small sample sizes as well as the possibility of non-normal distributed variables may limit the general validity of this finding. Nevertheless analysis suggests that drivers relying on a navigation system are in a better position to focus on the traffic situation in front of the car because of the simplified and 'outsourced' routing and decision making process.

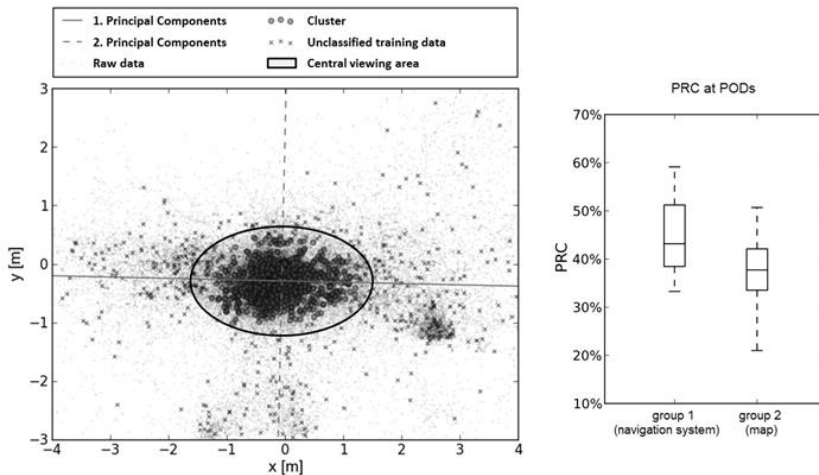


Fig. 3: Left: central viewing field. The dense region in the lower right part represents the navigation system. Right: Boxplot showing difference in PRC at points of decision

3.2.4 Gaze behaviour and driving dynamic data

In order to investigate changes in driving dynamics during gazes on the navigation aids, the cars' speeds, longitudinal and lateral accelerations and steering wheel, velocity pedal and braking pedal angles were compared visually before, during and after gazes ≥ 2 sec. No changes in driving dynamics could be identified.

4 DISCUSSION AND CONCLUSION

The project ORTUNG identified road safety related benefits and disadvantages of navigation systems when used on unfamiliar routes as opposed to navigating with paper maps.

The study confirmed expectations that navigation systems help decreasing travel times and distances.

Navigation systems are looked at more frequently than maps, but – as long as the vehicle is in motion – no differences in the relative amount of time looking at the navigation aid were recorded. However, the total duration of gazes exceeding 2 seconds – which can be considered critical in terms of road safety – is clearly higher for group 2. A comparison of the Percent Road Centre (PRC) indicator suggests that drivers supported by a navigation system are in a better position to focus on the road scene. No changes in driving dynamics during critical gazes were recorded.

The presented results indicate a lower visual distractive potential of navigation systems in the study setting (no data entry during the test drive was needed), when compared to paper map navigation. Less time is spent in traffic, fewer kilometres are driven and the total duration of critical gazes at the navigation system is shorter. However, these gazes do occur in both test conditions and bear risks in terms of road safety.

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ITS COOPERATIVE SERVICES AND HUMAN FACTORS – THE FOTSIS PROJECT EXPERIENCE

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ABSTRACT: Arial 10 – Justified – Margin 2.5

With the continuous development in the fields of sensors, advanced data processing and communications, road transport oriented applications and services have reached a significant maturity. The EC has been very active in promoting solutions which improve road safety, traffic efficiency and environmental sustainability. As the focus on these solutions shifts from the purely technological challenge to the actual deployment, there is an increasing need to evaluate the impact of the proposed services on the drivers and the services' users in general. In this paper, the experience of the FOTSis project in this area is presented, describing how human factors have been a cornerstone of the project from the design of the different services, which involve intelligent vehicle technologies, to the proposal of the evaluation methodology that will be used to assess their impact. The differences between the FOTSis project and other initiatives are highlighted.

1 INTRODUCTION

In the last decades, several initiatives have had a profound impact on the way road traffic and road safety is managed. The European Commission has been always very active in its activities towards the improvement of aspects of road safety, road mobility efficiency and transport sustainability. Their activities include the directing of efforts of all the relevant stakeholders or the promotion of direct R&D initiatives on the topic. Projects like CVIS took the first steps towards using advanced communications and sensors to support the drivers in their routine tasks, steps which have, through the years, lead the way to the current generation of Cooperative Services, exploiting the full concept of providing a complex data exchange framework between all the entities involved in the road environment.

Even though the foundation of the Cooperative Services is arguably the underlying communications architecture [9], as the prime technological

enabler of the whole Cooperative framework, Cooperative Services go beyond the communications and the data exchanges between entities to consider advanced data acquisition sub-systems and advanced processing procedures to achieve more ambitious goals towards improving road safety, traffic efficiency and the environmental sustainability in the road transport applications.

However, as technological solutions have become more consolidated, some of the most recent research initiatives in the field of Cooperative Services have been focused not so much on the systems to be deployed, and the technologies to support them, but rather on analysing their actual effectiveness on a set of more particular objectives or goals, or their impact on the driver's behaviour. The way of addressing these issues is still not clear, and different methodologies have been applied to try to successfully collect and analyse the data that would facilitate these tasks.

The FOTsis project is a currently ongoing Cooperative Services FOT (Field Operational Test) project focusing on the infrastructure aspect of the Cooperative ITS environment, which aims to evaluate the impact on the areas of road safety, traffic efficiency and environmental sustainability of 7 close to market applications. These applications or services cover road-safety oriented services as well as road efficiency oriented services, and will be tested in 4 different European countries [5].

In a similar way to other FOT initiatives, FOTsis is addressing the whole testing procedure as established by the reference FESTA project for Cooperative ITS impact assessment [4], but, while the FESTA methodology was designed primarily with vehicle-based systems in mind, the infrastructure-based approach of FOTsis services and applications poses a number of different challenges and it is expected that a significant contribution to the way of evaluating Cooperative ITS can be obtained at the end of the project.

In this paper the particular aspects of analysis of the impact of the FOTsis services on the drivers' behaviour will be described, from the formulation of the initial assessment assumptions to the final analysis methodology, going through the test design issues and the participants' recruitment process.

2 RELATED WORK

The impact on the drivers' behaviour of the Cooperative Services and earlier

initiatives has been explored in different ways. One of the initiatives that proposed in its day –and still being worked on- an overall methodology of testing Cooperative applications in general, and the impact assessment in different areas in particular, was the FESTA project. The project's resulting handbook [4] provides a foundation to support the overall tasks of preparing executing and evaluating Cooperative applications. The FESTA methodology however is not complete, and as new projects face and solve challenges, the FESTA handbook is enriched for future initiatives.

The FESTA methodology proposes two basic evaluation strategies: one based on impact areas, which results in specific measurements to be taken if the evaluation is to be carried out properly. The second strategy is based on the systems under test themselves, and results in a series of testing scenarios that allow for a direct evaluation of the performance of the services. Both strategies have their own limitations and that is the reason why several projects, including FOTsis, have opted instead for a combination of both. Another relevant aspect is the fact that even though the FESTA methodology considers both objective and subjective data collection, the proposed evaluation methodologies rely more heavily on objective data statistical analysis, which may not be sufficient for certain low-occurrence events, such as road accidents, which are critical for road safety assessment [15].

One of the most representative works contributing to the development of the most recent revision of the FESTA methodology was the TeleFOT project [16], a FOT project which investigated the impact of functions brought to the driver and aftermarket devices in vehicles for driver support and raise awareness of their potential [11]. The project built on the general methodology proposed by FESTA and expanded on the particularities of the devices under test, adapting the different stages to those particularities [8]. One of the most interesting contributions of TeleFOT in the field of user behaviour and acceptance was the application of the concept that usability of any device or system depends not only on the device, but also on the context and environment in which it is used [18]. Earlier efforts, such as the CVIS

project [2], initiated the assessment of user acceptance of advanced Cooperative Services and established a specific methodology to evaluate the utility, usability and user acceptability of the services proposed in the project, identifying relevant stakeholders and specifying the appropriate analysis methodology for each of them [12]. Both TeleFOT and CVIS used simulators to analyse the impact of the tested systems on the driver's behaviour, but introduced as well, following the FESTA recommendations, the “naturalistic driving studies”, which refer to studies undertaken using unobtrusive observation when driving in a natural setting. Naturalistic studies aim to minimize the impact on the driver of elements foreign to the system under test itself, thus providing more useful information on the devices, but on the other hand require more resources in terms of samples and test duration, together with the related resources for data collection, storage and processing/analysing [3].

3 THE FOTsis PROJECT

The starting point of the FOTsis project was the realization that a major source of information that may in fact have a significant impact on the drivers' behaviour was not fully utilized in the Cooperative ITS developments: the infrastructure-based data. Based on this data, a number of FOTsis Cooperative Services were proposed as a combination of functions serving a clear goal in terms of proposed impact, whether in road safety, road traffic efficiency or environmental sustainability; being necessary the definition of the particular hypotheses and measurements to carry out the assessment successfully.

Human factors needed to be taken into account too. Infrastructure-based road safety services involve different actors with different requirements and operative routines, from floating emergency teams to emergency coordinators, through road operator traffic managers and road users. The variety of users is a challenge both for the design and the analysis stages, but there was expertise in the FOTsis consortium to confidently address these challenges with the knowledge that the proposed changes would effectively have a positive impact on the operative of the tasks that the services support.

In this paper, analysis will be focused on Service 1/2 – Emergency/Safety Incident Management Service, a particularly complex service, which extends



the standardized e-call concept and that ultimately aims to combine the resources of the emergency response PSAP and the road operator when facing a road incident. The road operator becomes an actively agent in the incident response, being able to receive a call from the driver's application and dispatch its own teams to collect more data about the incident. At the same time, there is a real-time exchange of information between all the involved parties, including notifications to other drivers who may be approaching the area (Fig. 1).

Figure 1. FOTsis integrated Service 1/Service 2 diagrams



The major addition of this service to the current situation is the information about positioning (incident/accident, dispatched teams, overall scenario) and status (response protocol stage acknowledgements, additional incident information) that is exchanged in real time over the system.

3.1 FOTsis services design from human factor perspective

As mentioned in the previous section, one of the main challenges for the FOTsis services has been the variety of users who, sometimes in combination, can be involved in a certain service, and whose needs and requirements had to be taken into account when specifying the service and the analysis methodology for its impact assessment.

There are two aspects in which the design of the services has been taken into account. One is the operative design of the service itself: what is the task flow within the service and who needs to do what and in what order to achieve the expected results. The other is the way the actors of the service interact with the task flow operations.

The second factor is of course related to the Human-Service Interfaces (HSI) [14], critical for the services to work efficiently. The efforts to ensure a higher efficiency of new in-vehicles information services have led to the establishment of European principles and standards for HMI-HSI development at the same time that they resolve the main legal problems that could derive undesirable results of the new services. FOTsis has followed these recommendations in the design of the services with the objective to guarantee that the project results are not affected negatively by a wrong application of the HIS principles.

Therefore, recommendations for the final design of the FOTsis Services 1 and 2 are: (1) Incident reporting/Warning notification will be received in the tablet/mobile phone using a visual and audible signal; (2) Because there is a lot of communication between the control center and the driver, the number of intermediate steps (so that messages) must be reduced until the end of the incident, to avoid driver overload and distraction; (3) No part of the system should obstruct the driver's view of the road scene; (4) The driver should always be able to keep at least one hand on the steering wheel while interacting with the system; (5) The system should have adequate instructions for the driver covering use and relevant aspects of installation and maintenance; (6) System instructions should be in languages or forms designed to be understood by the intended group of drivers; (7) Product information should make it clear if special skills are required to use the system as intended by the manufacturer or if the product is unsuitable for particular users; (8) When driving with passengers, the use of tablet should be left only other passenger.

3.2 FOTsis services impact analysis

FOTsis impact assessment methodology is based on FESTA proposal and practical contributions from other project as TeleFOT, FOTsis particularities have required a special adapted methodology (Fig. 2).

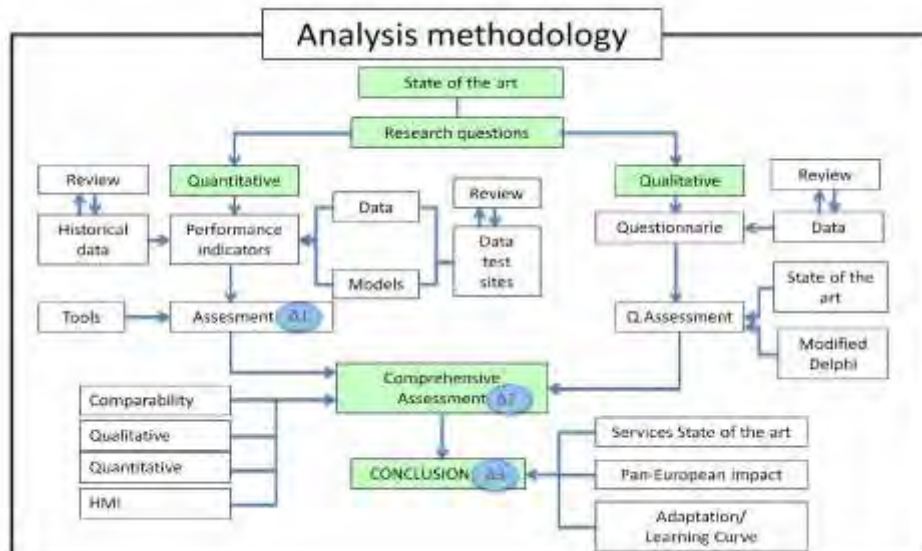


Figure 2. FOTsis proposed Impact Assessment Methodology

- 1) Preliminary assessment. The FOTsis impact assessment considers separately the quantitative or objective assessment and qualitative or subjective assessment. Quantitative assessment is based on the calculation of performance indicators (PI) from two different data sources: historical data as a reference and the test execution data. After filtering and processing the data, it is possible to estimate Delta 1 as the difference between the reference situation and the execution of the service. The qualitative assessment is based on the calculation of PI obtained from the evaluation of the questionnaires answered by the service users, which must also be filtered and process before they can be used in evaluation. A DELPHI based approach [10] is considered in FOTsis, due to the fact that statistical analysis may distort the results of what can be a reduced number of events on which to base the impact evaluation of the services.
- 2) In the comprehensive assessment, results from the preliminary assessment are further analysed. Three main aspects are considered in this stage: establishment of a broader reference line in terms of similar European efforts, the integration of qualitative and quantitative analysis results, and the

evaluation of the services' HMI. The final result of the comprehensive assessment is expected to be an overall image on what is the impact of the FOTsis services in the road environment from different points of view, and different reference baselines (Deltas 2 in Fig. 3).



Figure 3. Delta-based comparison diagram of impact of FOTsis Services

There are three major aspects to be taken into account when defining the tests to be undertaken in FOTsis: the participants, the study design and the experimental environment.

For FOTsis Services 1 and 2, the private driver is only one in a group of end-users that include professional drivers, highway and traffic management control centre operators and emergency response dispatch operators amongst others. The number of participants is in this case usually fixed and limited, and moreover, cannot be easily expanded. This focus on a professional target group has also prompted a new approach to the evaluation of the FOTsis services, relying more on subjective information than on statistical procedures as in other FOTs.

According to FESTA methodology, the study design is based on the selected Research Questions and Hypotheses –and the corresponding PI and Measures that will support the analysis of those- as established in the earlier stages of the FOTsis (Example given in Table I).

Finally, FOTsis explicitly includes environmental factors, due basically to the fact that evaluation is decided to be subjectively oriented –which means that it is necessary to gather more details about the circumstances around any relevant event. Another reason is that with 4 different countries involved in the tests –Spain, Portugal, Greece and Germany- regional differences are

considered to make a big difference in terms of Service design, the factors determining the user's acceptance of the service, and the way to evaluate the Services.

Table I. Selected Research Questions & Hypotheses for safety impact assessment

R03	Is there a change in the severity of the accidents?	The severity of accidents and injuries decrease.
R05	Is there a change in the travel time?	The travel time of service users changes.
R14	Is the service uptaken by the service users?	The service is adopted by the users in their daily work/life.
R15	Is there a change of the perceived safety?	Perceived safety increases.
R16	Is there a change in the level of attention?	The level of attention by the user is perceived to have increased.
R20	Is the information provided to the user (HMI/HSI) comprehensible?	The user considers the information of the service to be comprehensible.
R25	Is there a change in the emergency response time?	The time between incident detection and task assignation to the emergency vehicle decreases.
R26	Is there a change in the rescue time?	The response/rescue times decrease.

4 CURRENT STATUS AND DISCUSSION

Given the heterogeneous characteristics of the FOTsis services and the corresponding analysis to be conducted, it is not straightforward to extract a set of common ideas applying to all of them equally. It is clear that traditional statistical methods cannot be applied exclusively in some of the FOTsis services, given that their trigger incidents, the test subjects and the estimated data to be collected will not be enough to obtain significant results. For these cases, FOTsis takes the approach of complementing the statistical analysis with a combination of an expert-based approach and a participant-centred approach to data collection.

4.1 Expert-based approach – FOTsis approach to the DELPHI methodology

Delphi methodology is used in the FOTsis assessment in the preliminary evaluation stage and possibly in subsequent comprehensive assessment stages. The results of the focus group analysis conducted is expected to complement statistical analysis and also to provide significant insight in those cases in which objective data is not sufficient or when subjective data is critical to analyse the impact on the driver's behaviour [10].

As an initial step of this process, a first questionnaire was distributed during the first FOTsis Club meeting among different [1]. The objective of this document was to collect their opinion about certain deployment aspects in relation to the seven FOTsis services which were selected initially for their expected impact in terms of improvement of the mobility efficiency, road safety and environmental sustainability. Valuable feedback from relevant experts on the ITS world was received.

4.2 Subjective data collection

Meaningful subjective data aims to be collected not only from stakeholders but also from test drivers on FOTsis test-sites, giving hints on user preferences, user acceptance, and ease of use and usefulness of the FOTsis Services. This data will be mainly gathered by means of questionnaires that will be distributed to drivers at different stages around FOT execution. Most of the answers will be collected by means of Web-based questionnaires. Personal interviews, when required from impact area leaders, will be carried out to complement that information. Issues involved in the design of a structured questionnaire have been studied by project members, in order to obtain significant results [6]. As a result, a first list of questions is proposed (Table II). It will be distributed to drivers before the FOT execution, which will be used to gather information about the participants' background related to several aspects (experience, educational and social background, technical expertise...) and thus allow the identification of different groups of control. In addition, a number of questions to be formulated to drivers before, during or after their participation in the tests have been enumerated with the objective of compiling all the necessary information for satisfying the Hypothesis in accordance to the corresponding Performance Indicators identified for each FOTsis Service.

4.3 Practical Case

The proposed methodology is described in this section, applied to the FOTs Service 1 Emergency Management Service and the corresponding activities carried out at the M12 test-site in Madrid, Spain. Service 1 is interesting in the sense that it is a complex service involving different types of users and that it is based on emergency events, which are rare and therefore are not easily analysed with purely statistical methods.

Given the event-based nature of the service, and the involvement of many different actors in the service operations, the test plan specification for the Service 1 aims to collect both objective and subjective data during its execution. Both types of data are critical for evaluation, and special care was taken when designing the questionnaire methodology. Additionally, continuous feedback from the emergency response teams –the key actors in this service- is received in order to address possible areas to be improved to make the service more efficient in terms of its impact on road safety.

Table II. Selected Questionnaire items

WEEKLY	To what degree do you, based on your present knowledge, trust the service to provide you with accurate, real-time information?	1 .. 7
WEEKLY	In case the information provided you with inaccurate information, how did you react?	
FINAL	To what degree do you perceive that the service has provided you with accurate information?	1 .. 7
FINAL	Do you trust the service?	1 .. 7
FINAL	Did you find it difficult to learn how to use the service?	Y/N
WEEKLY	Did you find it difficult to use the service?	1 .. 7
WEEKLY	Do you think your stress level associated with the trip has changed as a result to your access to the service?	1 .. 7
WEEKLY	Did the service make you feel annoyed at any time during the trip?	Y/N

4.4. Preliminary analysis and selected results

The preliminary analysis aims to identify the potential areas in which it is considered that the service will have an impact. The results of this analysis for Service 1 are: It improves the guidance of the emergency teams by retrieval of the position of the incident via in-vehicle GPS and by providing a navigation interface. The ultimate improvement should be in the reduction of the response times; Service 1 improves the quality of the emergency assistance providing several tools which facilitate the exchange of relevant information amongst intervening actors; Service 1 improves resource allocation by means of emergency vehicle real-time tracking at the operations base.

During the full tests execution stage, results of the preliminary analysis have to be complemented with collected objective and subjective data to assess the Research Questions in different impact areas. Currently, the data collection stage is being carried out, and it is not considered that there is enough data at the moment to proceed to a significant impact assessment stage. Nevertheless, a brief overview of the response time of the emergency services is given as an example. The first step is to identify the baseline situation, which in this case is obtained through the SAMUR emergency services agency (Fig. 4). Relevant response times and their evolution are used as the reference against which the service impacts are compared.

In this case, the collected tests times (Table III) yield an average response time of 8:03 min, which is in principle an improvement over the average response time of the SAMUR in the district (SAMUR, 2011), but the large variance of the results will make it necessary a second detailed assessment round to evaluate the circumstances that affected the particular tests.

This is an activity part of the comparability analysis of the comprehensive assessment stage of evaluation, which is part of the planned tasks in the FOTsis project. However, after a first regression analysis as shown in Figure 4 right, it can be anticipated that every minute delay the survival rate increases a 4.7%; or in other words, every 20 seconds saved 1.5 out of 100 people survive.

Table III. Service 1 Response Time Collected Data

#	Detection time	Arrival time	Time elapsed
1	13:34:00	13:38:54	0:04:54
2	13:50:00	13:53:25	0:03:25
3	15:56:00	16:01:25	0:05:25
4	13:43:00	13:47:34	0:04:34
5	13:52:00	13:57:14	0:05:14
6	18:00:00	18:15:05	0:15:05
7	13:26:00	13:39:14	0:13:14
8	13:28:00	13:39:36	0:11:36
9	12:41:00	12:45:38	0:04:38
10	12:48:00	12:56:18	0:08:18
11	12:17:00	12:29:09	0:12:09

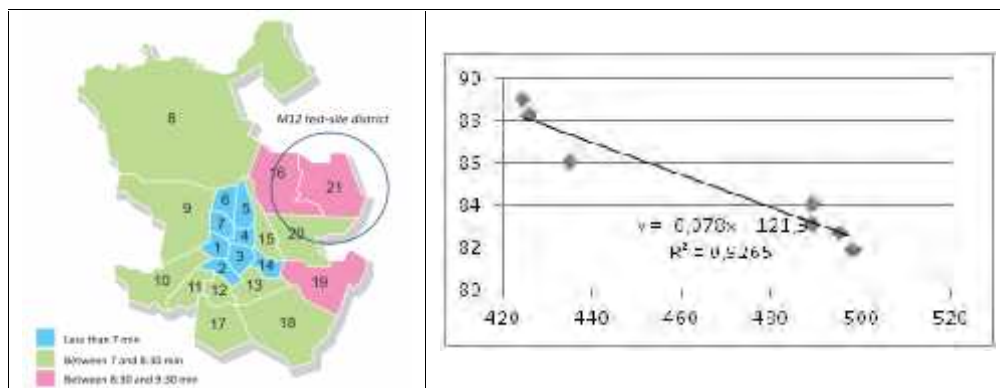


Figure 4. (Left)Emergency response times in Madrid per district. (Source: SAMUR). (Right) Relation between survival rate (%) and response time (in seconds)

5 CONCLUSIONS

In this paper, the FOTsis assessment methodology proposal has been presented. FOTsis services are complex in their interactions with different types of users, and the evaluation of their impact on these users is equally

complex. A first attempt at describing the practical approach of the evaluation methodology in FOTsis has been made using preliminary stages to the Service 1, based on data collected in the tests that have been carried out in the M12, Spain. Due to the fact that only a small number of tests have been conducted, the quantity of data available for analysis is limited at the moment. The description has included all the elements considered relevant for the assessment of the impact of the services, from the recruitment process, to the test design, going through the more theoretical different aspects of the overall FOT impact areas preparation. Special attention has been paid to the subjective data collection, which is considered one of the main differentiating aspects between FOTsis and other similar initiatives. Subjective data collection has to a large extent condition the design of the assessment methodology and as a consequence the data collection procedures in FOTsis. Pending final validation once data from all the services is available, the proposed methodology presents several novel aspects that could be applied to other initiatives addressing similar problems.

Acknowledgments

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TO DELEGATE OR NOT TO DELEGATE

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There have been significant advances in technology that will eventually see us viewing the use of autonomous cars as a common occurrence. Various systems are already on the market that provide the driver with different levels of decision support. This paper highlights the key human factors issues associated with the interaction between the user and an autonomous system, ranging from assistive decision support and the delegation of authority to the automobile. The level of support offered to the driver can range from traditional automated assistance, to system generated guidance that offers advice for the driver to act upon, and even more direct action as initiated by the system itself. In many of these instances the role of the driver is slowly moving towards one where they are acting as a supervisor of a complex system rather than taking direct control of the vehicle. Different paradigms of interaction are considered and focus is placed on the partnership that takes place between the driver and the vehicle. There is a wealth of knowledge in the aviation literature that examines such technology partnership and this paper will draw on relevant comparisons to assist the community to better understand the underlying issues that have already been witnessed in the cockpit between the human and their interaction with complex systems.

1 Introduction

With an increasingly congested road network the existing road infrastructure is insufficient at meeting the growing demand placed on it; with resulting economic, sociological and environmental consequences. Alongside this is a strong desire to improve efficiency and safety. This can either be achieved via sociological, economic or political means. Human error involving drivers is at the centre of accident causality and thus advances in autonomous systems¹ are hailed as the harbinger of a technology that can potentially

¹ In the scope of this paper, the term autonomous system will be defined as the quality of being able to perceive information from the environment and then the ability to act upon it.

reduce road fatalities in the future. What better way to reduce human error than by removing the human driver? The impetus behind some of these decisions is directly related to the advances in technology that can assist in the management of the traffic infrastructure (such as intelligent transport systems) or those technologies that can be provided in-vehicle such as driver assistance systems. Several states in the United States (including Nevada, Florida, Michigan and California) have reflected this growing appetite by passing legislation that allows the introduction of autonomous cars onto public highways.

2 Advances in Technology

If we look across the current range of autonomous cars (Google, Toyota, Nissan, BMW, to name but a few) we can see they are all actively researching the integration of autonomous decision making technologies into some vehicle models. Although there are differences across these manufacturers in terms of their approach to integrating autonomous systems, they all have one thing in common – a driver.

With the onset of smaller and cheaper sensors we have seen a migration of such technology transfer from other domains into the automotive community. For example, the development of LiDAR (“Light Radar”) was initially designed for uses in analysing meteorological conditions (specifically cloud density). Modern LiDAR systems have been used in unmanned ground vehicles for detecting obstacles whilst navigating. Perhaps the best known use of this within a car is the Google (‘Chauffeur’) car, with its recognisable spinning LiDAR mounted on the roof. At the moment this technology is expensive but there are already moves to produce a more affordable version of this technology that could be integrated into other cars.

LiDAR is but one of many different sensor technologies currently available to be integrated within an intelligent automotive system. Predominantly ultrasound technology is used in advanced driver assistance systems (ADAS) for parking and proximity/separation. Examples of the number of possible applications that sensors may be integrated into the vehicle are shown in Figure 1.

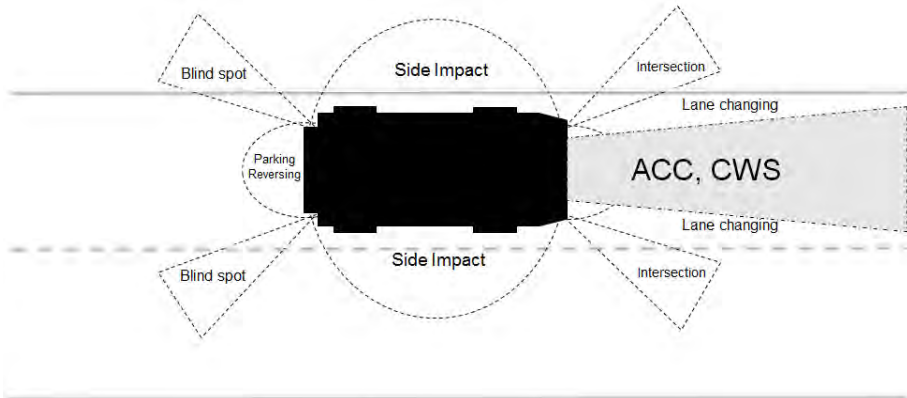


Figure 1: Some available automotive sensor applications

If we therefore assume that systems, such as intelligent collision avoidance, are integrated into the existing traffic network then how would drivers use such a system? There is one of two ways in which the system could be seen to interact with the user. For example, an autonomous car will be able to respond to an event or situation that is perceived by the system (using on-board sensors) as a potential threat and (1) will advise the driver on what action to take and place authority on the driver to respond, or (2) the car will be authorised to take action in order to avoid an accident. The need for a framework of delegating authority between the system and the user would clearly be of benefit.

3 Automation and Human Performance

The implication of incorporating an element of autonomy or automation predicates the delegation of authority, by the human, to the system.

There are many theories of automation that suggest that the human should always have the final say in any decision involving safety [1] [2]. Such a stance represents a human-centred approach to automation, whereby the human always has authority over the decision-making elements within the system. However, delegation of control authority has been outlined in theories of adaptive automation [3] [4] whereby the system is authorised to

make certain decisions on behalf of the human. An existing example of this is the demonstration of automotive collision avoidance braking systems [5] [6]. The application of automation can be viewed in most domains as an attempt to reduce the workload burden of the operator whilst also offering a higher level of safety and efficiency. This is particularly valid in the aerospace domain, where over the last thirty years we have witnessed a revolution in automated flight decks [7]. Of course, while there is a great deal of literature citing the benefits of increasing automation, there is evidence that points to its possible drawbacks. What we can conclude from the literature is that by increasing the level of automation in an attempt to mitigate instances of human error, it does not eliminate it altogether. In fact what we are confronted with is a different type of human error. Again, we can look at examples in aerospace where incidents of automation bias [8] and automation surprise [9] have been regarded as a confounding factor in many accidents. For example, the tragic flight of Air France 447 in 2009 is testament to how a highly skilled flight crew can suddenly lose situation awareness when a system is under automatic control. While cases such as these are rare, we are compelled to learn from them in order to assure that the same mistake is not made again. The importance of providing the human with a good understanding of what the system is doing (and why) is essential – especially in instances where a system failure or change in situation is presented. Much like humans, systems can fail and are fallable. Therefore it is important that we do not stand in awe of such advanced systems but rather try to optimise the relationship in a safe and effective manner.

4 Frameworks for Delegating Control Authority

Autonomous cars are sometimes referred to as 'driverless', which is misleading. It is not about taking control from the driver, but allowing them to delegate authority to the system. To facilitate the interaction between the human and the system a framework is required that defines the delegation of authority under a variety of different circumstances.

The traditional model for defining the levels of automation was put forward by Sheridan & Verplank (1978), and later revised by Parasuraman, Sheridan & Wickens (2000) [10,11]. This framework offers ten levels of automation between the human and the system, ranging from the human making all

decisions (Level 1) to the system making all decisions on behalf of the human (Level 10), as in Table 1.

Table 1: Levels of Automation (Sheridan & Verplanck, 1978).

LOA	DESCRIPTION
10	Fully Autonomous: The automation system decides everything; act autonomously, yet collaborating with other automation systems, ignores the human.
9	The automation system informs the human supervisor only if the system decides to.
8	The automation system inform the human, only if asked.
7	The automation system executes autonomously and then necessarily inform the human supervisor.
6	The automation system allows the human supervisor a restricted time to veto before automatic execution.
5	The automation system executes that suggestion if the human supervisor approves.
4	The automation system suggests one decision action alternative.
3	The automation system narrows the decision choice selection down to a few.
2	The automation system offers a complete set of a decision/action alternatives.
1	The computer offers no assistance, human must take all decisions and actions

It is possible to view this scale as a progressive change in delegation from the human to the system. There are various iterations of delegated authority between these two extremes and it thus provides us with a useful understanding of the type of interaction required.

Within the aerospace domain there is a variation of this, whereby a pilot may delegate authority to the aircraft to perform some preordained tasks. This is referred to as the PACT (Pilot Authorisation and Control of Tasks) framework, as shown in Table 2. Bonner, Taylor, Fletcher & Miller (2000) outline the different levels of delegated authority that can exist between a user (in this instance a pilot) and a system that may be either highly automated or autonomous [12].

Table 2: The PACT Framework (Bonner, Taylor & Miller, 2000).

Mode	Level	Operational Relationship	Computer Autonomy	Pilot Authority
AUTOMATIC	5	Automatic	Full	Interrupt
ASSISTED	4	Direct support	Advised action unless revoked	Revoking action
	3	In support	Advice, and if authorised, action	Acceptance of advice and authorising action
	2	Advisory	Advice	Acceptance of advice
	1	At Call	Advice only if required	Full
COMMANDED	0	Under Command	None	Full

The PACT framework offers three basic modes of automation: (1) fully automatic, (2) assisted, and (3) under human command. This provides a framework that can assign different levels of autonomy to different tasks; ranging from routine processes to safety critical events.

Within the automotive sector there has been a similar push to address the levels of autonomy for driver-vehicle interaction. In the United States of America the National Highway Traffic Safety Administration (NHTSA), a Government Agency concerned with writing and enforcing regulatory standards for the highways, has defined several levels of autonomous driving (see Table 3). Using this classification we can clearly see that the majority of autonomous cars (such as the Google system) may be viewed as adopting a system that is closer to Level 3.

There is a need for a better understanding of how a driver interacts with an intelligent vehicle. This must allow for different modes of autonomy that allows the driver the flexibility to delegate different levels of control to the system at different times.

Table 3: NHTSA classification of vehicle automation.

Level	Function	Description
0	No automation	Driver in control
1	Function-specific automation	One or more specific primary control system utilises automation
2	Combined function automation	At least two primary control systems are automated in order to assist the driver
3	Limited self-driving automation	Driver is able to cede all safety-critical functions to the vehicle in some instances
4	Full self-driving automation	Vehicle able to perform all safety-critical driving and monitor external conditions

There may be instances that dictate the driver having full control of the vehicle (simply to allow the individual to choose when they want to drive) or as a system that offers opportunities for the vehicle to be controlled by the autonomous system. This would either be seen as a benefit in the reduction of frustration or workload of the driver, or even have the potential to let the autonomous system act as the supervisor of the driver (basically as a safety mechanism). The model in Figure 2 highlights the relationship between the car and driver in terms of control, and the delegation of authority.

By examining the three levels it is possible to categorise manual (Driver Authority), semi-autonomous (Adaptive Assistance), and fully autonomous (Car Authority) modes. The shift in terms of control is seen as the balanced interaction between the driver and the car and the dynamic changes based on what level of control (direct/indirect) is delegated.

It is important to remember that in all instances the driver will always be responsible for the safe operation of the car, regardless of what level of assistance is engaged.

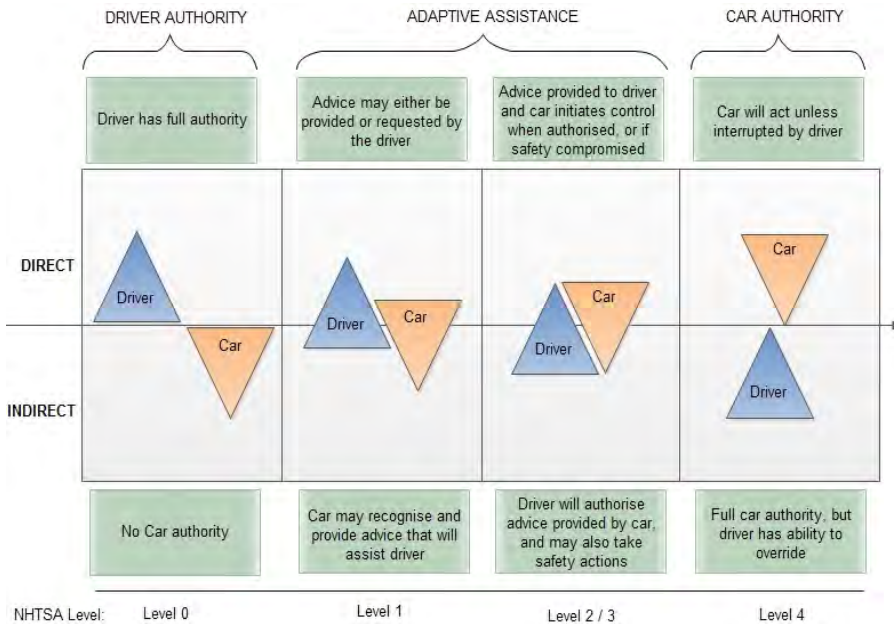


Fig. 2 Model of control delegation between driver and car

5 Cognitive Aspects of Supervisory Control

It may be argued that the more automation or decision support the user is provided then it is more important to provide the user with a better understanding of what the system is doing. The active monitoring of a highly automated system is cognitively demanding [13] and requires a high degree of vigilance on behalf of the user [14]. In order to reduce the likelihood of human error it is important that the individual attains a sufficient level of situation awareness pertaining to their situation and context [15]. Mental workload has also been cited as having a detrimental effect on human performance and safety [16]. However, if mental workload is reduced and situation awareness is maintained then the issue monitoring the system suddenly becomes a critical aspect in using the system [17]. The lack of vigilance has often been linked to a number of accidents that have ranged in severity [18]. The mental model that the user possesses is not only important in terms of evaluating when a mode error is made in automated systems [19], but also in terms of the change in perceived control that the user has over the system.

The introduction of an interactive cognitive task has been shown to

counteract the effect of mental underload both in terms of physiological measures of arousal and subjective assessment of alertness [20]. By providing a degree of cognitive effort, in terms of a secondary task, it is possible to maintain a degree of attention that facilitates a degree of *functional vigilance*. Traditionally adaptive decision support systems have been used to provide assistance to users who need to make timely (and sometimes) safety-critical decisions whilst under great task demand or mental overload. For example, if we consider an adaptive automation system on the flight deck the pilot would welcome a decision support system that would monitor user physiological indices for symptoms of mental overload. However, similarly an adaptive system could also monitor for signs of mental underload and provide cognitive cues (akin to an interactive cognitive task) in order to maintain levels of vigilance and alertness.

6 Discussion

We are seeing a shift in the traditional role of the driver, but this does not diminish the driver's responsibility; it merely changes how the driver interacts with the system. The majority of use cases for autonomous cars place the user in the traditional driving seat in front of a steering wheel, but in essence 'hands free'. However, that is not to say that the driver requires less opportunity to interact with the vehicle; in some instances we could argue that the driver requires more information. As soon as the driver delegates control authority to the vehicle then this is more than a simple task shift, but a more complex interaction of trust, reliability and safety. In autonomous mode the driver no longer requires the traditional control interface with the vehicle. The placement of hands on the steering wheel and feet situated above pedals seems superfluous to the act of delegation. Indeed, when the vehicle is within autonomous mode the steering wheel and pedals act as means by which the driver may take control back from the system – much like the way in which ADAS currently operates. However, there will still be a requirement for the driver to be supplied with appropriate cues for effectively

monitoring and supervising the autonomous system.

Taking examples from the highly automated flight deck there have been many instances of human error routed within vigilance and situation awareness. There are a number of psychological phenomena that have been cited as occurring in automated systems. These range from Mode confusion, automation bias to automation surprise.

Providing an increased level of support to the user by introducing automation and decision support has obvious benefits in terms of reducing cognitive load and reducing some elements of human error. However, Kantowitz & Sorkin (1987) observed that increasing automation can also leave the human as a simple monitor of automation and possibly requiring specific training. Humans are poor at monitoring systems due to the nature of vigilance and situations with low perceptual stimuli [21].

Some results have already suggested that users are willing to accept certain levels of delegated authority when it comes to safety. For example, Itoh, Horikome, & Inagaki (2013) found drivers approved of a semi-autonomous collision avoidance system that would present the driver with an auditory tone before performing a safety manoeuvre [22]. The technology that will facilitate the introduction of the autonomous car has entered a phase of demonstration, with the Technology Readiness Levels (TRL) getting closer to market introduction. What is less mature is the associated understanding of how drivers will adopt to this new style of driving. We often view these systems as being intelligent and in some cases out-performing the human, with little regard for the implicit nature of the sharing of the primary task and objective that in essence represents a shared goal between human and system [23]. On the occasion that the human is happy to delegate control to the system, thought is needed as to how to keep the user in-the-loop in terms of maintaining situation awareness. Good situation awareness is essential not just for monitoring the system in terms of ensuring it is safe, but more so for predicate events that suddenly occur when there is a system failure or the system recommends the human take control. In such instances human trust in the system may very well lead to a dangerous degree of complacency. As we have seen in other domains this is all too common and can lead to tragic consequences. This is why, for the foreseeable future, a driver of an autonomous car will be legally required to be paying attention to the road at all times (as is legally required in some of the US States that have already

passed legislation).

7 Conclusion

The use of an autonomous car is not about taking control away from the driver, but allowing him/her to delegate authority to the system. This changes the nature of the driving role with the driver adopting a more supervisory approach to monitoring an intelligent system. In order for this interaction to be effective it is important to design the system that allows the user to understand not only what the system is currently doing (and plans to do), but what the system *cannot* do also. This builds a partnership of honesty between the user and the system that recognises not just human limitations, but instances whereby the system will not be able to cope.

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ACCEPTABILITY OF DRIVING AN EQUIPPED VEHICLE WITH DRIVER RECORDER: THE IMPACT OF THE CONTEXT

Chloé Eyssartier

ABSTRACT:

The objective of this research conducted in the S_VRAI project [saving lives by road incident analysis feedback] is to present results about the acceptability to equip vehicle with an EDR [Event Data Recorder] without feedback. 5 focus groups were conducted in 2 different services of the French civil servants. The results show the importance to take into account the societal and professional context when studying the acceptability of an EDR.

1. INTRODUCTION

If studying the technical aspect of a new tool is essential, to study its acceptability is relevant. In fact, an automated system that is effective but not acceptable will not be used by the users. Some authors distinguish the social acceptability and the social acceptance [1]. The social acceptability is about the attitudes on a subject without the use of it. The acceptance is about the attitudes on a object on which the participant has an experience.

The objective of this research conducted in the S_VRAI project [saving lives by road incident analysis feedback] is to present results about the acceptability to equip vehicles with an EDR without feedback. The data concerning the acceptance of driving an equipped vehicle are being analysed so, at this time, we are not able to present them. In this research, insofar as, the participants have not yet driven an equipped vehicle, we are talking about the acceptability.

1.1 *Social acceptability of an EDR without feedback*

Few works [2;3] have been focused on the acceptability of an EDR without feedback on the driving behaviour, which gives to this work its innovative aspect.

1.1.1 *Lack of privacy*

The lack of privacy is the main element of the acceptability of the EDR. Concerning professional drivers, a lot of researches have been conducted on the impact of this system on the accident or about its impact on driving behaviors [4-8]. However, a few works have been conducted on its acceptability while « *the most important challenge in applying on-board safety monitoring to commercial motor vehicle driver safety management is likely to be achieving driver acceptance* » ([9], p. 29). So according to some works, for professional drivers, this technology increases their perceived stress [10]. It is a lack of privacy [9;11] that could decrease the driver judgement and modify his driving behaviour [9]. « *The measures will be acceptable if they are perceived as efficient and fair. At the opposite, the acceptability will be weakest if the measures are perceived as a lack of privacy* » [3 ; p.vii].

1.1.2 *Volunteering*

Even if the volunteering is often quoted in several theoretical models about the acceptability of a new system [12;13], it is not studied in the researches on the acceptability of the advanced driver assistance systems. This is perhaps because using these new technologies is based on an individual choice, and so, the volunteering is not a relevant element to take into account.

About the EDR acceptability, we can make the same comment, volunteering is not studied very often. As we saw in the last paragraph, in the S_VRAI project, the EDR is used in a professional context in a way to improve professional drivers behaviours. The drivers do not have choice and so the volunteering is not

relevant. However, a mandatory tool with a low acceptability will generate circumvention and avoidance strategies (see the commitment theory, [14;15]).

1.2.3 Social context

It should be wrong to consider that the acceptability of a tool is based on a single relation between the tool and its user without taking into account the social context (colleagues, friends, societal organization, ...).

So the elements quoted in the international literature do not take into account the context of use of the EDR. But, the importance of the social cognitions that permits a better understanding of the acceptability is defended by several authors [16;17].

So according to the explanatory levels [18], the inter-individual relations are important concerning the study of social influence. The social norm influence is a good illustration of this analysis level. Some authors distinguish two types of norm: a subjective descriptive norm (« what the others do ») and an injunctive subjective norm (« what I believe the others expect me to do »)[19]. We can consider that a tool will be more acceptable if other use it and if they agree with it.

Some authors add another element concerning the social organization : « *This organizational level will permit to take into account the specific context in which the individual is* » ([17], p.391). So we could suppose that the acceptability of a tool, in a professional context, is dependent on the organization of the company but also on the corporate culture. This last term is defined as a " global vision of the organization and its objective " [20].

The objective of this research is to study the acceptability of the EDR before civil servants have used it. For doing this, we based on the literature on the subject (lack of privacy, ...) and we make a focus on social aspects (professional context, societal context) .

2 METHOD

The S_VRAI project aims to equip fifty-four vehicles with an EDR called EMMA, that records data (speed, acceleration, geolocate data...) before and after an incident happens. However no feedback on the driving behaviour is made in this step of the project. The drivers are all volunteer to participate to the project and the data are anonymized before being analysed.

To study the social acceptability, we based on the focus group method, that can bring informations on an unknown subject. This qualitative method has already been used by several researchers about the acceptability of the EDR [2] but also concerning the acceptability of new technologies [21].

Two different structures of the French civil service agreed to equip some of their vehicles with drive recorder. The first one (called A) corresponds to governmental entity and the second one (called B) is a local authority. In this research we are talking about civil servants for which driving is not a main element of the job, even if they often drive to go to meetings for example.

The focus group (50-85mn duration) take place on time work and the participants gave a written consent to participate for discussion to be audio-recorded. A semi-structured interview format using open-ended questions was used, providing the opportunity for exploration on concepts of interest, as well as for free-flowing conversation amongst participants and expansion of ideas within group conversation.

27 civil servants participate this research, 22 in the entity A, with 4 non-volunteer to drive an equipped vehicle and 5 in the entity B. In the structure A, 3 focus groups made up of workers willing to drive an equipped vehicle (N=5, N=6, N=7) and one focus group of workers that refused to drive an equipped vehicle (Entity A-Non volunteer; N=4) were conducted. Groups were intentionally structured to be homogenous in

nature to encourage discussion amongst people with same hierarchic level. So the managers (Entity A- volunteer-M) were not mingled with their employees (Entity A- volunteer). In the entity B, one FG was conducted with all the respondents on the same hierarchical level (Entity B;N=5).

3 RESULTS

3.1 Differences between the 2 structures : volunteering and anonymization

The main results of this research are about the differences between the two entities and about the impact of the context on the acceptability of the EDR.

As mentionned at the beginning of this article, all the participants to the project volunteer to be involved and all the data are anonimized before being analysed.

3.1.1 Volunteering

For, the respondents of the structure A, volunteering is a non-negotiable element of the acceptability to be involved in the project, its lack could justify to refuse to be involved. However, for the respondents of the second entity, the volunteering is not important in a professional context, they consider that they have to apply the rules.

*Entity A-Volunteer : I think that it is essential to the acceptability, because it is true, if it was imposed...
Entity B :It is a vehicle in a professional context, so we obey*

The non-volunteer respondents (that are all in the entity A) speak about handling. According to them, it would give the false idea that the direction have already taken the decision to be involved in the project.

Entity A-non-Volunteer : They always give us the false idea that we are involved in the decision

3.1.2 Anonimization

If most of the respondents trust in the anonimization procedure, the two structures do not agree about its interest. So for the respondents of the entity A, the data anonymization is an essential element of their acceptability to be involved in the project, while it is not the case for the respondents of the entity B.

*Entity A-Volunteer : If the anonymization was not guaranteed, we will be against the project
Entity A-Volunteer : We would not agree to be involed*

Speaker : If it was not anonimized, would you be a volunteer ?

Entity B : Yes

Entity B : Yes

3.3 Context : professional and societal context

As the respondents mention that they speak about the project neither with their colleagues and their line-hierarchy, and nor with their relatives, we will focus on the general rules of the entity where the respondent works.

3.3.1 Professional context

In the entity A, the implementation of the projet is made at the same time as efforts to prevent abusive professional practices. Only the non-volunteer to participate to the project say that the reason why they refuse is because it is an other way to control their behaviours. The volunteers of the entity A highlight a higher contrôl of the travels but they adapt themselves to this in informing their hierarchy when they make a light twisting to the rules.

Entity A -non volunteer :They worry about the fact that peole do less work as possible, they do not trust on their employees.

Entity A- volunteer-M : The management say we can not do that, [go back home after a professional travel with a professional vehicle] or we have to say it in advance but they do not say anything at the end.

The implementation of the project is made at the same time as the implementation of GPS in fleet of vehicles in an other public entity. In each focus group, the event was mentioned. For this entity, the objective was to be more effective, in knowing where the employees are, they could tell them to go in a specific areas if needed. The employees did not agree such a measure, they had the feeling of being contrôl so they made protest and they, even, confined their manager. But for the participants of this research, this has nothing in commun with this research project, insofar as, in the S_VRAI project, the data are anonymized.

Entity A-Volunteer : They feeled control

Entity A -Volunteer : It was in real time, it was not anonymised...

Entity A-Volunteer-M : It was not a scientific project.

3.3.2 Societal aspect

The institutional aspect where the automatized systems are implemented has to take into account when we make an acceptability study. So in France, the CNIL [National Commission on support innovative and personal liberties] play a protective rôle of the French people privacy. Its objective is « to protect personal data, support innovation, preserve individual liberties » (<http://www.cnil.fr/english/>; 31 august 2013) The respondants put their trust in this entity and it is an important element of their acceptability. So the CNIL assure them that their privacy will be respected.

Entity A -Volunteer : The CNIL protects

Entity B : If the CNIL decides to put some limits, there will be respected whatever the circonstances.

4. DISCUSSION

The acceptability of an automatic system is not an exclusive relation between the user and the system but it needs to take into account the social organization in which the user is.

The main aspect of the work is about the importance of the context. So according to some authors [17], that write that the organisational context is an explanatory factor of the acceptability, we show in this research that the professional context has an impact on the acceptability.

So the acceptability of a new tool is linked to the professional identity of the society. So, between the repondents of the entity A and those of the entity B, the frontier is not the same. The volunteering and the data anonimzation are perceived by the respondents of the entity A as necessary elements to their willingness to be involved in the project, it is perceived as optional for the respondents of the entity B. We explain these differences by a « *different firm culture more precisely by a different « global vision of the organization and its objective* » [20].

To the explanatory levels developped by Doise [18] and completed by Terrade et al. [17] , we would add an other one, the societal context. This idea is quoted in other French works about new technologies, the researchers highlights that for French people, there is « *a strong feeling of a control paradigm added with a societal context, a feeling that French government control everyone* » ([22]; p.7). Insofar as the CNIL is a French entity that protect the individual liberty and in which the participants trust, if the CNIL give its consent to the S_VRAI project, it assures them that their privacy will be respected. So, we can see that the societal organisation, here the CNIL, has an impact on the acceptability.

This research is the first one made in France on the acceptability of an EDR without feedback. Our objective was to show that the acceptability of an automated system is much more complex than a relation between the system and its user even if it is what is made on most of the researches on the acceptability of new

technologies in the road safety field. To get the all complexity of the acceptability, we need to take into account the social, professional and societal context.

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Drivers' attitudes towards driver assistance systems

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Abstract

Based on the results of focus group discussions with car drivers a questionnaire was developed that asked for drivers' safety-related attitudes towards driver assistance systems (DAS). 211 drivers participated in the questionnaire survey. As in the focus group discussions, the participants had a DAS experience reaching from almost no up to a high experience. Drivers were asked about their risk-related attitudes towards 29 different systems that are available on the market. Results show, in terms of safety, drivers' evaluate the 29 systems differently. Some were valued positively, others rather neutral or even negatively. The outcomes are discussed in terms of potential contributing factors affecting drivers' attitudes towards DAS: driver characteristics (e.g. gender, DAS experience, level of sensation seeking), time of system introduction on the market and system functionality.

Key Words: *Driver assistance systems, attitudes*

1 Introduction

Driver assistance systems (DAS) are systems that, to a certain degree, automate and help the driver to fulfil the driving task for instance in throttling, braking and steering. Different DAS have different effects on the various personal goals. The success of DAS that intend to improve traffic safety depends not only on the functionality of the system, but also on the willingness of people to use these systems. Thus, attitudes towards DAS are a main factor contributing to the potential positive influence of DAS on traffic safety.

Attitudes can be defined as 'mental position', an evaluation towards a subject of interest. Thereby, attitudes are not necessarily based on reasoned considerations: persons may have attitudes that are belief-based (reasoned evaluation and deliberative cost-benefit analysis) or attitudes that arise automatically (spontaneous evaluation of attitude object as an automatic process). Conscious attitudes have a stronger effect on behaviour.

Two studies were conducted on the one hand to highlight the importance of involving the influence of attitudes when DAS effects on traffic safety are investigated; on the other hand to gain an in-depth view in drivers' attitudes towards DAS.

2 The Pre-Study: Focus group discussions

20 licensed drivers (14 ♂, 6 ♀) with a driving experience of at least 10.000 km and with different levels of experience (from very inexperienced to very experienced) in using DAS participated in four focus group discussions. Participants did not perceive DAS as necessary for themselves but strongly supported that close persons (e.g.: partners, children) should use DAS. This was explained by the fact that close persons were perceived as being more safe when driving cars equipped with DAS, thus the 'vehicle-driver-system' was evaluated as more safely when cars were equipped with DAS. Hence reasoning, the way of imposing the questions to participants seems to have a great influence while judging the safety of DAS. When drivers were asked in general how they perceive DAS they were rather sceptical concerning the safety relevance and mentioned risky effects that the use of DAS may have. But when they were asked if they want closely related persons to use DAS they immediately agreed and argued with the safety relevance of DAS (for more information see [1]).

3 The Questionnaire-Study

3.1 Methods

Based on focus group results a questionnaire was developed. 211 drivers (91 ♀, 120 ♂) participated in the questionnaire survey.

The questionnaire included items asking for participants' attitudes towards DAS and their level of sensation seeking. Further issues were asked within the questionnaire that will not be addressed here.

3.1.1 DAS experience

As presented in Haupt and Risser [2] within the questionnaire, DAS experience was determined by three main questions: (1.) *Did you - and if yes, when did you first - used the particular system?;* (2.) *How often do you currently drive with the particular system activated?* and (3.) *How familiar do you feel with the particular DAS?* The questions were asked for the systems listed in table 1.

An index of these three items was built for all systems representing the total DAS experience of participants.

Table 1. List of DAS including added technical support / ADAS (see also [2])

Name	Description
Anti-lock braking system (ABS)	system that reduces the brake pressure in case of a hard braking situation in order to avoid a possible blockade of the wheels
Traction control system (TCS), also known as anti-slip regulation (ASR)	system that prevents wheels from spinning when the driver accelerates
Electronic stability control (ESC)	(also includes traction control) a system that counteracts the break out of the vehicle by the specific breaking of the single wheels
Automatic headlamps	system that automatically switches the headlight on and off
Curve light	system that adapts the lighting direction of the headlights in a curve situation according to the curve direction
Advanced front-lighting system (AFS)	adaptive bright-darkness-threshold; a system that illuminates the road scene depending on the traffic situation
Automatic beam switching	system that automatically fades in and dims the high beam
Automotive night vision	optical system that gives the driver a better sight in dark environment
Rain sensor	system that automatically switches the wipers on and off
Head-up-Display (HUD)	display in the drivers glance direction; a front-view-display; display that projects important information in the driver's field of view
Braking Assistance System (BAS)	system that provides the necessary pedal pressure in a braking action
Emergency brake assist	system that in case of danger initiates an automatic emergency brake when recognizing critical situations
Pre-crash warning system	system that in case of danger that warns when recognizing critical situations
Hill-holder	system, that avoids rolling back while hill-starting
Hill Descent Control	system that provides driving stability while driving downhill
Cruise control	speed regulation system; a system that keeps the speed given by the driver
Adaptive Cruise Control (ACC)	system that automatically keeps the distance to the leading vehicle respectively in case no leading vehicle is present that keeps the speed given by the driver
Navigation system	system, that provides route guide information to the driver in consideration of desired criteria
Blind spot monitor	system that warns the driver of a threatening collision while lane changing
Car-to-Car communication	describes the exchange of information and data between vehicles with the objective to inform the driver in time of critical / hazardous situations
Tire-pressure monitoring system	system that serves to observe the vehicle's wheel pressure in order to avoid any accidents that are caused by defective wheels
Traffic Sign Recognition	system that identifies traffic signs of the driven road and displays this information on a in-vehicle- or head-up-display

Name	Description
Lane Keeping assistance (active)	system that supports the driver actively in keeping the vehicle in the lane by performing automatic steering corrections
Lane Keeping assistance (warning)	system that supports the driver in keeping the vehicle in the driving lane by providing an auditory and/or visual and/or haptical signal when he/she is about to leave the driving lane without indicating
Intelligent Speed Adaptation (active)	system that supports the driver in keeping the current speed limit by adapting the vehicle's speed automatically to the given speed limits in the driven section
Intelligent Speed Adaptation (warning)	system that supports the driver in keeping the current speed limit by providing a (auditory and/or visual and or haptical) warning signal and the information about the current speed limit
Parking system (active)	system that automatically steers the vehicle in the parking space
Parking system (warning)	system that supports the driver in parking by providing alarming signals when the driver gets too close to outside objects
Auto transmission	

3.1.2 Attitudes towards DAS

Following 7-steps-Likert-scale-items served to collect drivers' attitudes towards DAS:

"Would you wish that closely related persons (parents, children, partner, friends) use the respective system?" (asked for each system listed in table 1) (answering mode ranging from 1 'no, not at all' to 7 'yes, absolutely')

"When a child is a passenger in the car, the respective system should be activated in order to be able to inform, warn or intervene if necessary." (asked for each system listed in table 1) (answering mode ranging from 1 'absolutely not agree' to 7 'absolutely agree')

"The activation of the respective system so that it can inform, warn or intervene if necessary is dangerous." (asked for each system listed in table 1) (answering mode ranging from 1 'absolutely not agree' to 7 'absolutely agree')

An index of these three variables was built for each system listed in table 1. For calculating the index, the items were polarized in the same direction.

3.2 Results

The safety-related attitudes towards DAS differed between systems significantly, $F(28,1) = 62,151$, $p = .000$, $\eta^2 = .228$. Table 2 gives an overview how safe participants' judged the particular DAS. The DAS are arranged from the DAS perceived as less safely to the ones perceived as most safely.

Table 2. Arranged list of participants' attitudes towards DAS (answers from 1 'not safe' to 7 'safe')

Name	Mean index 'attitudes towards DAS'	Name	Mean index 'attitudes towards DAS'
Head-up-Display (HUD)	4.374	Lane Keeping assistance (warning)	5.221
Car-to-Car communication	4.506	Navigation system	5.273
Parking system (active)	4.510	Blind spot monitor	5.289
Intelligent Speed Adaptation (active)	4.611	Rain sensor	5.361
Auto transmission	4.629	Automotive night vision	5.365
Traffic Sign Recognition	4.670	Curve light	5.368
Hill Descent Control	4.703	Automatic headlamps	5.417
Lane Keeping assistance (active)	4.731	Tire-pressure monitoring system	5.446
Cruise control	4.762	Pre-crash warning system	5.509
Hill-holder	4.902	Braking Assistance System (BAS)	5.570
Intelligent Speed Adaptation (passive)	4.994	Parking system (warning)	5.578
Adaptive Cruise Control (ACC)	4.998	Traction control system (TCS), also known as anti-slip regulation (ASR)	5.885
Emergency brake assist	5.030	Anti-lock braking system (ABS)	6.504
Automatic beam switching	5.068	Electronic stability control (ESC)	6.229
Advanced front-lighting system (AFS)	5.183		

Note: According to Papadakis, the yellow marked system were classified as 'comfort driver assistance systems' and the green ones 'safety-relevant driver assistance systems'; the others were not included in the classification by Papadakis.

3.2.1 Gender differences

Significant gender differences in participants' attitudes towards DAS were found for the *Electronic stability control System* ($t(174.133) = -1.688, p = .047, d = .256$), the *Head Up Display* ($t(209) = -1.858, p = .033, d = .257$), the *Hill Descent Control* ($t(209) = -1.700, p = .046, d = .235$), the *Tire-pressure monitoring System* ($t(209) = -1.828, p = .035, d = .253$), the *warning Parking System* ($t(209) = -1.947, p = .027, d = .273$) and the *Auto Transmission* ($t(209) = -4.024, p = .000, d = .557$). Male participants judged these systems as safer than female participants did. Figure 1 illustrates the gender differences in participants judgements towards the mentioned systems.

No gender differences were found for the other 23 considered systems.

3.2.2 Sensation Seeking

One significant correlation was found for the effect of drivers' level of sensation seeking on attitudes towards a specific DAS. The higher participants scored in 'sensation seeking' the safer they judged the *Traffic Sign Recognition System*, $r = 0.135, p = .025$. No further correlations were found for the other 28 considered systems.

3.3.3 DAS Experience

Table 3 shows the correlations found between DAS experience and the safety-related attitudes towards the particular systems.

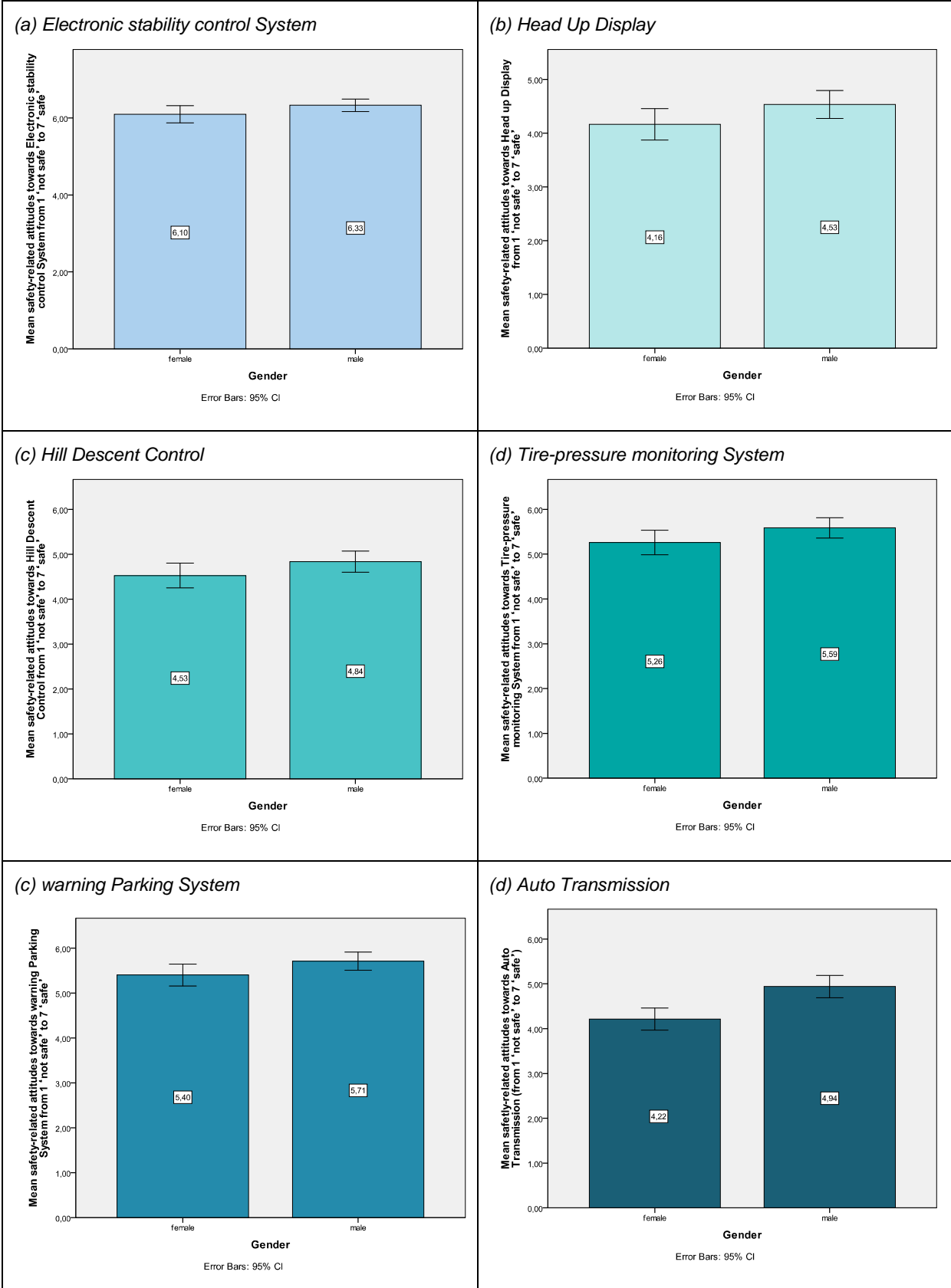


Figure 1. Gender differences in participants attitudes towards DAS.

Table 3. Correlation between attitudes towards DAS and DAS experience

Name	Correlation	Name	Correlation
Anti-lock braking system (ABS)	.214** $p = .001$	Cruise control	.180** $p = .004$
Traction control system (TCS), also known as anti-slip regulation (ASR)	.198** $p = .002$	Adaptive Cruise Control (ACC)	.120* $p = .041$
Electronic stability control (ESC)	.258** $p = .000$	Navigation system	.134* $p = .026$
Automatic headlamps	.257** $p = .000$	Blind spot monitor	.130* $p = .030$
Curve light	.170** $p = .000$	Car-to-Car communication	.056** $p = .210$
Advanced front-lighting system (AFS)	.176** $p = .006$	Tire-pressure monitoring system	.222** $p = .001$
Automatic beam switching	.174** $p = .006$	Traffic Sign Recognition	.128* $p = .032$
Automotive night vision	.092 $p = .092$	Lane Keeping assistance (active)	.101 $p = .071$
Rain sensor	.285** $p = .000$	Lane Keeping assistance (warning)	.187** $p = .003$
Head-up-Display (HUD)	.207** $p = .001$	Intelligent Speed Adaptation (active)	.063 $p = .183$
Braking Assistance System (BAS)	.252** $p = .000$	Intelligent Speed Adaptation (warning)	.075 $p = .140$
Emergency brake assist	.125** $p = .035$	Parking system (active)	.049 $p = .241$
Pre-crash warning system	.085 $p = .109$	Parking system (warning)	.268** $p = .000$
Hill-holder	.200** $p = .002$	Auto transmission	.349** $p = .000$
Hill Descent Control	.241** $p = .000$		

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

4 Conclusion

Results show, in terms of safety, drivers' evaluate the 29 systems differently. Some were valued positively, others rather negatively. When participants were asked for their safety relevant attitude concerning a system that is available as 'warning'-version and as 'active' intervening version (e.g. lane keeping assistance, ISA), participants evaluated the warning versions as safer than the active versions. As most safely, the ASR, ABS and ESC were assessed. Considering the ranking of the DAS, a potential influencing factor on drivers' safety-related attitudes towards a DAS could be the time how

long a system is available on the market already and to which extend the system is distributed in licensed cars. This statement should be investigated more detailed in future research.

Potential influencing factors on drivers' safety-related attitudes towards DAS that were raised within in the introduced questionnaire survey were: gender, drivers' level of sensation seeking and drivers' experience in using DAS.

Gender differences in participants' judgements on DAS were found for six of the 29 systems: ESC, HuD, Hill Descent Control, Tire-Pressure Monitoring System, warning Parking System and Auto Transmission. Thereby, male participants consistently evaluated those systems as safer than female participants did. The effect was highest for Auto Transmission. As for the majority of considered systems (23 of 29) no gender differences were found, it can be concluded that gender is not a decisive factor influencing if a system is perceived as safe or not.

The same can be concluded for drivers' level of sensation seeking. Only one correlation was found for the effect of participants' level of sensation seeking on attitudes towards a specific DAS. This effect was found for the Traffic Sign Recognition System.

In contrast, for the majority of considered systems (24 of 29) significant correlations with participants' DAS experience were found. No significant correlations were found for the active Lane Keeping Assistance System, the active ISA, the warning ISA, the active Parking System and the Pre-Crash Warning System. The found significant correlations were consistently positive: the more DAS experience participants had the safer they judged the systems. Thus, experiencing DAS and its functionality seem to have a positive influence how drivers judge the safety relevance of DAS. The availability of DAS and to be able to afford (also advanced) driver assistance systems might contribute to a higher DAS experience in general public and consequently to a more distributed positive view on DAS.

5 Acknowledgement

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In-field evaluation of the effects of Continuous Driver Support on driver behaviour

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Keywords: Continuous Driver Support, field tests, effects, driver behaviour, user opinions.

Abstract

User-related effects of a Driver Assistance System for Continuous Support on driver behaviour, were evaluated in a field test carried out in 2013. Twenty four drivers took part in test drives with a within-subject design along a 53 km test route containing motorway and rural-road sections. Driving data was logged and the test drivers were observed by means of an in-car observation method (Wiener Fahrprobe), i.e., by two observers in the car along with the driver. Questionnaires were used to assess the drivers' comprehension of and experiences with the system, experienced usefulness of and satisfaction with the system, as well as willingness to have and pay for the system. The results showed that there was no difference in general speed behaviour while driving with the system compared to driving without. The Curve Speed Warnings gave the expected effect. There were less dangerous lane changes with the system in active mode, but there were slightly more late adaptations of speed before intersections and obstacles. The test drivers were of the opinion that the system was useful, and that it would enhance safety especially in overtaking situations on motorways. The blind-spot warning was found especially useful in the overtaking process. The drivers appreciated the fact that the system did not give information all the time. The system was perceived as useful, while satisfactoriness was not statistically significantly different from zero. The findings provide important information that can be used by the system developer to improve system performance.

Keywords: Continuous Driver Support, field tests, effects, driver behaviour, user opinions.

1. Introduction

Advanced Driver Assistance Systems (ADAS) offer the possibility of helping the driver to avoid risky situations, e.g. inappropriately high speed, collision with an object ahead or with a vehicle in the adjacent lane, and the like. Previous studies evaluated the user-related effects of individual functions of ADAS, such as speed support (see e.g. Persson et al. 1993; Várhelyi & Mäkinen 2001; Hjalmdahl & Várhelyi 2004b; Peltola et al. 2004; Várhelyi et al. 2004; Jamson et al. 2006; Warner 2006, Regan et al. 2006; Vlassenroot et al. 2007; Adell et al. 2008; Adell et al. 2010; Lahrmann et al. 2011), warning of inappropriate distance to the car ahead (see e.g. Regan et al., 2006; Adell et al. 2010;), and blind-spot warning (see e.g. Chun et al. 2013).

In the EU-financed project interactIVe, a Continuous Support (CS) system was developed integrating such functions and this paper presents the user-related assessment of this system. When the system detected a hazard, it issued a warning to the driver. The level of warning depended on the degree of the hazard (at a higher degree of hazard sounds and active feedbacks were also activated in the safety belt). The system provided the following warnings to the driver:

- When the actual speed was above the speed limit, the display showed the speed limit icon.
- When approaching a curve at a too-high speed, the display showed a yellow curve icon as a pre-warning; the display showed a red curve icon, an alarm sound was activated and the safety belt was tensioned as an imminent warning.
- In a situation with the risk of a forward collision, the display showed a yellow obstacle icon as a pre-warning; the display showed a red obstacle icon, an alarm sound was activated and the safety belt was tensioned as an imminent warning.
- In a situation with a vehicle in the blind spot, the display showed a yellow blind-spot obstacle icon as a pre-warning; the display showed a red blind-spot obstacle icon as an imminent warning.

The aim of the user-related assessment was to evaluate the effects on driver behaviour, driver reactions to and acceptance of the Continuous Support system.

Based on findings of earlier studies, mentioned above, the following hypotheses (formulated as null-hypotheses) were tested:

1. Driving speed does not differ while driving with the system compared to driving without the system.
2. There is no difference in the number of alarm situations while driving with the system compared to driving without the system.
3. There is no difference in alarm length while driving with the system compared to driving without the system.
4. There is no other change in behaviour while driving with the system (lane keeping, lane change, interaction with other road users, etc.).

Besides these hypotheses, several issues concerning driver experiences, perceptions, opinions and acceptance were investigated, e.g. the driver's emotional state and mental workload while driving with the system, the drivers' experienced Usefulness and Satisfactoriness of the system and their willingness to use and pay for the system.

2. Method

Twenty four drivers took part in the test drives (13 males and 11 females). They were employees at Centro Ricerche FIAT (CRF) and not involved in the interactIVe project. They had been driving cars for between 9 and 37 years, with an average of 21.2 years (SD=7.2). They drove between 3000 and 35000 km a year, with an average of 17000 km a year (SD=8251). Seven of them usually drove an economy car (up to 15000 €), fifteen stated they drove a middle-class car (15000 – 25000 €) and one drove a luxury car (over 25000 €).

The test route was 53 km long, containing motorway and rural-road sections. It took approximately 40 to 45 minutes to complete. Every test driver was given time to become familiar with the situation and the car before the real observations started. Therefore, there was an additional 10 to 15 minute drive before the test drive.

The test drivers drove twice along the test route, and served as their own controls. The order of driving was arranged so that every other subject drove first with the system switched off and then with the system switched on. For each following driver the order of driving was reversed. By doing this, the effects of biasing variables, such as getting used to the test route, or to the observers and the test situation, could not be eliminated, but could be spread evenly across the situations.

Before the test drives, the drivers were informed that the trial was about the system and not about them as drivers, and that all data collected would be anonymous. They were instructed to drive as normally as possible, and ask any questions or express any doubts they might have during the test. Before using the system, the drivers were given a brief explanation of the system.

The test vehicle (a Lancia Delta passenger car with automatic transmission) was equipped with logging facilities, and data on vehicle status, system activities and driver-generated events was logged. The logged data was analysed in order to study the interaction between the test driver and the CS system, focusing both on general driver behaviour and behaviour after an alarm. The following variables were explored to study the impact of the system on driver behaviour:

- Number of generated warnings for speed, forward collision and side collision risk,
- Alarm length (time spent in alarm phase).

The test drivers were observed by means of an in-car observation method (Wiener Fahrprobe), originally developed by Risser (1985) and designed to observe learner drivers. The method also proved to be useful for studying driver behaviour in real traffic. The observations were carried out by two observers present in the car with the driver, with one of the observers (called the coding observer) studying standardised variables such as speed behaviour, yielding behaviour, lane changes, indicating behaviour etc. The other observer carried out “free observations” such as conflicts, communication with other road users and special events that are hard to predict, let alone standardise. The method was validated by Risser (1985) when he showed that there was a correlation between observed risky behaviour and accidents. Another validation work was done by Hjalmdahl and Várhelyi (2004a), who showed that drivers’ speed levels with observers in the car did not differ from their speed levels when they drove their own cars (without observers). They also demonstrated that it was possible to train observers to perform the observations objectively and reliably. In the present study, an instrumented vehicle was used in addition to the observers to increase the quality of registered standardised variables, e.g. speed, and to make it possible to measure and register time gaps to the vehicle in front. The variables of the standardised observations (driver performance, use of turning indicators, speed adaptation, lane change and lane use, overtaking, giving way, red running, and interaction with vulnerable road users were analysed both individually and on the aggregated level. The Wilcoxon (paired) sign rank test was used

to analyse differences between driver behaviour with the system on and with the system off. The variables registered by free observations were analysed through categorisation. The registered events were categorised with the system and without the system. The video recording and the logged data were used to examine any unclear events during the analysis. Within each category the nature of the events was compared with the system on and with the system off.

Questionnaires were used to assess the drivers' comprehension of and experiences with the system. After the first ride the drivers answered a short workload questionnaire. After the second ride a more comprehensive questionnaire was filled out. This questionnaire covered the following issues:

- Experienced effects of the system

To assess what effects the drivers' experienced while using the system, they were asked to state their thoughts on how different aspects of driving changed while using the system. They were also asked to compare their experiences of using the system to their experience of driving without the system, on a continuous scale from "decreased greatly" to "increased greatly" where "neither" represented the middle point.

- Subjective workload

Subjective measurements of the test drivers' workload were recorded with the help of the Raw Task Load index (RTLX) method proposed by Byers et al. (1989). According to this method, the subjects rate six different workload aspects, namely *mental demand*, *physical demand*, *time pressure*, *performance*, *effort* and *frustration level*. Continuous scales ranging from "very low" (0) to "very high" (100) were used. The difference in workload between driving with the system on compared to driving with the system off was calculated for each test driver as Workload (on) – Workload (off).

- Usefulness and satisfaction

Acceptance of the system was measured by the usefulness and satisfaction method proposed by van der Laan et al (1997). According to the method, the subjects assess nine components related to usefulness and satisfaction: "good – bad", "pleasant – unpleasant", "effective – superfluous", "nice – annoying", "likable – irritating", "useful – useless", "assisting – worthless", "desirable – undesirable", "raising alertness – sleep inducing". The test drivers were asked to rate the different components on a continuous scale.

- Willingness to have and pay

Questions were asked in order to get information on the willingness to pay for the system.

- Furthermore, after each test ride, the observers conducted a short interview with the test drivers, asking them about their general feelings about using the system, possible problems during the test drives and comments regarding the system and how it could be improved. Also, comments of the test drivers regarding the system, while driving on the test route, were noted by the observers.

To test the statistical significance of differences from the answer "unchanged", the one-sample t-test was employed. The open questions were analysed through categorisation.

3. Results

Free driving speeds

Free driving speeds, when the test drivers could choose their speed without disturbance of surrounding traffic on the different types of roads, were analysed for road sections with speed limits of 50, 90 and 130 km/h. Free driving speed profiles were plotted individually for each of these sections, after which profiles of mean free driving speeds were created for both driving without the system and driving with the system. No statistically significant difference in mean free driving speeds could be shown for any of the analysed sections, as the profile of mean driving speeds with the system was within the 95% confidence interval of the means of driving without the system. This finding indicates that the test drivers did not alter their general speed behaviour while driving with the system compared to driving without the system.

Speed warnings

All warnings the driver received along the whole test route while driving with the system on (and would have received while driving without the system, but with the HMI disabled) were registered. The codes of the various speed warnings and their content are presented in Table 1.

Table 1. Coding and content of speed warnings.

Code	Warning level	Action
2	Speed limit warning	display of speed limit icon
4	Curve speed pre-warning (yellow level)	display of yellow curve icon
6	Curve speed imminent (red level)	display of red curve icon tensioning of safety belt alarm sound

Speed limit warnings

The number of warnings while driving with the system was higher for 12 test drivers and lower for 9 test drivers than while driving without the system. The mean number of warnings per driver (26) was unchanged; hence it can be concluded that there was no change in the number of speed warnings. The length of the speed warnings while driving with the system was shorter for 12 test drivers, and longer for 9 test drivers, than while driving without the system. The mean length of speed warnings without the system was 12.29 sec and with the system 11.65 sec, a decrease of 0.64 sec, a statistically non-significant difference ($p=0.5$) according to t-test.

Curve speed warnings

Curve speed warnings were concentrated to one specific site, i.e. just before entering a roundabout. Otherwise, only 5 individual speed warnings (code 6) were received at four other places along the whole route for all rides. The speed profiles for all passages with curve speed warnings (code 6) were plotted individually from 10 seconds before to 10 seconds after a warning was issued. The profiles of speeds in Figure 1 represent the mean of 10 individual curves while driving without the system (HMI disabled) and 14 curves with the system. As Figure 1 illustrates, when the warning is issued, the driver has already started to decrease speed, but, while driving with the system, the mean of lowest speeds is statistically

significantly lower throughout the roundabout (outside the 95% confidence interval of the means of driving without the system), than while driving without the system.

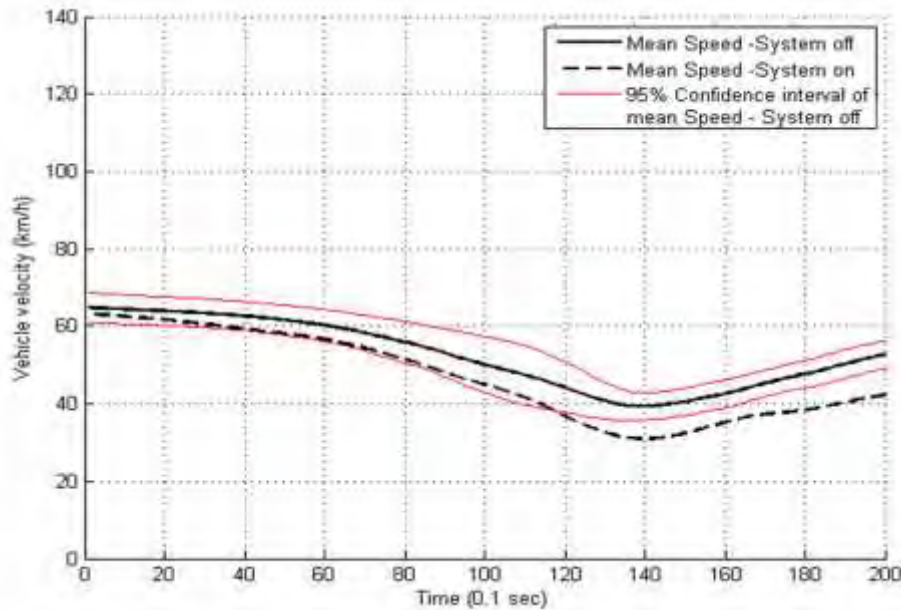


Figure 1. Profiles of mean speeds while driving without and with the system and a curve warning (code 6) is issued (warning issued at 100).

Forward collision warnings

The codes of the forward collision warnings and their content are presented in Table 2.

Table 2. Coding and content of forward collision warnings.

Code	Warning level	Action
5	Forward collision pre-warning (yellow level)	display of yellow obstacle icon
7	Forward collision imminent (red level)	display of red obstacle icon tensioning of safety belt alarm sound

The number of pre-warnings (code 5) during driving with the system was higher for 15 test drivers and lower for 6 test drivers than during driving without the system, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings (code 5) per driver increased from 8.95 to 10.19 by 1.24.

The number of imminent forward collision warnings (code 7) during driving with the system was higher for 11 test drivers, lower for 7 test drivers and unchanged for 3 test drivers, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings per driver increased from 2.95 to 3.57.

The conclusion is that there is some tendency for an increased number of forward collision warnings while driving with the system, but no statistically significant difference can be shown ($p=0.05$). This tendency might be due to test drivers challenging the performance of the system.

The length of the forward collision pre-warnings (code 5) during driving with the system was shorter for 8 test drivers and longer for 13 test drivers than during driving without the system.

The mean length of warnings without the system was 16.19 sec and with the system 16.71 sec, a slight increase of 0.53 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

The length of imminent forward collision warnings (code 7) during driving with the system was shorter for 9 test drivers and longer for 12 test drivers than during driving without the system. The mean length of warnings without the system was 2.19 sec and with the system 2.67 sec, a slight increase of 0.48 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

Side collision warnings

The codes of the side collision warnings and their content are presented in Table 3.

Table 3. Coding and content of side collision warnings.

Code	Warning level	Action
1	Side obstacle	display of yellow blind-spot obstacle icon
3	Side obstacle + stalk	display of yellow blind-spot obstacle icon
4	Side obstacle + lane drift	display of red blind-spot obstacle icon

Left side warnings

The number of side obstacle warnings (code 1) from the left during driving with the system was higher for 8 test drivers and lower for 13 test drivers than during driving without the system, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings (code 1) per driver decreased by 1.96, from 30.10 to 28.14.

The number of side obstacle warnings of code 3 during driving with the system was higher for 11 test drivers, lower for 7 test drivers and unchanged for 3 test drivers, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings per driver increased from 1.81 to 2.10.

The number of side obstacle warnings of code 4 during driving with the system was higher for 8 test drivers and lower for 13 test drivers, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings per driver decreased from 5.10 to 3.48. The conclusion is that there is no difference in the number of side collision warnings from the left while driving without and with the system.

The length of the side collision warnings from the left (code 1) during driving with the system was shorter for 10 test drivers and longer for 11 test drivers than during driving without the system. The mean length of warnings without the system was 126.6 sec and with the system 123.5 sec, a slight decrease of 3.1 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

The length of code 3 side collision warnings from the left during driving with the system was shorter for 9 test drivers and longer for 11 test drivers (one unchanged) than during driving without the system. The mean length of warnings without the system was 2.16 sec and with the system 3.76 sec, an increase of 1.6 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

The length of code 4 side collision warnings from the left, during driving with the system was shorter for 14 test drivers and longer for 7 test drivers than during driving without the system. The mean length of warnings without the system was 7.78 sec and with the system 6.88 sec, a slight decrease of 0.9 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

Right side warnings

The number of side obstacle warnings (code 1) from the right during driving with the system was higher for 11 test drivers and lower for 9 test drivers (one unchanged) than during driving without the system, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings (code 1) per driver decreased by 1.43, from 26.14 to 24.71.

The number of side obstacle warnings of code 3 during driving with the system was higher for 4 test drivers, lower for 12 test drivers and unchanged for 5 test drivers, a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings per driver decreased from 3.43 to 2.67.

The number of side obstacle warnings of code 4 during driving with the system was higher for 8 test drivers and lower for 12 test drivers (one unchanged), a statistically non-significant difference according to the sign test ($p=0.05$). The mean number of warnings per driver decreased from 11.9 to 11.33. The conclusion is that there is no difference in the number of side collision warnings from the right while driving without and with the system.

The length of the side collision warnings from the right (code 1) during driving with the system was shorter for 10 test drivers and longer for 10 test drivers (one unchanged) than during driving without the system. The mean length of warnings without the system was 51.45 sec and with the system 48.88 sec, a slight decrease of 2.57 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

The length of code 3 side collision warnings from the right during driving with the system was shorter for 13 test drivers and longer for 6 test drivers (2 unchanged) than during driving without the system. The mean length of warnings without the system was 2.58 sec and with the system 1.91 sec, a decrease of 0.67 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

The length of code 4 side collision warnings from the right during driving with the system was shorter for 12 test drivers and longer for 9 test drivers than during driving without the system. The mean length of warnings without the system was 11.54 sec and with the system 10.19 sec, a decrease of 1.35 sec, but a statistically non-significant difference ($p=0.5$) according to t-test.

Observed driver behaviour

Several conflict situations (test driver on a collision course with another road user followed by an evasive action by one of them) were observed on both rides with and without the system activated. While driving with the system activated, 6 conflicts were caused by the test drivers, and while driving without the system activated, 2 conflicts were caused by the test drivers. In most of the cases the evasive action to solve the conflict was taken by the test driver. Only in one conflict situation was the evasive action taken by another road user, while in another situation both the test driver and the other road user took the evasive action.

Driving too fast according to the situation was observed to be statistically significant less often with the system activated. Also, driving too far to the right and dangerous lane changes were observed to be statistically significant less often with the system activated. The test drivers chose a wrong lane while driving through an intersection or roundabout less frequently with the system activated.

On the negative side, it can be noted that slightly more late adaptations of speed before intersections and obstacles were observed while driving with the system. Also, statistically

significantly more errors regarding dangerous distance to the side were observed with the system activated. It also was observed that the test drivers turned at a speed that was too high, but only while driving with the system activated.

No major differences were found regarding speed choice while driving with or without the system. The test drivers drove over the speed limit (on both rural-road and motorway sections) on both driving occasions. Moreover, the test drivers drove too fast through curves and approached a roundabout or drove through it too fast, in addition to accelerating before leaving the roundabout to the same extent on both driving trips. Sticking to own priority was observed in equal numbers on both occasions, with and without the system. No statistically significant differences between the two drives could be shown regarding dangerous distance to the vehicle in front, illegal or aborted overtaking manoeuvres, correct indicating behaviour, drifting or crossing the solid line, crossing a stop line at intersections or roundabouts, driving against yellow at a traffic light, yield behaviour and ignoring pedestrians/cyclists. Regarding interaction behaviour with other road users, hardly any differences could be observed. Situations on both drives were noted where the test drivers either made errors in the interaction processes or showed respectful behaviour towards other road users. On both occasions, situations were observed in which the test drivers did not choose the correct speed, drove without foresight or too close to other road users, showed unclear behaviour to other road users or did not behave correctly in overtaking manoeuvres. The test drivers also showed respectful behaviour towards other road users on both drives by giving way in different situations or adapting their speed and lateral position well.

Questionnaire answers

To assess the drivers' perceptions of the system, they were asked to state how they thought different aspects of driving changed while using the system. The drivers were asked to compare their experience of using the system to driving without the system on a continuous scale from "decreased greatly" to "increased greatly" where "neither" represented the middle point.

According to the test drivers, safety in traffic increased with the system, see Figure 2. The risk of getting a speeding ticket, travel time and fuel consumption were not believed to be affected by the use of the system. The system did not affect the emotional state of the drivers fundamentally, but the drivers experienced an increase in irritation ($p < 0.05$). The test drivers thought that stress, enjoyment while driving, the feeling of being in the way of others, the attention to traffic, the image and the comfort were not affected by the system.

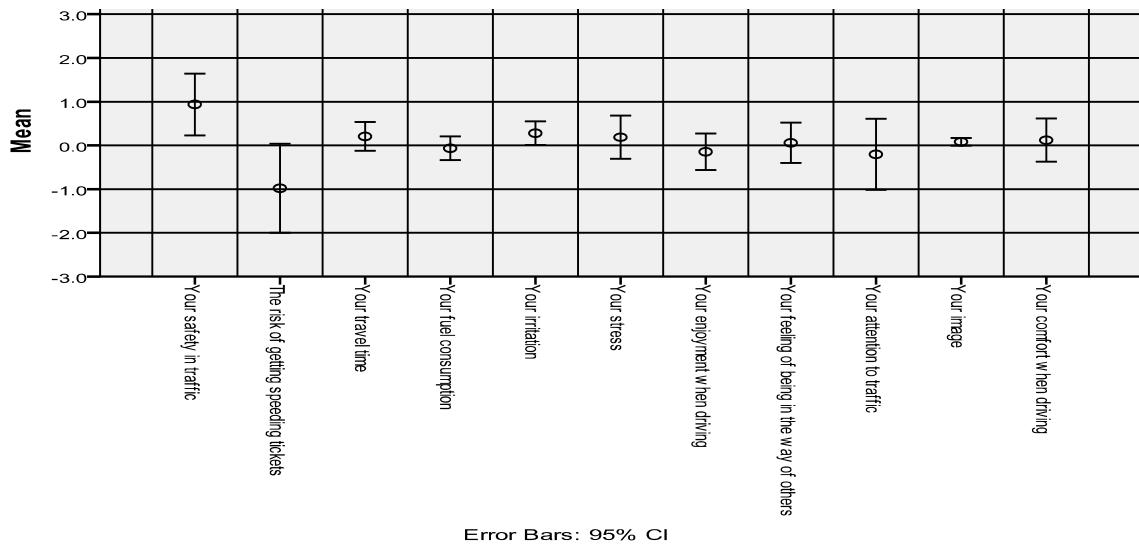


Figure 2. Mean values and 95% confidence intervals of answers to the question: What differences did you notice while using this system compared to driving without the system? (lower values = Decreases greatly; higher values = Increases greatly).

Usefulness and satisfaction

The system was perceived as useful (“useful”, “good”, “effective”, “assisting” and “raising alertness” – all items $p < 0.05$), while “desirable” was the only item on the satisfactory scale which was assessed significantly higher ($p < 0.05$), see Figure 3.

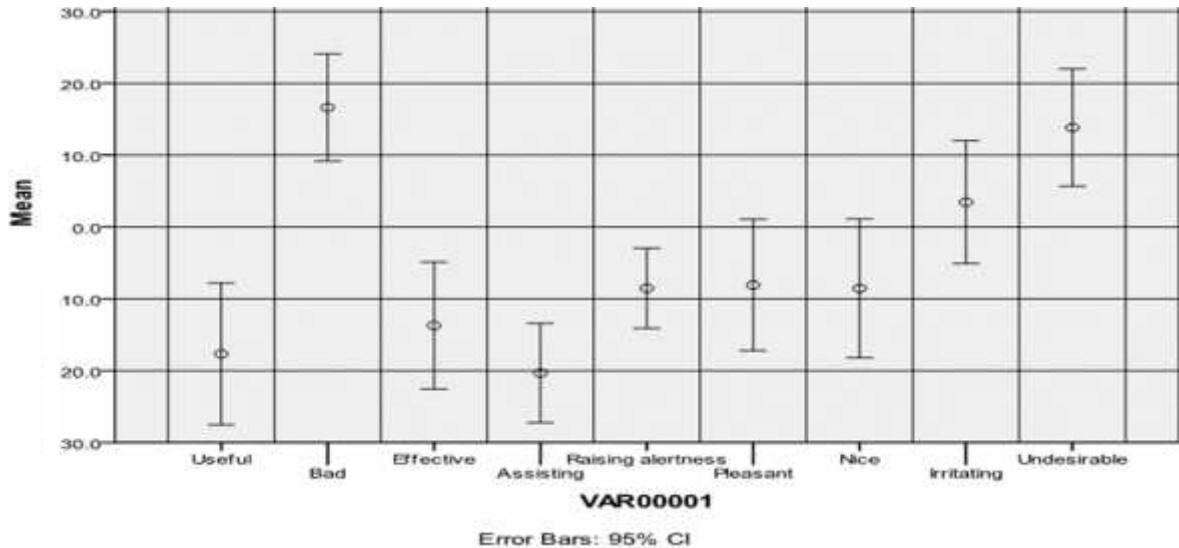


Figure 3. The drivers’ rating of the items included in the assessment of “usefulness” of and “satisfaction” with the system.

Subjective workload

The subjective workload in general was not affected by the use of the system. The drivers assessed only one item, i.e. their performance to decrease statistically significantly ($p < 0.05$) while driving with the system, see Table 4.

Table 4. The mean, minimum and maximum numbers of subjective workload and results from the Wilcoxon (paired) signed rank test between driving with and without the system.

	Without system activated			With system activated			Sign. of difference
	Mean	Min	Max	Mean	Min	Max	
Mental activity	-1.5	-4.9	2.9	-1.2	-4.7	3.2	0.268
Physical activity	-2.8	-4.8	0.7	-2.5	-4.8	0.8	0.112
Time pressure	-2.5	-4.8	1.1	-1.5	-4.9	3.8	0.072
Own performance	1.6	-0.7	5	0.9	-1.4	4.9	0.001
Effort	-2.0	-4.9	1.7	-1.7	-4.9	3.1	0.391
Frustration	-2.1	-4.9	2.9	-2.5	-4.8	1.4	0.410

Test drivers' comments

Table 5 shows an overview of the comments of the test drivers regarding the system in general, as well as for each specific function.

Table 5. Overview of the test drivers' comments in general and regarding each specific function.

	Advantage	Disadvantage	Proposed improvements
General	<ul style="list-style-type: none"> • system was helpful • did not give information all the time on what the driver should do • no problems using the system and easy to use the different functions • enhanced safety especially in overtaking situations on motorways 	<ul style="list-style-type: none"> • warnings came too late, possible dangerous situations were recognised before the system showed it • in some emergency situations no visible information was given or it was shown only for a short time • some test drivers did not trust the system or "instinctively" doubted the information • in the long run, the system might reduce the attention 	<ul style="list-style-type: none"> • the visual display for the warning should be put as high as possible so that it will not be covered by the steering wheel while driving through a curve • „training“ with the warnings would be useful
Speed warning	<ul style="list-style-type: none"> • draws attention to the current speed limit • helps to avoid fines • especially useful when the speed limit changes 	<ul style="list-style-type: none"> • non-accurate speed limit warnings 	
Blind spot warning	<ul style="list-style-type: none"> • important information about vehicles coming from behind • especially useful in an overtaking process 	<ul style="list-style-type: none"> • one might not use the mirrors anymore as the information on the dashboard is very reassuring 	<ul style="list-style-type: none"> • additional haptic warning especially for the blind-spot warning
Forward collision warning	<ul style="list-style-type: none"> • helpful to keep a safe distance especially in overtaking processes 	<ul style="list-style-type: none"> • false alarms • annoyed by the wrong seat belt warnings • seat belt warning not correlated with the real hazardousness of the situation • too short visual information • distracted by the warnings (aborted overtaking manoeuvre) 	<ul style="list-style-type: none"> • warning signal could be “stronger” in order to get the attention of the driver in situations when he/she might be distracted
Curve warning		<ul style="list-style-type: none"> • false alarms • annoyed by the wrong seat belt warnings • seat belt warning not correlated with the real hazardousness of the situation 	

Willingness to pay and use

The test drivers were asked to indicate the price they would be willing to pay for the system. Eleven (almost half) were willing to pay up to 250 Euros to implement the system in their cars. Eight (about one third) were willing to pay between 250 and 500 Euros and two were willing to pay between 500 and 750 Euros for the system. Two drivers had no opinion regarding this question and one did not answer the question.

The drivers were also asked to estimate, in terms of their driving time, how much they would use the system on different types of roads. More than two thirds thought that they would use the system up to 60 % of the time while driving on motorways, while 14 stated that they would use it up to 60% of the time while driving on rural roads. On urban roads, “only” nine test drivers (about one-third) stated that they would use the system up to 60% or more while driving. On the other hand, six test drivers (about one-quarter) stated that they would use the system on motorways, and seven on rural roads, up to 40 % of their driving time, while twelve stated that they would use the system in urban areas up to 40% of their driving time, see Table 6.

Table 6. Number of answers regarding “How much of your driving time you think you would use the system?”

	0-20% of time	20-40% of time	40-60% of time	60-80% of time	80-100% of time
Driving time on motorways	3	3	1	7	10
Driving time on rural roads	4	3	3	9	5
Driving time on urban roads	9	3	3	5	4

Discussion

The hypotheses 1 – 3 concerning unchanged speeds, number of alarms and alarm lengths cannot be rejected. No major differences were found regarding speed choice (driving over the speed limit, speeds through curves and roundabouts) while driving with or without the system. There was no difference in the number or length of the speed warnings, or the number or length of the side collision warnings from left or right while driving without and with the system. Some of these findings are in contrast to the earlier findings of Adell et al. (2010), who found that while driving with a system that warned of unsafe speed or unsafe distance to the vehicle ahead, the number of alarm situations was smaller than while driving without the system. However, in Adell et al., the curve alarm length and obstacle alarm length were lower on motorway sections and unchanged on rural roads and urban roads; for a summary, see Table 7.

When it comes to hypothesis 4, about any other changes in behaviour while driving with the system, the majority of observed behaviour variables are unchanged, but there are changes in a positive direction for some behavioural variables, and in a negative direction for other variables.

No differences between the two drives could be shown regarding distance to the vehicle in front, overtaking manoeuvres, correct indicating behaviour, crossing the solid line, late or hesitant lane change before an intersection, stopping behaviour at intersections, driving against yellow at traffic lights, yield behaviour and interaction behaviour with other road users. The last finding is not in line with the findings of Persson et al. (1993), who assessed driver behaviour while driving with a speed limiter, and found a slight increase of incorrect behaviour towards other road-users at junctions. In addition, assessing the effects of a system warning of unsafe speed or unsafe distance to the vehicle ahead, Adell et al. (2010) revealed

that the drivers seemed to show worse facilitating behaviour towards other road users with the system on. However, evaluating the effects of a speed support system, Hjalmdahl & Várhelyi (2004b) showed that the drivers' behaviour towards other road users improved. They showed a more correct yielding behaviour at intersections, and yielded early for pedestrians to a higher extent when driving with the system. Adell et al. (2010) also noted, in contrast to findings of the present study, that the number of times the drivers crossed the centre line increased when the system was on.

Driving too fast, given the situation, was observed less often during driving with the system activated. Due to curve speed warnings, the test drivers passed the roundabout at lower speeds while driving with the system. Driving too far to the right and dangerous lane changes were observed less often while driving with the system activated. Wrong lane choice when driving through an intersection or roundabout was less frequent while driving with the system on.

On the negative side, it can be noted that slightly more late adaptations of speed before intersections and obstacles were observed while driving with the system on. More errors regarding dangerous distance to the side were observed with the system activated. Only during driving with the system activated was it observed that the test drivers made turns at too high speeds.

Table 7. The effects on driver behaviour while driving with the system (along with findings from previous studies).

Variable	Effect			
	Present study	Persson et al. (1993)	Hjalmdahl & Várhelyi (2004b)	Adell et al. (2010)
Speed adaptation to the situation	+			
Speed in curve	+			
Lane choice	+			0
Lane change	+			0
Lane keeping	+			0
Number and length of speed warnings	0			+
Number and length of forward collision warnings	0			+
Number and length of side collision warnings	0			
General speed behaviour	0	+	+	0
Distance to the vehicle in front	0	+	+	
Overtaking manoeuvres	0			0
Use of turning indicator	0			0
Crossing the solid line	0			-
Stopping behaviour at intersections	0			
Driving against yellow	0			0
Yielding behaviour	0		+	
Interaction/communication with other road users	0	-	+	-
Late speed adaptation before intersections and obstacles	-			
Turning at high speed	-	-		
Dangerous distance to the side	-			

+ = Improvement; 0 = No major change; - = Deterioration

The system did not affect the emotional state of the drivers, but they did feel an increase in irritation. They thought that safety in traffic increased while using the system. The subjective workload was in general not affected by the use of the system; the drivers assessed only one item, i.e. their performance to decrease statistically significantly while driving with the

system. The system was perceived as useful, while satisfactoriness was not statistically significantly different from zero.

Conclusions

The user and observer comments provide important information that can be used by the system developer to identify major problems (mainly false alarms) and improve system performances with updated releases of the application software.

To summarize, the system was assessed to be useful with respect to the following:

- It was felt that the system would enhance safety especially in overtaking situations on motorways.
- It was noted that the system did not provide information all the time.
- It was thought that the speed warning drew attention to the current speed limit. It will be especially useful when the speed limit changes, and consequently help in avoiding fines.
- The blind-spot warning was found especially useful in the overtaking process.

On the other hand, the following improvements are necessary:

- The test drivers were annoyed by the wrong seat belt warning, as it made them anxious. The pressure was not correlated with the real hazardousness of the situation, and it came in addition to the acoustic warning.
- Warnings came too late and possibly dangerous situations were already recognised before the system showed it.
- In emergency situations no visual information was given or it was shown only for too short a time, so the test drivers did not know the reason for the haptic or acoustic warning.

The most relevant findings on how the driver interface can be improved are as follows:

- The signal for the forward collision warning could be “stronger” in order to get the attention of the driver in situations when he/she might be distracted.
- The warning icon should be kept for a longer period after the warning is issued.
- The visual display for the forward collision warning should be put as high as possible so that it will not be covered by the steering wheel while driving through a curve.
- The test drivers would prefer an additional haptic warning for the blind-spot warning.
- Safety belt tensioning should not be used for both speed warning and forward collision warning.
- Another proposal was that some training with the warnings would be useful before using the system, at least to get to know the different warning signals in order not to be surprised when they appear the first time.

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THE RANGE COMFORT ZONE OF ELECTRIC VEHICLE USERS – CONCEPT AND ASSESSMENT

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ABSTRACT:

Enhancing usable range and the range-related user experience in battery electric vehicle (BEV) use is an essential task in advancing electric mobility systems. We suggest the concept of comfortable range (i.e., the users' range comfort zone or range safety buffer) as a benchmark variable for evaluating range-optimization strategies. The methodology for assessing comfortable range is described and evaluated. Data from three BEV field trials are analyzed. Results show that the developed comfortable range indicators have good psychometric characteristics and are able to track the effects of behavioral adaptation.

1. INTRODUCTION

The improvement of battery electric vehicle (BEV) range is an essential task in advancing electric mobility systems. However, besides striving for improvements in battery capacity, research and development also must focus on strategies to provide users with the maximum mobility resources (i.e., usable range) based on a given battery capacity, while simultaneously safeguarding an optimal user experience. Driver information and assistance systems for range estimation and eco-driving, as well as training approaches can improve usable range and enhance range-related user experience. A key task for human factors research is the evaluation of the utility of those strategies.

Within the present contribution, we discuss the concept of comfortable range (i.e., a user's range comfort zone or preferred range safety buffer) as a potential benchmark variable for evaluating strategies that aim to improve usable range. We describe and evaluate the developed methodology for assessing comfortable range and give an overview regarding the magnitude of range safety buffers.

2. THE CONCEPT OF COMFORTABLE RANGE

The comfort zone concept has been used in different fields of psychology. An important theoretical foundation of this concept is derived from the proxemics approach [1] in which the notion of personal space (i.e., preferred distances) is most relevant. Based on this and further research, it has been theorized within the driving safety context that drivers have a certain comfort zone in terms of safety margins that they accept/prefer when controlling their vehicle so as to avoid collisions [2]. Somewhat similar concepts have been discussed in the adventure education literature [3], where the comfort zone metaphor is used to describe the learning process (e.g., learners can expand the limits of their comfort zone by moving outside of this zone).

Within the field of BEVs, range anxiety is a widely discussed topic and research has aimed to develop methods for reducing range anxiety in BEV drivers. However, research has shown that range anxiety is not the most salient qualitative experience when driving a BEV [4]. Stressful range situations seldom occur [4, 5, 6]. Rather, range interaction is characterized by the avoidance, not the experience, of range anxiety (i.e., range stress [7]). Consequently, the concept of comfortable range (i.e., a user's range comfort zone) represents a more reliable and valid indicator of users' everyday interaction with limited range. Therefore, we conclude that the increase in comfortable range is a more optimal benchmark variable for evaluating range-optimization strategies than the decrease in stressful range situations (i.e., range anxiety).

Comfortable range in the context of limited mobility resources is defined as users' preferred range safety buffer, which means a specific configuration of available range resources and range resource needs that does not yet impair the user experience (i.e., is still in line with a best feeling state [2]).

3. DESCRIPTION OF THE METHODOLOGY

The methodology for assessing comfortable range was continuously developed and refined over the course of three BEV field trials. The first version of the comfortable range scenario task (CRST), labeled "range game" (RG), has been described previously [4]. Here, we describe the final

version of the CRST developed for the field trial “BMW ActiveE Leipzig – long-distance commuters”.

The CRST consists of a scenario description and a special response grid. Scenario description (shortened): Imagine you are on a trip with your BEV on a familiar road in a rural area (rather flat terrain, light traffic, good weather, 20°C). You have already driven 30 km and you still have 60 km to drive before reaching your destination. There are no charging possibilities en route. Yet, at the destination, there is both time and an opportunity to recharge the BEV.

Participants then receive four separate cards with one item on each (e.g., “I am sure I will reach the destination with my BEV”). There is a response grid for each item with a six-point Likert scale on the y-axis (*completely disagree* to *completely agree*, coded as 1 to 6) and 10 displayed remaining range values on the x-axis (45 km to 90 km, graded in 5 km intervals). Hence participants must answer the following question: Given that I still have to drive 60 km and I have 90 km range remaining in the battery – am I comfortable with this situation (e.g., am I sure I will reach the destination)? Participants rate this for each of the 10 remaining range values (i.e., 60 km with 85 km range, with 80 km range,...).

The comfortable range threshold is defined as the point of transition from (a) the *best-feeling state* [2], where users are still perfectly comfortable with the range resource situation (i.e., lowest remaining range down to which users still mark the response scale value 6 on the Likert scale) to (b) *decreased range comfort* (i.e., highest remaining range where participants mark a value <6). For scoring, we take the mean of these two remaining range values (e.g., $a = 75$ km, $b = 70$ km, score = 72.5 km). This is done for each of the four items. If a participant reports that he/she is already not in the best-feeling state with 90 km range, 95 km is set as the best-feeling-state range. Finally, a mean score is computed from the four item scores. By dividing 60 km (i.e., trip distance) by the mean score value (i.e., preferred range), the proportional comfortable range utilization can be derived (e.g., 83%). The inverse of this percentage is the preferred range safety buffer (i.e., 17%).

In addition to the CRST, other more economical indicators were developed to assess the preferred range safety buffer. Four of these are: (1) *Minimum range safety buffer (MinBuff)*, item text: “Which range buffer do you set for yourself, below which you would not be willing to drive the BEV anymore (except in exceptional circumstances)?”; (2) *proportional range safety buffer (PropBuff)*, item text: “In general, I want to have a safety buffer of x% in the battery. That is: What percentage should the displayed range be above the total trip distance?” (item framed to overland trips); and (3+4) *comfortable trip distance* items (*ComfDist*). For these final indicators, participants are presented with a scenario description very similar to the CRST. Then participants are asked: “If the BEV shows a range of 100 km, I would still feel good about driving a total distance of up to x km” (*ComfDist*₁₀₀). For the second item, “100 km” is replaced with “50 km”(*ComfDist*₅₀).

4. EMPIRICAL EVALUATION OF THE METHODOLOGY

The objective of this section is to examine the comfortable range indicators in terms of their psychometric properties and their ability to assess for the presence of expected behavioral adaptation patterns.

4.1 CRST

4.1.1 Data basis

The primary data are derived from the field trial “BMW ActiveE Leipzig – long-distance commuters” (labeled *LDC* here; methodology is described in [6]). Data from the first two usage phases are utilized here ($N = 29$). Additionally, we report findings from previous field trials, including “MINI E Berlin powered by Vattenfall V1.0” and “V2.0” (labeled *ME1* and *ME2* here) to give an impression of findings in different studies. From *ME1* (methodology is described in [8, 9]; RG in [4]), only data from the second user study with $N = 40$ are reported (data from first user study have already been reported in [4, 10]). In *ME1*, users had a home-based charging opportunity and typically drove approximately 38 km with the BEV per day [11]. Instead, the $N = 18$ users in *ME2* (methodology is described in [12]; RG with same scenario description as in *ME1* but already with revised response scale, i.e., as in *LDC*) could only use public charging and typically drove

around 25 km with the BEV per day [13]. For all studies, the RG/CRST was assessed after an initial short test drive with the BEV (T0) as well as after significant BEV driving experience (T1).

4.1.2 Results

Results are displayed in Table 1. Sample sizes were slightly lower than indicated above because of problems with data collection (single missing values, 1-2 data sets where one item could not be scored). In the LDC trial, the Cronbach's Alpha (α) of the four CRST item scores indicated excellent internal consistency, and test-retest reliability (r_{T0T1}) was acceptable. A similar pattern was found in the ME1 & ME2 data, yet, test-retest reliability was less satisfactory.

Table 1: Results based on the RG/CRST data

<i>study</i>	<i>time point</i>	<i>N</i>	<i>M</i>	<i>M</i> _%	α	p_{T0T1}	d_{T0T1}	r_{T0T1}
LDC	T0	27	71.6 km	84%	.93			
(CRST)	T1	27	67.2 km	89%	.97	.005	0.58	.70
ME1	T0	37	84.6 km	71%	.91			
(RG)	T1	37	81.2 km	74%	.94	.019	0.40	.51
ME2	T0	17	81.8 km	73%	.91			
(RG)	T1	17	79.1 km	76%	.93	.127	0.39	.43

Note. M_% is proportional comfortable range utilization, α is Cronbach's Alpha, p -values are two-tailed.

In terms of indicated comfortable range utilization, data from ME1 & ME2 were similar, while LDC data exhibited smaller range safety buffers. As the same response grid was used in ME2 and LDC, this difference might have originated from a combination of: (1) the scenario description which provided more explicit specification of favorable scenario conditions in LDC than in ME2, (2) the sample of long distance commuters which may have had a higher "mobility competence" (i.e., were more adept at planning trips and judging trip distances), or (3) the BEV used in the LDC study which had a more precise range prediction algorithm than the BEV used in the ME1 & ME2 study. The only conclusion which the data allows is that the latter

possibility (3) cannot fully account for the effect because the difference between ME1/ME2 and LDC was already high at T0 (i.e., before BEV users had extensive driving experience).

Furthermore, in all three studies, the RG/CRST was able to depict the known effect of behavioral adaption to limited range (i.e., improvement in comfortable range with experience [10, 14, 15, 16]). In ME2, the effect was likely not significant because of the very small sample size. The effect size in ME1 (i.e., second user study in ME1) and ME2 is also consistent with the effect size reported in the first user study in ME1 ($d = 0.38$, see [10]). Hence, the CRST should also be capable of assessing the effects of intervention strategies or changes in system design. The larger effect found in LDC, compared to ME1/ME2, is also consistent with the fact that users in LDC more often had to drive the BEV in more challenging range situations and had more daily range practice (i.e., had to interact more actively with the range). Such factors have been known to lead to better adaptation to BEV range [4, 5, 10].

Finally, the CRST scores were also found to correlate with actual range utilization behavior: The correlation between the indicated proportional comfortable range utilization derived from the CRST (at T1) and the lowest displayed state-of-charge value that a user experienced over the course of the entire trial was significant, $r = -.43$, $p = .027$, $N = 27$. Similar results have also been found using data from ME1 [17, 11]. Hence, the CRST indeed seems to be a valid indicator of preferred range utilization (i.e., preferred range safety buffer).

4.2 Additional comfortable range indicators

4.2.1 Data basis

For the additional indicators of comfortable range, data from all four points of data collection in LDC (see [6]) were available ($N = 29$ for all items): T0, T0+1 (approximately 1 week after T0), T1 (after 6 weeks), and T2 (after 12 weeks).

4.2.2 Results

Results are displayed in Table 2. Regarding indicated comfortable range utilization, the mean score of the last three indicators (PropBuff, ComfDist₁₀₀, ComfDist₅₀) was equal to the CRST score (84% at T0, 89% at T1). Yet, the individual indicator scores varied considerably around this value. Moreover, the four indicators performed differently in assessing the effect of behavioral adaptation.

Furthermore, the results of the CRST in Table 2 show that T0-T1 comparisons underestimate the effect of behavioral adaptation, because range safety buffers first increase during the period from T0 to T0+1 before they again decrease.

Finally, the *M*-values of the four indicators (values at T1) correlated with lowest ever displayed state-of-charge, with a magnitude comparable to that observed between this variable and CRST: (1) MinBuff $r = .44$, $p = .017$; (2) PropBuff $r = .37$, $p = .046$; (3) ComfDist₁₀₀ $r = -.54$, $p = .003$; (4) ComfDist₅₀ $r = -.62$, $p < .001$.

Table 2: Results based on the additional comfortable range indicators

<i>item</i>		<i>T0</i>	<i>T0+1</i>	<i>T1</i>	<i>T2</i>	p_{T0T1}	d_{T0T1}
MinBuff	<i>M</i>	13.8 km	14.3 km	7.4 km	6.9 km	<.001	0.74
	<i>M</i> _%	-	-	-	-		
PropBuff	<i>M</i>	12.4%	15.0%	11.1%	9.9%	.227	0.23
	<i>M</i> _%	88%	85%	89%	90%		
ComfDist ₁₀₀	<i>M</i>	85.0 km	80.9 km	92.1 km	93.9 km	.002	0.63
	<i>M</i> _%	85%	81%	92%	94%		
ComfDist ₅₀	<i>M</i>	39.1 km	37.2 km	43.2 km	44.7 km	.089	0.33
	<i>M</i> _%	78%	74%	86%	89%		

Note. *M* is in original item units, *M*_% is proportional comfortable range utilization, *p*-values are two-tailed.

5. GENERAL DISCUSSION

Overall, the results indicate that the developed methodology for assessing comfortable range may provide a valuable tool for quantifying the effect of range-optimization strategies or behavioral adaptation on usable range.

However, there is also some potential for further improvement of the methodology. For example, it might be advantageous to include remaining range values >90 km (e.g., up to 100 km) to reduce the likelihood of ceiling effects (i.e., data sets where participants were already outside of their best-feeling state at 90 km of range) which might be especially relevant under less favorable conditions.

Furthermore, although the *average* comfortable range values were the focus of our analysis, it should be acknowledged that there was a high degree of variability among individual scores. Consequently, if one wants to interpret, for example, the score values from the CRST in an absolute sense (i.e., the extent to which we have already reduced the problem of range resource losses due to psychological range safety buffers), it may be more advisable to consider other statistical parameters (e.g., the 80th percentile of range safety buffers). In the end, a design-for-all approach should not only provide the average user, but ideally all users, with an optimal range-related user experience.

Moreover, it must be noted that comfortable range is only one of three psychological range levels in the adaptive control of range resources model [17, 11, 5, 4], the others being competent (maximum achievable) and performant (average available) range. Given that all three drive the discrepancy between technically available range and actual usable range, all three psychological range levels must be optimized. In order for this to occur, range optimization strategies must provide users with the capability to substantially extend the available range, if needed. This consideration is also partly addressed in the methods described above: If available range of a certain BEV is “elastic” for the user, the preferred range safety buffer can become very small. That is, users do not have to plan for a safety reserve if they can extend the range when needed. Still, it may be necessary to use additional variables that explicitly target the assessment of experienced

range elasticity to more comprehensively evaluate this facet of usable range.

Finally, given that the interaction with limited resources is a vital topic of our time in many fields, a critical question may be: To what extent can the concept and methods discussed in the present contribution be generalized to other areas in which people have to interact with limited resources (e.g., energy resources)? We suppose that the existence and extent of comfort zones within the context of interaction with limited energy resources is essentially dependent on the specific features of the resource situation. Comfort zones may exist in all resource interaction situations in which the outcome of suboptimal resource management can be severe (e.g., can result in a significant loss in other resources like time, health or information) and decisions have to be made under conditions of uncertainty (e.g., uncertainty regarding the predictability and controllability of resource dynamics, uncertainty regarding balance of resource needs and available resources).

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ECO-DRIVING STRATEGIES IN BATTERY ELECTRIC VEHICLE USE – WHAT DO DRIVERS GET TO KNOW OVER TIME?

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ABSTRACT: Eco-driving is of high importance when driving battery electric vehicles (BEVs) in terms of prolonging the vehicle's limited range. A longitudinal field study with 40 participants was conducted to examine which strategies users know before and after driving a BEV for 3 months. Additionally, user requirements regarding information or assistance on energy consumption in the BEV were addressed. Users reported significantly more eco-driving strategies after experiencing the BEV for 3 months. Furthermore, drivers rather agreed that there is a need for additional information on the BEV dashboard, such as displaying the energy consumption of auxiliary functions (e.g., radio, air-conditioning). The results imply that drivers gain a deeper understanding of factors that influence energy consumption by experiencing the BEV for a longer period of time and that it would be helpful to support the driver in terms of energy consumption and eco-driving.

Keywords: battery electric vehicle, eco-driving, field study, human-machine interface.

1 INTRODUCTION

Given the goal of reducing CO₂-emissions in the transportation sector, the implementation of 'green solutions' has gained importance in recent years. On the one hand, there are many technical developments that aim to make individual mobility efficient, like producing fuel efficient cars with smart technologies which operate independently of the driver. On the other hand,

the driver himself has the potential to save energy, for instance, by applying an energy saving driving style or choosing energy efficient routes (e.g., [1]). With respect to battery electric vehicles (BEVs), which are supposed to be an inherently 'green' transportation technology, reducing energy consumption confers an additional benefit compared to conventional vehicles in terms of prolonging range. Given the limited battery capacity and relatively long charging durations, an energy efficient driving style might lead to a longer usable range per charge [2]. Bingham, Walsh and Carroll [3] found that the energy consumption (i.e. range) of an EV can vary by about 30% depending on driving style. Furthermore, EVs are equipped with a regenerative braking system which enables the driver to actively save energy in deceleration maneuvers. This is also one of the reasons why results of studies examining eco-driving with internal combustion engine (ICE) cars cannot readily be transferred to BEVs [4].

According to Sivak and Schoettle "eco-driving includes those strategic decisions (e.g., vehicle selection and maintenance), tactical decisions (e.g., route selection), and operational decisions (e.g., driver behavior) that improve vehicle fuel economy" [5, p.96]. For the current study, we use the term eco-driving in a more narrow sense focusing on 'operational decisions' meaning strategies a driver could apply in order to drive more energy efficiently, 'strategic' and 'tactical decisions' are of minor importance.

Eco-driving with conventional vehicles has been studied in depth, but besides some research on predominantly technical issues (e.g., [3]), not much is known about eco-driving strategies when driving a BEV. In the present contribution eco-driving in BEVs is approached from a user perspective. More specifically, the objective of the current research is to examine which strategies drivers know in order to save energy with a BEV. We are further interested in determining if there are differences between reported eco-driving strategies after a short test drive with the BEV and after 3 months of BEV driving. Focusing on the human-machine interface we address whether there is a need for additional information regarding energy consumption and retrieval in the BEV.

2 METHOD

The current research was part of the second BEV user study of a large scale field trial in the metropolitan area of Berlin [6, 7], embedded within a series of international field studies [8]. Data were collected three times throughout the study: when receiving the BEV (T0), after 3 months (T1) and after 6 months (T2) of BEV driving. At these three points of data collection participants, completed questionnaires and answered structured interview questions. For the current contribution data were collected at T0 and T1.

A converted MINI Cooper with a range of around 170 km under normal driving conditions was used as the test BEV for the study. The implemented regenerative braking system returned energy to the battery whenever drivers lifted their foot from the accelerator. The two-seater contained some BEV-specific gauges: the state of charge display, the remaining range display, the average consumption display and the instantaneous power meter (for further information regarding the displays see [9]).

2.1 *Participants*

A sample of 40 users was selected to use the BEV for 6 months in a private household setting (for more details regarding the selection process see [10]). The 35 men and 5 women were on average 49.9 years old ($SD = 10.19$) and held their driving license, on average, for 31.0 years ($SD = 9.94$). The sample was well educated, 72.5% held a university degree. Some of the users (40%) stated that they had already driven some kind of electric vehicle (hybrid and/or BEV) before the beginning of the study. Yet, most of them (81.25%) tested such a vehicle only for a short test drive. The majority of the participants (80%) had an annual mileage of about 10.000 to 30.000 km. One participant dropped out after T1.

2.2 *Data collection*

In order to examine which eco-driving strategies participants know, the following open-ended question was addressed after a short test drive with the BEV (T0) and after 3 months of BEV driving (T1): 'Which strategies do you know to actively prolong the BEV's range?' ('...to drive energy efficiently

with the BEV' at T1). All answers to this question were recorded and transcribed; afterwards the statements were coded using inductive category development according to Mayring [11]. A system of categories, developed by reviewing the material several times while defining and re-defining categories, was applied to all answers. As most statements were clearly formulated, minimal effort was required to clarify interpretation. In order to control for possible bias that might occur during the coding process, 50 % of the material was independently coded by two involved researchers. Calculating Cohen's κ , results reveal an almost perfect interrater reliability ($\kappa = .958$; [12]). After the coding process was completed, the frequency of each assigned category was analyzed.

In order to assess the need for further information or assistance regarding eco-driving, the following general item was administered at T1: 'I would like to have some additional information regarding the energy consumption displayed in the BEV.' Participants were asked to indicate their agreement on a 6-point Likert scale (1 = '*completely disagree*', 6 = '*completely agree*'). Furthermore, participants were instructed to rate the perceived benefit of four possible additional information and assistance systems for eco-driving on a 6-point scale ranging from 1, '*less helpful*', to 6, '*very helpful*'. The systems were described as follows:

- (1) Statistics for energy consumption (per trip, per day, per week),
- (2) Navigation system with eco-routing,
- (3) Information about the energy consumption of auxiliary functions (e.g., air condition, radio),
- (4) Eco-driving advices (can be switched on and off).

3 RESULTS

BEV drivers reported several strategies for improving driving efficiency. Amongst others, they stated that *avoiding high speeds*, *choosing an anticipatory driving style*, *avoiding auxiliary functions* (e.g., air conditioning, radio), *using regenerative braking* and *choosing the most energy efficient route to the destination* would save energy while driving (see Table 1). Reported strategies were similar for both points of data collection. However,

in order to investigate whether or not the proportion of participants mentioning a specific category changed significantly over time, the exact McNemar test was calculated for each strategy (Table 1).

Table 1: Comparison of reported strategies for BEV eco-driving before and after driving the BEV for 3 months

Strategy	Percentage of participants (%)		<i>p</i> (McNemar)	effect size ^b
	T ₀	T ₁		
Avoid high speeds	47.5	35.0	.332 ^a	-0.13
Accelerate moderately	52.2	77.5	.031 ^a	0.25
Drive evenly (speed & acceleration)	17.5	20.0	1.000 ^a	0.03
Use regenerative braking /avoid braking	62.5	72.5	.454 ^a	0.10
Choose anticipatory driving style	47.5	52.5	.832 ^a	0.05
Avoid auxiliary functions (e.g., air conditioning, radio)	55.0	77.5	.022 ^a	0.23
Drive in a way that the instantaneous power meter indicates low energy consumption	7.5	7.5	1.000 ^a	0.00
Let the car roll (sailing)	0	5.0	.500 ^a	0.05
Choose the most energy efficient route to destination	5.0	7.5	1.000 ^a	0.03
Choose optimal tires/tire pressure	10.0	5.0	.625 ^a	-0.05
Minimize load	20.0	10.0	.289 ^a	-0.10

Note. *N* = 40; Categories were included if greater than or equal to 5% of the participants reported it; exact McNemar test was calculated for pre-post-testing; ^a binomial distribution was used because precondition was violated; ^b effect size calculation according to Green and Salkind [13].

Results show that the impact of experience was significant for the following reported eco-driving strategies: *avoiding auxiliary loads* ($p = .022$) and *accelerating moderately* ($p = .031$). In addition to the changes for each specific eco-driving strategy, we investigated the sum of all strategies stated at T0 and T1 for each participant. As the data violated the assumption of normal distribution, the Wilcoxon test was calculated revealing significant

differences ($Z = -2.252$; $p = .024$; $r = -.25$). Results show that drivers reported significantly more strategies after driving the BEV for 3 months ($Mdn = 4$) than after the first test drive with the BEV ($Mdn = 3$).

Furthermore, we addressed the question of whether drivers feel sufficiently informed regarding energy consumption or if they require a specific kind of assistance or additional information. Results reveal that users largely agreed that they would like to have further information regarding the consumption of the BEV ($M = 4.73$, $SD = 0.91$) after driving the BEV for 3 months. Moreover, users assessed the possible additional information and assistance systems as moderately to very helpful. Specifically, the information about the energy consumption of auxiliary functions ($M = 4.72$; $SD = 1.025$) and the navigation system with eco-routing ($M = 4.46$; $SD = 1.374$) were regarded as 'helpful' to 'very helpful' by the users. Whereas displaying statistics for energy consumption (per trip, per day and per week; $M = 4.15$; $SD = 1.443$) and eco-driving advices (can be switched on and off; $M = 3.82$; $SD = 1.430$) were evaluated as 'moderately helpful' to 'helpful'.

4 DISCUSSION

The main objective of the present research was to examine participants' knowledge regarding energy efficient BEV driving strategies, and to evaluate whether any experience effects occur in this domain. Results of the conducted field study indicate that drivers gained knowledge about eco-driving strategies when driving the BEV for 3 months. Although the stated eco-driving strategies did not substantially differ in their content, users reported significantly more strategies after driving the BEV for 3 months. Specifically, the avoidance of auxiliary functions, such as air conditioning or radio, and a moderate acceleration style were reported more often after a longer period of BEV-use. These results point in the same direction as findings from Bingham et al. [3], who analyzed logger data from different drive cycles. They found that auxiliary functions, as well as low acceleration and low variance of acceleration, are important influencing factors on BEV energy consumption. This in turn implies that drivers develop a deeper understanding of BEV energy consumption and learn which factors have a high impact on the energy efficiency of a BEV. This expertise is, at least in

part, based on experiencing driving the car for a longer period of time. In this regard, it could be helpful to incorporate additional information into the BEV in order to support the driver in understanding energy consumption, and thereby range prolonging factors, on the first BEV drive.

One could have assumed that regenerative braking usage as a strategy to actively regain energy would have been mentioned more often after gaining BEV experience. However, results from T0 indicate that after the short test drive this strategy is mentioned by the highest percentage of drivers. The number is even a little higher after 3 months of BEV usage.

The mentioned eco-driving strategies, except for regenerative braking usage, do not substantially differ from strategies to drive efficiently with an ICE vehicle. Due to the limited range of EVs, restricted recharging opportunities and long charging durations, BEV drivers are more likely forced to think about and use eco-driving strategies compared to ICE vehicle drivers that mostly save energy for ecological and/or economic reasons. This could be an explanation for the increased knowledge of eco-driving strategies after gaining BEV experience. However, as also Bingham et al. [3] found common ICE eco-driving strategies (smooth acceleration, limited usage of auxiliary features) as important influential factors for BEV energy consumption, drivers in the current study might have experienced this similarly.

Results regarding the human-machine interface reveal a need for further information about energy consumption and BEV-specific assistance for eco-driving as also reported elsewhere [14, 9]. With regard to the reported strategies, users assessed information on the energy consumption of auxiliary loads as 'helpful' to 'very helpful'. User assessment is similar for navigational range assistance, statistical information on energy consumption and eco-driving advice. Given that these results have been found with a highly educated sample of early adopters, it is likely that these findings, especially with regard to the provision of more information and assistance, might have even more relevance for other user groups.

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USER EXPERIENCE WITH ELECTRIC VEHICLES WHILE DRIVING IN A CRITICAL RANGE SITUATION – A QUALITATIVE APPROACH

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ABSTRACT: A frequently discussed phenomenon within the context of electric vehicles (BEV) is range anxiety, which can occur in a critical range situation. The objective of the present research is to better understand user experience in critical range situations (i.e., range anxiety). After driving a BEV in a critical range situation on a 94 km long unaccompanied trip, 68 participants were asked about experienced stressors and stress buffering factors, as well as additional strategies for reducing stress. The information obtained here can be utilized to inform design recommendations to help future BEV users better handle critical range situations.

Keywords: battery electric vehicle, range experience, range anxiety, field experiment

1 Introduction

One of the most important barriers to the widespread acceptance of battery electric vehicles (BEV) is their limited range [1]. Range anxiety has been repeatedly discussed in this regard and was found to be negatively related to efficient usage of BEV range resources (e.g., [2], [3]). We propose that range anxiety is best conceptualized as a domain-specific form of psychological stress, which can occur within a critical range situation [4].

There is some indication that relevant domain-specific knowledge regarding range and a better understanding of range dynamics while driving might help to alleviate range anxiety [2]. Hence, advanced driver assistance systems and an improved user interface design might both represent fruitful approaches for reducing range anxiety. However, in order to develop a user-centered system design, it is important to comprehensively understand the user experience in critical range situations (i.e., range anxiety). To our knowledge, there is currently a dearth of published research that focuses specifically on user experience in critical range situations. Previous evidence suggests that managing BEV range in everyday use is typically not characterized by experience with, but by avoidance of, such situations [2]. Therefore, studies examining user experience in critical range situations as one of several variables within a field trial lasting several weeks (e.g., [5], [6]) might fail to produce much usable data. Additionally, users typically cannot be interviewed immediately after experiencing such situations, but only after a few days or weeks, which subjects the data to retrospective biases and memory degradation.

The objective of the present study is to examine user experience immediately after a critical range situation by using a qualitative approach. Our approach is exploratory, focusing on the identification of different stress-inducing and stress buffering factors participants experienced in a critical range situation, as well as their additional ideas for reducing experienced stress.

2 Method

We conducted a field experiment in which participants were instructed to drive a round trip, on which they experienced a critical range situation (i.e., remaining range appeared only marginally sufficient to complete the trip). The BEV used in this study had a maximum available driving range between 130 and 160 km, depending on driving style [7]. The BEV had an ECO PRO mode that can be selected to automatically adjust the drive configuration and comfort functions to achieve a higher range. Range information was displayed via a digital remaining range display in km (range estimation based on charge level and energy consumption over the last 30 km, as stated in the user manual) and there was an onboard navigation system, which displayed the route and the remaining km the participants had to drive.

2.1 Participants

Participants were recruited via an online screening questionnaire. Seventy-four drivers completed the experiment. Six participants did not fulfill the criterion of driving in a critical range situation and were therefore excluded from the analysis. This criterion was defined as having a minimal experienced available range buffer throughout the trip that was smaller than average preferred minimum range safety buffer (item: “Which range buffer do you set for yourself, below which you would not be willing to drive the BEV anymore (except in exceptional circumstances)?”). The 68 participants (50 male and 18 female) were on average 31 years old, possessed a driver license since $M = 12$ years, drove $M = 1300$ km per month with a conventional car and had $M = 15.73$ km BEV driving experience.

2.2 Field experiment setup

With an average available driving range of 113 km ($MIN = 97$; $MAX = 137$; $SD = 7.5$), participants drove on a 94 km unaccompanied round-trip in a hilly rural area, with small villages and country roads. In the last section of the route, there was a 17 km long section of a German Autobahn. The round trip was designed to lead to a critical range situation due to the energy consumption profile of the first sections (e.g., driving mostly uphill: start of the trip at 298 m above sea level, after approximately 37 km at 600 m over sea level). Over the whole trip, participants experienced a minimum available range safety buffer of $M = -2.45$ km ($Min = -27.0$ km; $Max = 11.0$ km; $SD = 9.14$; participants’ preferred minimum range safety buffer was $M = 11.93$; item assessed before the trip).

2.3 Data collection

Participants reported their experience of the critical range situation immediately after the round trip in a structured interview. They were asked with open-ended questions (Q1) for stressors (“What worried you during the test drive? Which situations led to increased stress?”), (Q2) for stress buffering factors (“What calmed you down? Which situations decreased your stress level?”), and (Q3) for further strategies for reducing stress level (“What

would have helped you to be less stressed (e.g., which additional information before or while driving)?”).

2.4 Data analysis

Interview data were analyzed using the inductive category development methodology according to Mayring [8]. First, all answers were recorded and transcribed. After that, all relevant statements were coded and a system of categories was developed. Over the course of several coding processes, the system of categories was refined until a sufficiently condensed categorical structure was obtained for describing how participants experienced the critical range situation.

Following an exploratory approach, we were not primarily focused on the absolute number of participants in each category (i.e., the importance or relevance of, for example, certain stressors). Rather, we focused on the identification of a wide range of categories describing participants' experience in a critical range situation (i.e., which aspects caused stress and which aspects reduced stress). Still, we report in the following only those categories, which were mentioned by at least 7 participants (i.e., approximately 10%).

3 Results

In the following section, we present the extracted categories (reported by a minimum of 7 participants; labeled with C, e.g., C1) of (Q1) stressors, (Q2) stress buffering factors, and (Q3) additional stress reduction ideas. For a better understanding of the categories, and thereby, user experience in a critical range situation, we provide translated examples of actual participant statements, which are representative of the categories (alongside the participant number, e.g., P12). Thus, the actual wording of the statements was preserved as closely as possible given the necessary changes inherent to the translation process. Annotations by the authors for better clarification of some statements are written in parentheses in italics.

As one might expect, when asked for (Q1) stressors during the trip, participants reported: (C1) decreasing range (e.g., limited available range safety buffers) and (C2) uncertainty (e.g., regarding consumption on different parts of the trip).

Regarding (C1) decreasing range, one participant stated:

"[...] at the beginning the range display - the remaining range - decreased relatively fast." (P12)

For some participants, the clearly noticeable decrease in range was surprising:

"I think it was the first section when I left Chemnitz (*Chemnitz was the starting point for the trip; annotation by the authors*) - the remaining range display decreased relatively fast as I drove uphill, well, it was clearly noticeable - surprising." (P26)

More often they endorsed the decreasing range safety buffer (i.e., difference between displayed remaining range and remaining trip length) rather than the decrease of remaining range in general as stress-inducing:

"But it was just every time, when the buffer became a little bit small." (P11)

"[...] that there was temporarily just a 3 kilometers difference between the route I still had to drive and the total distance the car still was able to drive. Well, I really was temporarily very nervous." (P35)

The moment when the range safety buffer became negative (i.e., remaining range was smaller than remaining trip length) was especially stress provoking for participants:

"Well, every time when range fall below the remaining trip length." (P39)

Regarding (C2) uncertainty, for example with respect to BEV energy consumption, participants stated:

"Well, actually only in the first section, because at this time I could not estimate how much I will consume and how much I can regain." (P43)

"Well, sometimes the unexpected fluctuation of range [...] sometimes it decreased faster, sometimes slower [...]. That irritated me a little bit. And then I was always wondering: will it decrease or increase?" (P73)

The uncertainty regarding consumption, particularly the anticipation of the potential for high consumption on the last part of the trip (i.e., on the Autobahn), stressed participants:

"And then the Autobahn - well, as I realized that we have to drive on the Autobahn, I was not sure anymore." (P77)

"[...] and I thought: Okay, the Autobahn is still ahead! [...] the large distance [...] I will not make it anymore." (P64)

Regarding (Q2) stress buffering factors, the data indicated that (C1) sufficiency of / increase in range while driving, (C2) certainty enhancement factors (e.g., appropriate user-interface allowing for accurate tracking of the range buffer, familiarity with the route), and (C3) energy consumption assistance factors (e.g., regenerative braking, Eco-Pro mode) would be helpful.

Regarding (C1) sufficiency of / increase in range, participants reported:

"Simply that you had enough remaining range to reach the destination." (P17)

More frequently, they endorsed a sufficient range safety buffer (i.e., difference between displayed remaining range and remaining trip length) rather than the remaining range in general as stress-reducing:

"Well, as long as the remaining range was higher than the remaining trip length, everything was okay." (P36)

One additional interesting finding related to C1 was, that users endorsed an increase in range safety buffers as a stress buffering factor, even if this buffer was still very small.

"[...] When I was successful, or alternatively it just happened that the difference became bigger – once it increased to 8 kilometers or so between the remaining range and remaining kilometers to drive." (P83)

"Well, first the fact that there is a negative buffer, well that... yes, that it was negative, because I realized that I calmed down when it, at the start, was at least plus/minus zero." (P99)

Regarding (C2) factors that increase certainty and therefore reduce stress, participants reported an appropriate user interface that allowed for accurate tracking of the range buffer:

"It calmed me that I could always see: How much remaining range I have and how many kilometers I still have to drive? And this difference was always positive." (P13)

"[...] the precise feedback of the range display. Well, you effectively always had the feeling that the range display really showed a value that is trustworthy. Because it changed frequently and adapted to the driving style. (P34)

Furthermore, also regarding (C2), participants reported familiarity with the route:

"[...] that it goes downhill at the end and you can save some energy, that was relatively clear to me, because I know the route" (P09)

"I would say, because I know the route well [...], that it will go into the mountains

and then, on the way back, downhill – well, knowing that it will go downhill." (P68)

Regarding (C3) energy consumption assistance factors, participants mentioned, for example, existence of the Eco-Pro mode:

"After finding the Eco-Pro mode - that calmed me, too." (P60)

Regarding (C3), participants also reported a successful energy-efficient driving style as a stress buffering factor:

"And that you got experience with this special electric powertrain while driving. That you know you can calculate how much range remains. That you see, how much energy you can regain, that you reach the kilometers you need to drive. And then you got a feeling for the gas pedal to drive really efficiently." (P23)

"Well, that you learn, as time passed, that your own driving style can contribute to a slower decrease of range." (P69)

"On the one hand, certainly the range display. That you can see how through a special – well, through a predictive driving style - that you also add kilometers. That it is appreciated, I will say." (P91)

Another point regarding (C3) is the regenerative braking, which was mentioned by participants:

"Well, also that kilometers were added through this recharge-thing. But that was actually the main reason, it was very calming." (P22)

"And also to see, when you are driving downhill, and two or three kilometers are regained through regenerative braking – you see at least, that it is somehow of use and it does something." (P26)

Regarding (Q3), additional ideas for reducing stress, participants reported (C1) more knowledge in general (e.g., about energy-efficient driving style, Eco-Pro mode, interpretation of display information, consumption under different conditions such as Autobahn driving or using different electrical loads like heating or radio, elevation profile of the entire trip, existence of a range reserve), and (C2) more information while driving with a comprehensive user-interface (e.g., feedback on individual driving style, charging station network, detailed consumption information). A variety of statements, which provide an impression of participants' additional ideas for reducing stress, is shown below:

"But I don't know if it is possible: that by entering this route profile into the navigation system [...]. That you just say, when it goes a bit uphill that it [*the navigation system*] calculated how much [*range*] you need on the basis of the

route profile." (P12)

"What would help me is such a head-up-display, so that you don't always have to look down, because you have on the one hand the display where you can see the charging or discharging status, the remaining range, and from the navigation system, the remaining distance you still have to drive. It [*the head-up-display*] projected this data on the inside of windshield. So you can concentrate fully on the road and have all of the important information in the field of view." (P23)

"That there is a display that shows how efficiently I drive. That means, I know that my battery, my engine, my complete energy consumption inside [*the vehicle*] worked optimally." (P28)

"Well, maybe hints, how you can drive... well, from the car. [...] Yes, energy-efficient driving style. Or, I also think that the pedal is very, very sensitive. You have to habituate to it so that you may find somewhere the right millimeter when the use of power and the [*energy consumption?*] are lowest. (P40)

4 Discussion

Results show that participants endorsed a variety of different responses to the interview questions (Q1-Q3). Out of these responses, (A) critical factors related to user experience could be extracted which might provide a starting point for improving the user experience, and (B) derive system design recommendations from these improvement suggestions that could help future BEV users better manage critical range situations.

Regarding (A), one relevant factor is the available range safety buffer. Results indicate that the difference between displayed remaining range and remaining trip length is very important for users (i.e., it is the primary variable that determines user experience). When this buffer decreases, usage comfort also decreases. In particular, the moment in which the range buffer becomes negative marks a substantial change in the quality of the user experience (i.e., it represents the tipping point for range stress). When the buffer increases, users calm down, even if the range buffer is still within the critical range. Data shows that, in a critical range situation, participants used the available range buffer, rather than the absolute remaining range values when evaluating the situation. Therefore, it is essential to provide users with the information needed to accurately evaluate this buffer (e.g., remaining range, remaining trip length) in an easily accessible way. Another major critical factor is uncertainty with respect to BEV energy consumption. When users are unsure about the BEV's consumption due to individual factors (e.g., driving style), environmental factors (e.g., route profile, Autobahn) or

BEV-related factors (e.g., different driving modes, effects of regenerative braking), the quality of the user experience is reduced. On the other hand, familiarity with the route (e.g., route profile, shortcuts) and “getting a feeling” for the BEV (e.g., regarding the drive pedal, consumption and regeneration of energy under different conditions) improve the user experience. Therefore, in order to feel comfortable even in a critical range situation, it is important to provide relevant knowledge for reducing uncertainty (e.g., help users to understand BEV energy consumption and development of BEV range under different conditions affected by various individual, environmental and BEV-related factors; provide information about route profile).

Regarding (B), a fruitful approach might be the incorporation of more detailed/domain-specific information management systems. This approach would be especially helpful in reducing uncertainty as a stress-inducing factor. Here, two approaches appear important: 1) provision of information about the BEV (e.g., about eco-driving, different driving modes, interpretation of display information, consumption under different conditions), with, for example, interactive manuals or trainings. And 2) provision of more information while driving (e.g., feedback and hints for individual energy-efficient driving style, information about the range safety buffer, detailed consumption information, trip elevation profile) through a comprehensive user interface. Therefore, effective displays (i.e., precise, dynamic, reliable) are needed. Individualized feedback regarding the success of users' efforts to reduce energy consumption and recommendations for additional range enhancement strategies seem to be important issues.

Moreover, displays should allow for accurate tracking of the range buffer (i.e., matching of remaining range and remaining trip length), which means that the relevant information is optimally displayed (e.g., information visible simultaneously or perhaps the range safety buffer could be automatically computed by the BEV's information management system and shown as a percentage or in total kilometers). As continuous information on this variable appears to be important in critical range situations, a head-up display or a similarly visible display location would appear to be particularly helpful.

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CONSIDERING THE POTENTIAL OF PHONE APP DRIVER MONITORS FOR YOUNG PEOPLE – A SYSTEMATIC REVIEW OF MONITORING ACCEPTABILITY AND EFFECTIVENESS

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ABSTRACT

A systematic review of the driver monitoring literature was conducted to answer two key research questions relating to the potential acceptance and effectiveness of smartphone monitoring. A total of 14 studies met the inclusion criteria and were selected. The synthesis indicated that perceived accuracy, accessibility, personal barriers and facilitators influence monitor acceptance. Results would also suggest that in-vehicle monitoring can reduce extreme driving manoeuvres, speeding and seatbelt non-use. Findings are discussed in light of the unique features smartphone monitors retain.

1 Introduction

The ‘young driver problem’ refers to the global phenomenon wherein drivers under the age of 25 are significantly overrepresented in the road traffic fatality and injury statistics. Recent figures have indicated that approximately half a million young people are killed in Road Traffic Collisions (RTCs) each year [1]. New approaches to improve such statistics are clearly needed.

The use of smartphone applications that monitor and provide driver feedback may provide one such intervention [2,3]. Phone Application Driver Monitors (PADMs) harness the advanced properties of modern smartphones (such as assisted GPS, high resolution cameras etc.) to monitor driver behaviour in-vehicle and provide both real-time, safety-relevant feedback (via audio and visual alerts) and summary reports online. Although many of these are currently available for personal download and use (e.g. the ‘iGuardian Teen’), academic publications on this innovative technology are lacking.

The rationale and model preceding PADM development originates from the increasing use and study of In-Vehicle Data Recorders (IVDRs; e.g. [4,5]). These too act to detect and record behavioural data (such as speed or

braking manoeuvres) in transit and match unsafe driving patterns with support functions (such as real-time feedback) when detected to moderate risk-taking. IVDRs differ from PADM in that they are installed into a car and can physically limit driver risk-taking through, for example, restricting speed [6]. Despite this, we believe that the fundamental principles underlying monitoring and feedback use as an intervention are conceptually similar in both cases, and that both influence behaviour through the same pathways.

Given the lack of PADM specific research, and their conceptual similarities to IVDRs, we conducted a systematic review of the young driver IVDR literature to inform and guide current thinking on the potential for smartphone monitoring as an intervention. Two key research questions were identified; 1) Acceptance: What factors are likely to impact on the willingness of young drivers to accept, adopt and use PADM?; and 2) Effectiveness: What is the likely impact of PADM on risky driving behaviour?

2 Method

2.1 Search Strategy

Five electronic databases were systematically searched for relevant material using our specified keywords (e.g. 'young driver', 'acceptance', 'in-vehicle monitoring' etc.). Four road safety related journals were hand searched for relevant articles, and key researchers contacted for additional material.

2.2 Inclusion and Exclusion Criteria

'Effectiveness' studies had to feature field research, participants less than 25 years of age and the use of an in-vehicle feedback device. 'Acceptance' research had to involve detailed usability perceptions of monitors. Only studies published between 2003-2013 were considered for inclusion.

2.3 Data Extraction

All studies identified were first transferred to an Endnote database (total n=4306). Duplicate articles were removed (n=2803 remaining) and studies with irrelevant titles were excluded (n=116 remaining). Article abstracts were then assessed (n=58 remaining) and last, full text articles were examined. Six articles were selected to answer question one 'Acceptance', and eight to answer question two 'Effectiveness' (total n=14).

2.4 Data Synthesis

Due to a lack of consistent quality across 'Effectiveness' studies, and the qualitative nature of the 'Acceptance' research identified, the results from both searches were subject to a narrative synthesis process [7].

3 Results

3.1 Acceptance

Ensuring that driver monitors are effective in moderating risk taking is clearly a crucial issue, however if young drivers are unwilling to accept PADMs for use, devoting time and resources to studying their effects is futile. From six acceptance studies, the following emerged as key influential factors.

3.1.1 Perceived Accuracy

The importance of device reliability for acceptance was highlighted within the reviewed studies. A device should be "100% reliable" or a young driver would "just have to disconnect" it [8]. That a monitor could "malfunction" and provide false alerts was also frequently voiced as unacceptable. Similarly, one study [9] found that when IVDR using drivers reported receiving 'undeserved' alerts, less satisfaction was reported with the system overall. Young drivers also believed that they or others could easily "tamper with" certain monitors [8-10] such that advantages (e.g. lower premiums) could be undeservedly earned, rendering them less acceptable and adoption worthy.

3.1.2 Accessibility

Accessibility relates to the ease with which a monitoring device can be adopted and used over time. The cost of IVDRs was identified by Lerner et al.'s study [11] as prohibitive, and "Price definitely" was declared as an issue [8]. The technological complexity of monitors, which require high levels of computer competence, was also seen to negatively influence accessibility for some parents and drivers, resulting in a lack of engagement with driver feedback [8,11]. Finally, the need for expert mechanics to maintain in-vehicle monitors was voiced as a negative factor associated with potential use [8,10].

3.1.3 Personal Barriers and Facilitators

A number of personal barriers to use were also identified by young drivers

throughout the six acceptance studies. In particular, the perceived loss of personal privacy associated with monitor use as a “stalking system” or “baby monitor” was highlighted [10,11]. The loss of vehicular autonomy associated with the use of a system that actively intervenes to brake and reduce speed, was also identified as “dangerous” [8]. Last, concerns were raised as to the personally distracting nature of in-vehicle feedback for novice drivers as, for example, the “beeps... might scare you and make you have a crash” [11].

Some young drivers do willingly adopt monitors however, and a number of personal facilitators enhancing acceptance were observed. Many view IVDRs as a tool to build their confidence and driving skills, to help them “improve and be more careful” [3,10]. The provision of objective feedback and parental reinforcement of good behaviour is valuable to certain young drivers, and even “fun to get a good report” [10,12]. Finally, personal insurance benefits may significantly enhance acceptance of monitors, as “obeying the rules... to get lower insurance rates” was deemed appealing to many [11].

3.2 Effectiveness

The question of effectiveness is of critical importance, as, if PADMs cannot serve to reduce risk-taking, their use and promotion is futile. Eight studies examined the impact of monitor usage on specific driving behaviours.

3.2.1 Extreme Maneuvres

Extreme manoeuvres are driving events that exceed acceptable vehicle g-force levels to trigger and record an alert (such as sudden acceleration, or improper turning, e.g. [4,5,13]). A total of six monitoring studies examined such manoeuvres, of which two were RCTs. The first reported significant differences between their feedback receiving group (23.4 unsafe events) and control (50.49) during their 15 week, 90 teen driver intervention [13]. The second reported decreases in sudden acceleration and braking across their three treatment groups in their 24 week, 84 teen driver study. These were not significant however, and increased during the post-treatment phase [5].

Four studies utilised a single group, pre-post test design. Musicant and Lampel [14] reported reductions of 50% in extreme manoeuvres following their six-month, 32 teen driver Green Box intervention study. The 26 newly licensed drivers in McGehee et al.'s DriveCam intervention [4] reduced

extreme manoeuvres by 76% which was maintained until the end of the treatment phase (36 weeks). Eighteen teen drivers in a 52 week, DriveCam intervention study reported 61% reductions in extreme events [15]. Finally, Albert et al. [16] reported decreases (but not significant changes) in unsafe event frequency for 32 young drivers from Israel throughout their treatment (3.5 months) and second baseline (2 months) phase.

3.2.2 Speeding

Speeding in a monitor use context refers to the violation of legal limits or pre-set vehicle speeds [5]. Three speeding studies met the review inclusion criteria. Farmer et al. [5] reported reductions in total miles speeding for all treatment groups throughout their intervention, however these were not significant, and all increased during the post-treatment phase. Bolderdijk et al. [6] reported reductions solely for their intervention group (insurance incentive + feedback, n=100), which decreased from 18.6% to 17.6% in their eight month study. This increased to 20.5% post-treatment however. Finally, a pilot smartphone monitoring study [2], found that 16 teen drivers reduced percentage speeding on a 30 minute circuit from 30.9% to 18.2%.

3.2.3 Seatbelt Use

Seatbelt usage is a protective driving behaviour that significantly decreases the likelihood of injuries and fatality should a crash occur [4]. Two studies examined the impact of monitoring on this driving behaviour. McGehee et al. [4] found that baseline usage rates of 81.8% improved to 96.9% during their 36-week DriveCam intervention. Farmer et al. [5], reported non-use improvements at 4.92 miles unbelted per 100 versus 9.41 miles before monitor use for one group. All reported non-use reductions (although these weren't significant), excluding the control group, which increased throughout.

4 Discussion

In the absence of PADM-specific research, we cannot state with certainty as to how well they will be accepted, or moderate risk-taking. We believe the findings of this systematic review however, indicate the following:

A) In terms of acceptance, PADM's may prove particularly advantageous, in that smartphones can provide comparable, if not improved (e.g. through

assisted GPS), levels of accuracy to IVDRs [2,3,17]. An increasing proportion of young people already possess smartphones for personal use, and as such, cost may not prove an obstacle [17]. Familiarity with app interfaces and standard download and maintenance procedures may also enhance perceived accessibility and acceptance.

PADM users may still experience barriers in terms of privacy and autonomy loss, however this may be lessened with personal phones [3]. Distraction may prove an issue [2,3] and PADM-specific research will be necessary to assess this. The potential for improving driving skills with use, the provision of feedback and parental support, and insurance incentivisation may still motivate users and facilitate acceptance to similar IVDR levels however.

B) Regarding effectiveness, through enhanced self-awareness of driving styles, and subsequent self-regulation of risk-taking behaviour, we propose that PADM users may have similar positive effects upon key risky driver behaviours (e.g. extreme manoeuvres) as in the IVDR studies reviewed. The use of rewards to reinforce rule adherence (such as insurance discounts), and punishments (e.g. parental restrictions) for unsafe driving with PADM users may prove similarly effective in moderating behaviour [6,13].

C) Monitoring is an emerging research area however, and numerous issues such as the optimal feedback medium and alert type, the potential for distraction, or the exact role of parents in maximising behavioural change still remain to be resolved. PADM users also possess unique limitations, such as the ease with which they may be deactivated, which may prove problematic. Thus, the findings of this systematic review suggest promising levels of acceptance and effectiveness for PADM users should they be implemented, but further monitoring, and indeed, PADM-specific research is clearly necessary.

4.1 Review Limitations

Given the limited number of papers published within this emerging research field, few stringent inclusion criteria could be applied, and thus an 'Effectiveness' meta-analysis could not be conducted. Participants in the studies reviewed were also typically self-selecting, and as such, the findings may not represent the young driver group at large.

5 Conclusions

PADMs may play a successful role in improving young driver safety, but a number of barriers will have to be surpassed before they can be widely implemented. Should this occur, we propose that PADM-generated feedback may increase self-regulation and decrease crash risk for users, particularly when incentivised. PADMs then, can be viewed as a promising road safety tool, but must be subject to greater scientific enquiry.

6 Acknowledgments

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SETTING THE STAGE FOR SELF-DRIVING CARS:

Exploration of future autonomous driving experiences

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ABSTRACT

Self-driving cars are under development and are predicted to reach the market within a few years. There is a need to understand how users will respond to the technology, and what possible benefits or difficulties they perceive. User involvement is a prerequisite for eliciting this information at the same time as several studies have demonstrated the problems associated with investigating “the future”. In this paper, two different approaches for exploring future automotive technology were applied in two studies of users’ future experiences with self-driving cars. Both studies used materials to mediate a shift in focus from today to tomorrow, but the outcomes varied with the different approaches. The results of the two studies provide insights into users’ expectations of autonomous cars and contribute to our knowledge on how different studies on the same topic can elicit different types of data.

1 INTRODUCTION

Self-driving cars are under development and are expected to reach the market in a near future. The major benefits of such solutions are argued to be safety, convenience, fuel economy and lower emissions (Davila & Nombela, 2012; Rupp & King, 2010; Verberne, Ham, & Midden, 2012). These issues are being extensively researched from a technical perspective but there is also a need to understand how the users will react to the technology, and what possible benefits or difficulties they perceive. This information is needed when designing the interfaces and interior of autonomous cars; as the driver’s role will change, opportunities to design for entirely new types of future in-vehicle experiences open up. User involvement is a prerequisite for eliciting information on user experience at the same time as several studies have demonstrated the problems

associated with investigating “the future” (Brandt & Grunnet, 2000; Vavoula, Sharples & Rudman, 2002). This calls for new user research methods, which allow a transition from the current situation to the future possibilities of technology, without falling into stereotypes. One possible way of bridging the difficulties in performing user research of what is yet not testable, is to allow the user to have a more active role in user studies (examples can be found in Halse, Brandt, Clark & Binder, 2010). Self-driving cars are a close future, but with an opportunity to be very different than today’s cars, if given the chance to move from incremental design changes to new design opportunities. This paper takes on the challenge of performing user research of what is not yet there.

2 FRAMEWORK AND INSPIRATION

The creation of the methodology was founded in the tradition of Participatory Design, where props and triggers often are used to stimulate imagination and conversation. This has, in combination with the enactment of future activities, proven fruitful in probing into users’ future experiences with technology and creating empathy with users (Brandt & Grunnet, 2000; Buchenau & Suri, 2000). Inspiration for the methodology development was also found in the film industry. Film and theatre have an inherent power to convey experiences of others. This power is particularly strong in Lars von Trier’s film “Dogville” from 2003. The representation language is limited to a minimal design with white lines on a concrete floor representing walls and objects. The audience will have to imagine what is not there in this minimalistic setting, and the usage of the audience’s imaginative power results in a strong, artistic film. In studies of future designs, simple and open designs have been claimed to stimulate participants’ fantasy to a greater extent than more elaborated designs (Ehn & Kyng, 1991). Also, the use of both body and mind, by for example enactment of future usage, appears fruitful for obtaining more informative data from user studies about future technology (Brand & Grunnet 2000).

3 STUDIES

Two different approaches were applied in two studies (A and B), designed to investigate users’ future experiences with self-driving cars. Both studies were

grounded in the process of relating to the users' current driving experiences, envisioning the future autonomous driving experiences and finally imagining how this could be embodied; how would time be spent? What emotions would this experience bring? What would be the value of self-driving cars? How would the design of the car change? However, different materials for stimulating responses were applied in the respective studies as experimentation on how study designs on the same topic can elicit different types of data. The first study had a broader material scope, giving the participants the opportunity to collage their vision of self-driving cars, in terms of types of cars but also cityscapes. The power of imagination and acting, supported by a minimalistic representation language, was an inspiration for the second study. All together, 18 persons participated in the two studies situated in Denmark and Sweden.

3.1 Study A – Drawing and Collaging Future Automotive Experiences

The first study included drawing, collaging and interviews about future experiences with self-driving cars. The approach was informal and spontaneous engagements by altogether nine participants, six men and three women, in a Copenhagen shopping mall. Props were used in form of collage material of existing car models, car concepts and images of Copenhagen. The participants were asked to choose one type of car that represented their vision of autonomous driving. They were also requested to choose one cityscape important for them, and note down how they expected that to change with the introduction of autonomous driving. In addition, they were encouraged to draw or narrate any car design and city change they thought autonomous driving would bring about. The participants were asked what their imagined journey back home with the self-driving car would be like. Qualitative data was generated in terms of the user's collages, drawings and narratives, and was sorted into themes.

3.1.1 Social implications of the self-driving car

All but one participant drew rotated seats for a more social setting in the car,

emphasizing the increasing social capabilities. Being able to engage more in other passengers was perceived as one of the main values of self-driving cars. However, there was also a concern that other road users would be worried and even afraid of a self-driving car. On one hand, there was an aspiration to not scare others with the cutting edge technology, and on the other hand a desire to show off the novelty of such a hi-tech and futuristic car. Six participants, interestingly all men and no women, wanted to keep the exterior very traditional to allow a smooth transition into the realm of autonomous cars. The three women that participated desired a futuristic image to display on the roads, enjoying the novelty of the technology. One woman was even imagining a flying car and another woman imagining that the car would interact with her and teach her to become a better driver.

3.1.2 Every-day life in the self-driving car

Some would use the time to catch up on sleep or prepare/conclude the working day. One participant opened up for a giant sunroof, as to be able to gaze up at the sky and relax during the ride home to his family. The mental transition between places was expected to become smoother. There was a hope that future travel will be more predictable and exact, giving the users greater control of their time. As timing would be more predictable, the car would allow the traveller to disconnect from time management, free to rest or work. One participant who regularly travelled between Germany and Denmark saw a great value in extending his morning activities into the car, resting and finally arriving more energetic and prepared for the day's meetings. Another participant imagined having more freedom to take longer and more demanding trips by herself. But on shorter trips, there would also be a value of disconnecting from driving.

3.1.3 Anticipation of a smarter way of using resources

Many were expecting smarter ways of using resources with the introduction of autonomous cars. All the participants had high expectations for the self-driving car's intelligence, and that the power of automation should be used for more than just transporting the owner from A to B, for example transporting other family members, doing errands and driving to the car wash and garage by itself. Sharing their car with others would lead to more efficient and economic car use and fewer cars in the city. There was an appeal to think of how the "robotic car" would fit neatly into its spot in robotic parking

houses, leading to fewer parking lots. Two participants expected the cars being closer to each other in traffic, resulting in less queues.

3.1.4 Trusting self-driving cars

In terms of trust, the views of the participants diverged. One participant would rather trust the technology to drive him home the 90 kilometres from Copenhagen to Sweden, than his friend (a devoted car enthusiast). In addition to communicating a message concerning his friend's driving style, his views were an example of a readiness to take this technology to his heart which was expressed by many users, while others were much more reluctant. For some, it would take months of close surveillance until they could finally relax and trust the car. Although some worries about the initial phase of usage, all were convinced they would sooner or later take it to practice, as the possibility of disengaging from driving was attractive.

3.2 Study B – “Setting the stage” for Future Automotive Experiences

In study B, the method focused on a more embodied experience, investigating how this approach might spur imagination and reflection. Chalks and sparse scenery was used as material on a parking lot in Gothenburg, Sweden. A car was drawn on the ground and a few chairs were placed on it to represent possible seating, giving the methodology the name “Setting The Stage”. By-passers, one by one or in groups, were welcomed to imagine and design a new self-driving car, using the chairs and chalks. In total nine persons participated; seven men and two women. This meant that they were also collectively building upon each other's ideas. The participants were also asked what their imagined journey back home with the self-driving car would be like. In contrast to study A, a scenario was also presented at the end of the session, where the car asked for the driver's attention and control. The participants were encouraged to imagine the process of entering-the-loop again (i.e. driving). The scenario aimed at encouraging imagination and enactment of an interaction situation with the “car”. Again, photos taken during the session, the participants' drawings and stories were analysed by

categorizing them into themes.



Fig 1. Examples of photographs from study B

3.2.1 The extended living room

The results of this study were closer tied to the interaction- and interior design of the car compared to Study A. The car was expected to turn into a living room like space, more adapted to comfort, social activities and relaxation, with a softer, cosier design language. Soft lights and low sounds would result in a calm interior mood. The participants envisioned how everyday life would continue in their self-driving car, relaxing with family, enjoying a good movie, and performing light work tasks. Some participants completely removed the chairs and instead had reclined, relaxed positions (as shown in Fig 1). A number of rotating seats were drawn, expressing the fascination that the participants had for the new, more social interior design opportunities of a self-driving car. Although work tasks would be done, the environment spoken of was more similar to a home environment than an office. Activities like reading and quick replies to e-mails were referred to, not more demanding work like writing longer texts or editing spread sheets.

3.2.2 Interaction and interior metamorphosis

The metamorphosis of the car was a common topic, both in terms of an imagined new interior design language but also by a physically moving interior, for example receding seats and steering wheel. For many participants, the car interface transformed to a very passive role during the autonomous drive. Traditional driving information would continue to exist, but have a more subdued position in the car. The car would only occasionally come into focus, for example when it was needed to re-route the trip. The input of destinations to the car was imagined to be performed via voice command, for comfort and for a hi-tech experience. Big screens in the

interior also provided a sense of hi-tech novelty. This novel, high-tec image was perceived to characterize the introduction of self-driving cars.

3.2.3 Trusting self-driving cars

The sense of trust in the technology varied from one extreme to another; from a positive and trusting attitude, with visions of smooth and seamless technology interactions, to one participant's nightmare vision of technology unfit to human reaction capabilities and needs. However, the majority had very positive expectations. In a group of three young men, the extremely relaxed atmosphere with reclined positions was only briefly interrupted for the driver when the scenario called for manual control. He imagined that the steering wheel would smoothly move towards his hands, and his reclined seat would stretch towards an upright seating position. If given a fair amount of time and preparation without stress, the participants perceived that they could conveniently take back control of driving. They expected to be given substantial time to reposition into driving. The designs of the transitions were surprisingly exactly imagined by the participants, with unattractive extremes of "red flashing lights and sounding alarms" to more attractive "soft, smooth sounds" discretely and politely asking for the driver's attention. Several participants mentioned the need to have a familiar speedometer to quickly glance at from time to time, being reassured that everything was in order. There appeared to be reluctance of entirely letting go of the traditional driving interface; the system could only be trusted if it was continuously and calmly reassuring the user.

4 REFLECTIONS AND CONCLUSIONS

The "designs" created by the participants are not to be seen as design solutions as such; they are intended to be seen as indicators of areas where users' design concern lies. For example, in the many drawings of speedometers, additional screens and rotating seats, important issues and values manifest themselves; such as a desire for novelty, time management and social relatedness, as well as issues of trust and safety. The result of the two studies provides in this way insights into users' expectations of

autonomous cars. More importantly though, the two studies contribute to our knowledge on how different studies on the same topic can elicit different types of data. Study B resulted in more elaborate and in-depth reflections on the participants' trust, interaction expectations and interior car design expectations, whereas study A gave less informative answers about interior and interaction. Instead, study A gave more information on how the technology would shape every day life and the city. In study B, the bodily placement in the "car" appeared to create a situation to act and anticipate future use. The participants were able to express themselves more precise and informative. Less preconceived ideas about the technology (for example of "flying cars") were aired in study B, and more informative specifics about the designs and expected use were expressed. The situation provided a possibility to bridge body and mind in the enactment of future experiences, in accordance with Brandt and Grunnet previous studies of studies of future technology (2000). Both methods pointed towards possible ways of probing into the future without time taking and expensive prototypes, providing an open surface to more freely project expectations on, as noted also by Ehn and Kyng (1991). The methods applied in this research are best used in early design processes as inspiration for value-creating interior and interaction designs. The methods must naturally be used in concert with more traditional methods for researching user needs and design requirements in a user centered design process. At later stages in the design process, other inquiring materials such as prototypes are available to continue the experimentation and exploration of future users' every day user experiences, involving both body and mind (Buchenau & Suri, 2000). This can challenge preconceived design concepts, leading to ideas of less incremental qualities.

Both studies contribute to the repertoire of methods that can be used for studying users' expectations of future automotive technology. Both types of inquiries generated relevant information but the results also show that method props should be chosen and used with careful regard to what the focus of the research question is. Future work is needed to continue explore the future of autonomous driving with human needs and values in focus, and also to obtain further information of what approaches similar to those in this study will result in.

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IMPROVED SAFETY SURFACE ACCESS AT LOW COST AIRPORTS: PREFERENCES BY LOW COST PASSENGERS FOR PEDESTRIAN FACILITIES AT KUALA LUMPUR INTERNATIONAL AIRPORT, MALAYSIA

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ABSTRACT

The purpose of this Paper is to evaluate the importance of airport access pedestrian safety based on the specific experiences, supported by an extensive survey, of passengers at Kuala Lumpur International Airport (Malaysia) Low Cost Airport Terminal (KLIA LCT). The survey will allow a ranking and prioritisation to be made, supported by the selected safety preferences of business and leisure passengers, of the most important pedestrian facilities that should be provided for future airport surface access development. To allow a meaningful interpretation of the survey results, the ANOVA (Analyses of Variance) Test to compare the mean of variances or differences between the factors was used to evaluate the relative safety importance of different pedestrian access facilities according to the varying viewpoints of low cost passengers. It is hoped that the results of this Paper will be useful both as theoretical guidelines and also as an example of best practise for airport planners who are engaged in the design of safety airport access pedestrian facilities.

1 INTRODUCTION

Pedestrian defines as people who walk, sit, stand, or use a wheelchair in public spaces. The examples of pedestrian are children, teens, adults, elderly, and people with disabilities. In addition, pedestrian facilities could be identified as walkways such as sidewalks, walking and hiking trails, shared-use paths, pedestrian grade separations, crosswalks, and other improvements provided for the benefit of pedestrian travel (FHWA in Kar, 2009). Even though to have a proper or better pedestrian facilities is been an important aspect, the safety of pedestrian much more important in the transportation field (Sisiopiku and Akin, 2003).

Based on Malaysia scenario, the Malaysian authorities (i.e. MIROS, MOT and Royal Malaysian Police) are responsible to provide funds, system, planners, installing, retrofitting sidewalks, and other tools in order to ensure people who walk receive adequate facilities for their comfort and safety. The Malaysian authorities are aggressively promoted the safety campaign and awareness at Malaysia (i.e. safety education and speeding limit). However, based on MIROS statistics in 2009, pedestrian fatalities by mode of transport has contributes 589 cases or 9% of total road accidents and the highest rate of accident are in Johor which contributed 1,060 cases.

The preferred facilities of pedestrians area in Malaysia is highly recommended as the country is developed with high volume of vehicles on the road daily. Based on Malaysia experiences, the transport system was rapidly developed especially in land transport along with developing of highway system, increasing of car users, type of vehicles, diversity of driver's age, and road technology. The airport planner should taking consideration the differences of user levels which include normal, disabilities, children and group of age. Sisiopiku and Akin (2003) stated that the airport planners and traffic engineers should consider the importance of pedestrian preferences and perceptions when designing efficient and pedestrian friendly facilities. In addition, initiative should be taken to promote pedestrian travel (e.g. appropriate pedestrian facilities) which offers potential users an assured level of convenience, efficiency, comfort, and security for successful applications.

2 RESEARCH METHODOLOGY

The theoretical framework has been established in view of the relationship of current and future provision of pedestrian facilities. It represents the process within the development of the methodology and the concept of basic pedestrian facilities provision. The development of the conceptual framework has also considered the roles of participants, users' expectations, time, strategic processes and adaptation of the research structures into a research context. The discussion about the success factors of the proposed methodology is necessary in order to achieve the aims and objectives of the research. The primary source of data consisted of feedback from 180 respondents of pedestrian users. A questionnaire was developing to collect and support research frameworks were completed by them to determine their viewpoints on the provision of pedestrian facilities to be included in pedestrian design. The survey was conducted at Kuala Lumpur International Airport, Malaysia. The results were processed by SPSS (Statistical Package for Social Sciences) and the data was coded, counted and presented. Quantitative data was used in order to evaluate the relationship of the current, future and business and leisure travelers' expectation and pedestrian facilities.

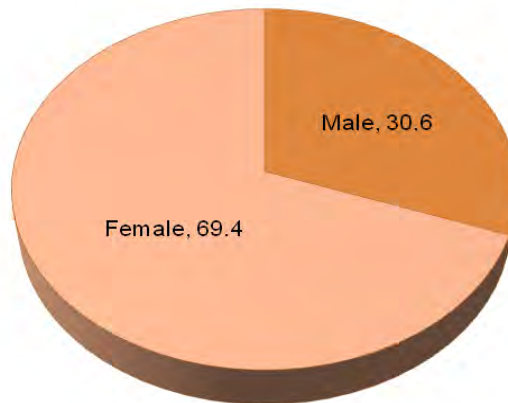
The ANOVA (Analyses of Variance) Test to compare the mean of variances or differences between the factors was continued to measure the provision of pedestrian facilities linked to user' current provision of pedestrian facilities and ideal facilities as a result of the importance of users' needs and safety, and a significant relationship between the importance of future provision of pedestrian facilities.

3 DISCUSSION

3.1 Demographic background

Figure 1 shows the proportion of respondents by two gender groups: Male and female. In the survey, 30.6% (55) out of 180 of respondents is male and 69.4% (125) is female. The survey was randomly distributed among the users and showed that the highest response rates are from female walkers, which indicated that they have their own purpose and preference to travel along the pedestrian walkway.

Figure 1: Proportion of pedestrian users by gender



3.2 Perception of pedestrians on the usage of pedestrian facilities

Table 1 shows the differences in significant values for purpose of travel (business and leisure) in pedestrian users' preferences for pedestrian facilities in pedestrian pathway, in significant order: Lighting (0.012), hump (0.016), air conditioning (0.019), bollard (0.024), and disabled facilities (0.025). Therefore, the hypothesis alternative is accepted as these facilities have been highly significance to the business and leisure users. Table 1 also shows that specific pedestrian facilities are rated as not being significance to the purpose of travel, as shown by high p values (0.05), by both business and leisure pedestrian users [for example, children facilities (0.882), median (0.546), internal use of plants and trees (0.453), information board (0.306), and bicycle lane (0.093).

Table 1: Perception of pedestrian users on the usage of pedestrian facilities

Pedestrian Facilities	F Value	Significant Value (p)
Air Conditioning	3.045	.019
Bicycle Lane	2.022	.093
Bollard	2.893	.024
Children Facilities	.293	.882
Disabled Facilities	2.864	.025
Hump	3.133	.016
Internal Use of Plants and Trees	.922	.453
Information Board	1.208	.309
Lighting	3.328	.012

Median	.771	.546
Advertising Board	1.655	.163
Pavement	3.869	.005
Physically Separated Walkway	3.132	.016
Public Phone	.277	.893
The View of Outside	1.829	.125
Seating Availability	1.374	.245
Self-service Vending Machine	3.862	.005
Spatially Separated Walkway	3.970	.004
Speed Breaker	.266	.900
Stroller Ramp	.774	.543
Way Finding	2.286	.062
Zebra Crossing	1.064	.376
CCTV	1.297	.273

The differences in significant values for purpose of travel in pedestrian users' preferences for pedestrian facilities in pedestrian pathway, has shown in significant order: Spatially separated walkway (0.004), pavement (0.005), self-service vending machine (0.005), and physically separated walkway (0.016). Specific pedestrian facilities are rated as not being significant to the purpose of travel, as shown by higher p values (0.05), by both business and leisure pedestrian users [for example, speed breaker (0.900), stroller ramp (0.543), zebra crossing (0.376), CCTV (0.273), seating availability (0.245), the view of outside (0.125), advertising board (0.163), public telephone (0.093), and way finding (0.062).

The significant test values (ρ) representing the ranking of pedestrian facilities by purpose of travel; business and leisure. The Table 1 also shows the statistical significant test of the pedestrian users' type of travel at 5% sensitivity level. There is strong significance between the rankings of the pedestrian facilities, regardless of the purpose of travel. From the Table 1, all facilities are significant to the type of travel, as important as an ideal pedestrian facilities; bollard (0.024), hump (0.016), pavement (0.005), physical separated walkway (0.016), and spatial separated walkway (0.004). These pedestrian facilities are needed and applied to the safety of pedestrian users. However, although, median (0.546), speed breaker (0.900), and stroller ramp (0.543) not significant to the purpose of travels, users were strongly agreed these facilities are more important.

3.3 Perception of pedestrians on the comfort levels of pedestrian facilities

Table 2 shows the differences in significant values for purpose of travel on the comfort levels in pedestrian users' preferences for pedestrian facilities in pedestrian pathway. By ANOVA test to

compare with p values, it is more significant to walk on the pathway less than 5 minutes (0.024). Walking with bags to 1.8sq.m space is more significant for only one person (0.044) compare to two persons (0.057) and more than 2 persons (0.187). While without bags to 1.4sq.m is comfort to walk for more than 2 persons (0.035). For elderly or disabled person, facilities such separated pathway especially for them was highly important as significant by 0.003. From analysis also shows there is significant to reduce in access to natural environment (0.026) such as restriction to step on grass (as spatially separated walkway) or to access to trees (physically separated walkway). More likely, CCTV or security booth nearest to pedestrian pathway is compulsory as analysis is significant by 0.016 to increase the safety aspect.

Table 2 : Perception of pedestrian users on the comfort levels of pedestrian facilities

Pedestrian Facilities	F Value	Significant Value (p)
Walking Distance Less Than 5 mins	2.893	.024
Walking Distance 5-10 mins	.771	.546
Walking Distance More Than 10 mins	1.374	.245
Standing Space With Bags to 1.8 sqm for 1 person	2.508	.044
Standing Space With Bags to 1.8 sqm for 2 persons	2.335	.057
Standing Space With Bags to 1.8 sqm for more than 2 persons	1.582	.181
Standing Space Without Bags to 1.4 sqm for 1 person	1.103	.357
Standing Space Without Bags to 1.4 sqm for 2 persons	1.265	.286
Standing Space Without Bags to 1.4 sqm for more than 2 persons	2.655	.035
Separated Queuing Lines Between Users With Family/Elderly/Disable People	4.194	.003
Separated Queuing Lines Between Users Without Family/Elderly/Disable People	1.057	.380
Reduced in Access to Natural Environment	2.830	.026
Increased of Safety Concern	3.132	.016

4 CONCLUSION

The research shows the negative responses of pedestrian users which many pedestrian facilities has been designed are not provided. Examples include pedestrian facilities where access to destinations

is difficult, and strip development along high-speed roads where no sidewalks or pedestrian crossings exist. When streets and roads are evaluated for improvements, it is helpful to consider whether the design effectively meets all the desired functions of the roadway. This may help proactively identify locations for pedestrian safety improvements in the process of improving safety and mobility in the airport area.

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EVALUATION OF THE TACTILE DETECTION RESPONSE TASK (TDRT) IN A LABORATORY TEST USING A SURROGATE DRIVING SET-UP

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ABSTRACT:

This paper presents findings of a laboratory experiment which aimed at evaluating the sensitivity and intrusiveness of Tactile Detection Response Task (TDRT) methodology. Various single task, dual task and triple task scenarios were compared. The task scenarios consisted of a surrogate of driving (tracking task) and different secondary tasks (n-back, SuRT). The results suggested that the TDRT was sensitive to load levels of a secondary task which primarily demands for cognitive resources (n-back). Sensitivity to variations of visual-manual load could not be shown (SuRT). TDRT was also sensitive to different modes of primary task which varied in terms of cognitive load (visual vs. auditory tracking task). Results indicated intrusiveness of TDRT on primary task performance and secondary task performance depending on the type of underlying task scenario.

1 INTRODUCTION

The Detection Response Task (DRT) is a novel method based on a simple stimuli-response task similar to the well-known Peripheral Detection Task (PDT) (Martens and van Winsum, 2000). Both methods measure effects of secondary task load on driver attention and are intended for evaluation of in-vehicle information and control system interfaces. The participant presses a button in response to frequent stimuli presented at a randomly varied interval of 3 to 5 seconds. PDT uses LEDs for presenting visual stimuli. However, visibility of the stimuli can vary with lighting conditions. To avoid this limitation, the TDRT has been developed which presents a vibrating (tactile) stimulus to the participant's shoulder (Engström et al., 2005).

The experiment presented in this paper was part of a set of coordinated international studies which supported the ongoing development of an ISO

standard on the DRT (ISO, 2013). The standardization is in process and there are still open questions with regard to sensitivity of the new method. Although the main focus of the TDRT is to measure effects of cognitive load, other types of secondary task load such as sensory-actuator demands and/or perceptual-motor demands may also affect TDRT results. Other open questions refer to intrusiveness, as the effect of TDRT on primary task and secondary tasks have not been systematically investigated so far. The current study was designed to examine these issues by focusing on the following research questions:

- To what extent is the TDRT sensitive to different load types and load levels of both primary task and secondary task?
- How does the TDRT affect the task performance of primary task and secondary task?

2 METHOD

The experiment was performed in the HMI laboratory of BAST.

2.1 Participants

22 licensed drivers (10 female, 12 male) volunteered in participating in the study. Age of the participants ranged from 19 to 64 years (mean 41.7, SD 13.9).

2.2 Surrogate driving task

A surrogate of driving was used as primary task in the experimental set-up. Participants had to perform a continuous sensomotor tracking task using a steering wheel as input device for manually controlling the tracking deviation. The task was to minimize tracking deviation over a given winding track.

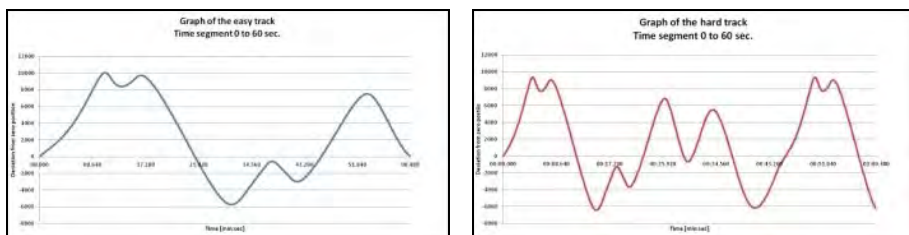


Fig. 1 Tracks used for the easy (left) and hard tracking task

Two types of tracking task with different modality of feedback to the participant were used: a) visual tracking, b) auditory tracking. Each tracking

type was conducted at two difficulty levels depending on the bendiness of the track: easy = low bendiness, hard = high bendiness (Fig. 1).

Track and tracking deviation were visually presented to the participant when performing the visual tracking task. No visual feedback was presented to the participant during the auditory tracking task. In this case, the participant only received acoustic feedback indicating the extent of deviation (via tone frequency) and the direction of deviation, i.e. the side of the track where the deviation drifted to (via left/right speaker). The cognitive load imposed to the participant by the auditory tracking task, i.e. mental effort to control tracking deviation, was higher than for the visual tracking task (Gelau and Schindhelm, 2010). Thus including both modes of tracking task (visual, auditory) in the experimental set-up allowed for variation of primary task in terms of perceptual-cognitive demands, whereas the difficulty levels of tracking task (easy, hard) primarily varied the perceptual-motor demands of primary task.

2.3 Secondary tasks

Two secondary tasks were included in the study, the Surrogate Reference Task (SuRT) and the n-back Task. SuRT is a visual-manual search task, while the n-back Task imposes mainly cognitive load on the participant. Each secondary task was conducted at two load levels.

The SuRT (Mattes et al., 2007) required the participant to visually search a display for a target circle which was surrounded by a set of distractor circles. After detection of the target circle the participant responded by pressing the right or left key of a numeric keypad thus inducing a visual cursor moving to the target circle. Visual perceptual load was varied in terms of size of the distractor circles in comparison to the target circle (easy = large difference in size; hard = small difference in size) (Conti et al., 2014). The two SuRT levels additionally differed in terms of manual load. Only few keystrokes to reach the target were needed on the easy level, whereas the hard level required a higher amount of inputs. A new sub-task appeared on the screen as soon as the participant confirmed completion of the preceding sub-task.

During n-back Task (Mehler et al., 2011) a series of spoken digits were presented to the participant by a computer. In the 0-back condition (easy) the participant was required to orally repeat the last number heard. In the 1-back condition (hard) the participant had to repeat the second last digit.

2.4 TDRT

The tactile stimuli of the TDRT were presented by a small electrical vibrator which was fixed to the participant's shoulder or upper arm. A push button was attached to the participant's left index finger or thumb. The participant responded by pressing the push button against the steering wheel. TDRT stimulus was on for max. 1 second and switched off when a response was given. Time between stimuli was randomly varied between 3 and 5 seconds.

2.5 Experimental set-up

The participant's seat was centrally positioned behind the steering wheel and a LCD display. Track and tracking deviation were visually presented on the LCD display during visual tracking task. The acoustic feedback of tracking deviation during auditory tracking task was presented by two speakers, one on the left and the other on the right hand side of the LCD display. A small LCD display and a keypad were located on the right hand side of the participant. These elements were used for the operation of the SuRT task (Fig. 2).



Fig. 2 Experimental set-up for the triple task scenario which combines visual tracking task, SuRT and TDRT

2.6 Experimental design

A within-subject design was employed with primary task, secondary task and

use of TDRT (with, without) as independent factors. Primary task included four levels which varied by modality (visual tracking, auditory tracking) and difficulty (easy track, hard track). Secondary task was varied by task type (SuRT, n-back, no secondary task) and difficulty (easy, hard). An incomplete factorial design was implemented which covered the research questions to be examined and resulted in various task scenarios (triple-task, dual-task, single-task scenarios).

Dependent variables were derived from TDRT measures (reaction time, hit rate), tracking task performance (root mean square deviation), SuRT (mean response time) and n-back performance (percentage of correct answers).

2.7 Procedure

Following a brief introduction, participants performed several trials for training of single-task and dual-task scenarios (tracking tasks and TDRT, but without secondary tasks). They then performed the main trials of the same task scenarios. In the second part of the experimental session dual-task and triple-task scenarios (visual tracking task, secondary tasks and TDRT) were applied. The participants again received some training on the scenarios in the beginning and then performed the main trials. The order of trials was randomized between participants.

3 RESULTS

TDRT response times

Mean hit rate was above .8 for all applied task scenarios and conformed to ISO-draft. Therefore, only mean response times are reported below.

Two-way repeated measures ANOVAs were used to identify the effects of task type (secondary: n-back, SuRT; primary: visual, auditory) and task difficulty (easy, hard) on response time. The level of α was set to .05. Partial η^2 is reported as a measure of relative effect size. Effects of primary task difficulty were analyzed with paired-samples t-Tests. Significance levels are displayed in Figure 3.

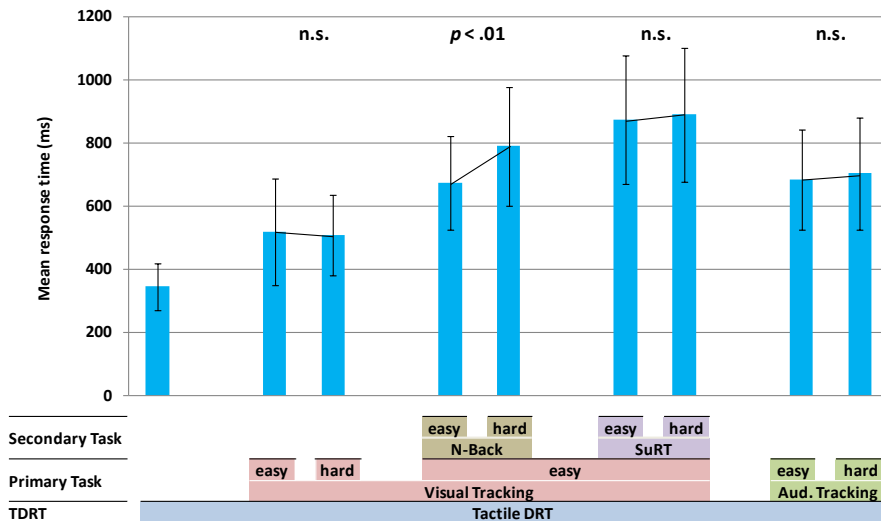


Fig. 3 TDRT response time in different task scenarios. Error bars: standard error of the mean

For the triple task conditions, the main effect of secondary task type was significant ($F(1, 21) = 31.1, p < .001, \eta^2 = .60$), as was the main effect of secondary task difficulty, ($F(1, 21) = 6.9, p < .05, \eta^2 = .25$). The interaction between these two factors was also significant, ($F(1, 21) = 10.1, p < .01, \eta^2 = .32$). The hard n-back task resulted in significantly increased TDRT response time compared to easy n-back task. There was no significant difference between TDRT response time for the hard and the easy SuRT. The dual-task scenarios (visual tracking + TDRT, auditory tracking + TDRT) did not display any significant differences between response times of easy and hard tracking task. However, tracking mode (visual, auditory) revealed a significant effect on TDRT response times ($F(1, 21) = 79.4, p < .001, \eta^2 = .79$).

Due to the violation of normal distribution, non-parametric tests (Wilcoxon signed-rank test) were applied for the remaining analysis of effects of TDRT on primary and secondary task performance. Significance levels are reported in the figures below.

Root mean square deviation of tracking task

Figure 4 shows the effects of TDRT (with/without TDRT) on tracking deviation.

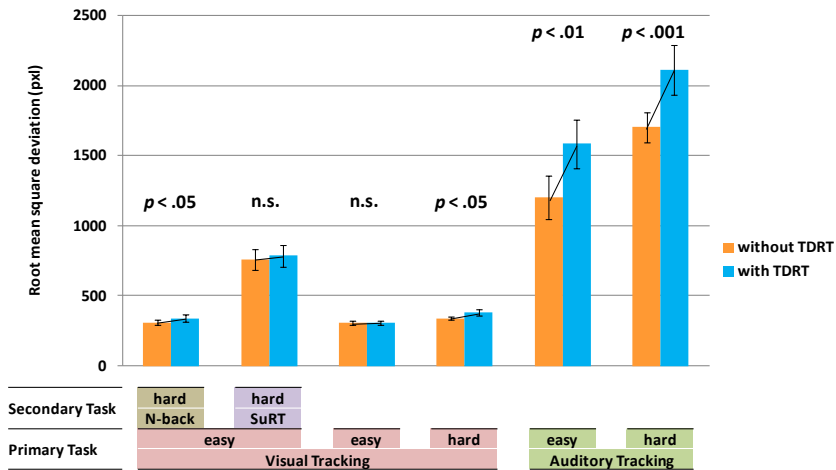


Fig. 4 Root mean square deviation of tracking task in different task scenarios. Error bars: standard error of the mean

The triple-task scenario consisting of n-back, visual tracking and TDRT resulted in a significantly higher tracking deviation compared to the task scenario without TDRT. Tracking deviation also increased when combining TDRT with SuRT and visual tracking, but no significant difference could be shown for SuRT difficulty. In case of task scenarios without secondary task, tracking deviation significantly increased when TDRT was performed concurrently with primary task, except for the scenario including easy visual tracking.

N-back performance

N-back performance (percentage of correct answers) was used as an indicator in the task scenario consisting of n-back task, visual tracking and TDRT (with/without). There was no statistically significant difference between conditions with and without TDRT.

SuRT response times

SuRT response time was used as an indicator of the task scenario which consisted of visual tracking, SuRT and TDRT (with/without). SuRT response time significantly increased when TDRT was applied (Fig. 5).

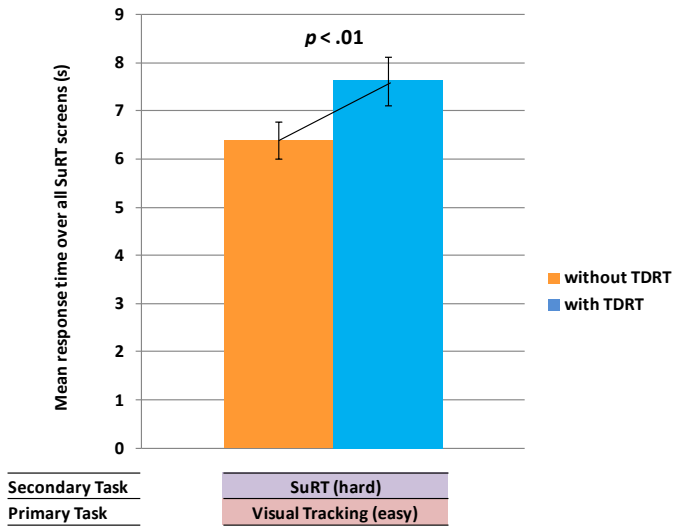


Fig. 5 SuRT response time in task conditions without TDRT vs. with TDRT. Error bars: standard error of the mean

4 CONCLUSION

Sensitivity of TDRT to different levels of cognitive load imposed to the participant was studied in task scenarios which contained n-back as a secondary task (TDRT + visual tracking + n-back). The TDRT response times for the two difficulty levels of this task were shown to be significantly different. The results suggest that TDRT is able to differentiate between different load levels of secondary tasks which primarily demand for cognitive resources.

No significant difference in TDRT response time could be shown between easy SuRT and hard SuRT (task scenario: TDRT + visual tracking + SuRT). However, there was a significant difference between the two secondary task types, SuRT and n-back. TDRT response times of triple task scenarios containing SuRT were significantly longer than those of triple task scenarios containing n-back task.

The results shown for n-back and SuRT are in line with findings from previous studies (Bruyas & Dumont, 2013; Young, Hsieh & Seaman, 2013). As both the SuRT and the TDRT demand for motor resources, a possible interference between SuRT and TDRT may be the reason why TDRT performance decreased. Further, due the possibility to self-pace the response frequency in the SuRT, the manipulation of visual-manual workload

might not have worked in the intended way, i.e. there might not have been a difference in total visual load between the easy and hard condition. Future studies should address this issue by including tasks, where visual workload can not be self-regulated by the participant.

Another hypothesis of this study addressed sensitivity of TDRT to load levels of primary task in dual-task scenarios, i.e. tracking task + TDRT, but without secondary task. No significant differences between the load levels of tracking tasks in dual task scenarios could be shown in terms of TDRT response time. A difference in mental load between the two load levels of this tracking task had been shown in former studies using the Rating Scale of Mental Effort (RSME) as an indicator (Gelau and Schindhelm, 2010). The results of the current study suggest that the TDRT was not sensitive to this variation of tracking task load.

Mode of tracking task showed a large effect on TDRT response time. The TDRT response time of the auditory tracking task was longer than that of the visual tracking task. This result reflects the difference between the different task demands, as the auditory tracking task demands for more resources of working memory and uses cognitive resources more intensively than the visual tracking task. The results indicate that the TDRT is sensitive to differences in primary task demands, thus confirming findings of a driving simulator study performed by Diels (2011). However, with regard to the two load levels of auditory task which showed no significant difference, there seems to be a minimum difference in cognitive load beyond which the TDRT is not able to differentiate between load levels.

The results show some indications for intrusiveness of TDRT on primary task performance. It can be seen from Figure 4 that including TDRT to the task scenarios resulted in a decrease of tracking task performance, i.e. root mean square deviation increased. As both tracking task and TDRT are manually operated, one may assume that the decrement of primary task performance was caused by interferences between tracking task and TDRT due to the demand for motor resources. However, it seems that also mental demands of

TDRT intruded on primary task performance, especially in those cases where the cognitive demand of the underlying task scenario was high. This can be seen, when the scenario “visual tracking + n-back + TDRT (with/without)” is compared with the scenario “visual tracking + TDRT (with/without)”: the task scenario visual tracking + n-back imposed higher cognitive load on the participant and showed a significant higher root mean square deviation when performed with TDRT.

The effect of TDRT on secondary task performance depended on the type of secondary task. TDRT did not intrude on n-back task performance. However, SuRT response time increased significantly with TDRT, thus indicating that TDRT intruded on SuRT performance.

Summarizing the results of this study, a recommendation of the DRT Task Force to not use TDRT for task scenarios with strong motor demands can be confirmed. The results suggest that TDRT is sensitive to effects caused by differences in cognitive load. Further experiments are recommended to confirm sensitivity for secondary tasks other than the n-back task.

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EXPLORING MEASURES OF USABILITY FOR IN-VEHICLE TECHNOLOGY

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ABSTRACT:

This paper examines various tools and information resources available to designers and usability professionals when developing or evaluating the HMI (Human Machine Interaction) of IVIS (In-Vehicle Information Systems) with regard to usability. It starts with a consideration of what the word 'usability' means and how it has been defined in the literature, along with a discussion of how it is relevant to IVIS. The paper then reviews HMI guidelines that have been produced and are in current usage, and finally looks at some of the usability assessment methods available to HMI professionals.

1 INTRODUCTION (WHAT IS USABILITY?)

The late 1970's and early 80's saw the arrival of personal computers in the public domain, and kick-started the movement towards 'usability' as a design consideration. Whilst usability is now an accepted concept, it is not rigidly defined (though definitions have certainly been proposed). This section will review what is meant by usability, and which aspects are of greatest importance when considered in the context of IVIS, specifically with regard to the HMI of IVIS.

Nielsen [1], whilst not necessarily defining usability, proposed five key usability attributes for products:

- Learnability
- Efficiency
- Memorability
- Errors
- Satisfaction

One of the most widely quoted definitions of usability is from ISO 9241 [2], which takes three of the attributes from Nielsen to define usability as:

'The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'

The first two of the three concepts can be broadly defined as follows:

- Effectiveness – extent to which a product does what it was designed to do
- Efficiency – resources required to achieve a task

However, satisfaction as a concept is much less tangible and, indeed, is a highly subjective construct. The ISO definition also makes no allowance for the dimension of time or the idea that prolonged exposure to a product or system may change a user's perception of usability. Jordan [3] addressed this with his proposal of five higher-order components within the concept of usability:

- Guessability
- Learnability
- Experienced User Potential (EUP)
- System potential
- Re-usability (or memorability)

Jordan's concept places a much greater emphasis on how the user experiences the product/system over the course of its use; from initial access through to the experienced user.

This raises the question of whether usability is an inherent property of the product/system or an outcome of its use; a question raised more explicitly by Bevan [4]. This, perhaps, is of particular interest in relation to in-vehicle systems, because use of a particular system in isolation is not necessarily of great importance. The focus for in-vehicle technologies is, instead, typically on how that technology will affect the safety of the overall driving task. ISO 17287 [5] defined a new and related concept - 'suitability' - as:

'The degree to which a [system] is appropriate in the context of the driving environment based on compatibility with the primary driving task'

The usability of a particular product has therefore to consider carefully the context of its use. A user may well regard a product as being extremely usable, but fail to consider fully how use of that product may interact with the

driving task. If a product is potentially to be used within a vehicle the designer must first understand the user and the context of use (driving experience, technology experience, expectations and so on).

Incorporating the earlier concepts of satisfaction and acceptability leads to a consideration of both the usability and the utility of a product/system in order to understand how it will be received (and used) by a user. Indeed, the Technology Acceptance Model (TAM) [6] describes how perceived usefulness and ease of use are the main determinants of attitude towards a technology, which in turn predicts intention to use and, ultimately, actual system use. It can therefore be seen as the responsibility of the designer to ensure that systems are not only perceived as easy to use but are, in fact, usable within the driving context.

In determining the usability of an IVIS (whether designed specifically for use in a vehicle or not), there must be an understanding of how the system fits into the larger vehicle-driver-road system. It must be useful to the driver within the higher driving task, efficient such that it presents a minimal distraction, and its ease of use must be compatible with any competing demands on the driver at the time of use (which may or may not be when driving).

2 DESIGN GUIDELINES

This section reviews a range of standards and guidelines, available to designers, that aim to promote usability in the driving context.

2.1 *Regulations and Standards*

2.1.1 International regulations

International standards may not be legally binding, but do form a framework within which designers can seek to create products and systems that subscribe to a common philosophy. Standards, by their nature of attempting to define best practice, are often referenced in national regulations or supply contracts and so often influence mandatory requirements. As such they have an important role to play, but only if they are kept up to date. At least three

ISO groups are currently working in areas relevant to IVIS and usability:

- ISO TC 22 SC13 WG8 covers basic standards for human factors design of in-vehicle systems;
- ISO TC 204 WG14 concerns vehicle and cooperative services (and some interface issues) including, for example, Lane Departure Warning and automatic Emergency Braking Systems; and
- ISO TC 204 WG17 concerns nomadic and portable devices for ITS services.

A multitude of standards have been produced that cover the design of visual and audible driver interfaces, much of which has formed the basis for current design guidelines and codes of practice.

2.1.2 United States regulations

In the US, laws about in-vehicle distraction generally fall under the jurisdiction of individual states but with some at the national (federal) level. As an example of state provision, the US state of Nevada passed a law in June 2011 concerning the operation of driverless (fully automated) cars whereby the Nevada Department of Motor Vehicles is responsible for setting safety and performance standards and for designating areas where driverless cars may be tested.

As an example of national provision, in October 2009 President Obama issued an Executive Order prohibiting Federal employees from texting while driving. This order is specific to employees' use of Government owned vehicles, or privately owned vehicles while on official Government business, and includes texting-while-driving, and using wireless electronic devices supplied by the Government.

2.1.3 European regulations

There is currently little in the way of European legislation specifically related to the HMI of IVIS. However, the European Commission published a Directive in 2010 [7], which has provisions for the development of specifications and standards for ITS road safety including HMI and the use of nomadic devices. European regulations may be a consideration in the future.

2.2 *Design Guidelines*

2.2.1 Europe: European Statement of Principles

The European Commission (EC) [8] has supported the development of a document called the 'European Statement of Principles on HMI' (referred to as ESoP) which provides high-level HMI design advice. As an EC Recommendation it has the status of a recommended practice or Code of Practice for use in Europe. The EC Recommendation also contains 16 Recommendations for Safe Use (RSU), which build on Health and Safety legislation by emphasising the responsibility of organisations that employ drivers to attend to HMI aspects of their workplace. Adherence to the RSU is intended to promote greater acceptance of technology by drivers.

The design-guidelines part of the ESoP comprises 34 principles to ensure safe operation while driving. These are grouped into the following areas: Overall Design Principles, Installation Principles, Information Principles, Interactions with Controls and Displays Principles, System Behaviour Principles and Information about the System Principles.

2.2.2 United States: Alliance and NHTSA

The US motor vehicle manufacturers have developed 'Alliance Guidelines' that cover similar, high-level, design principles to the ESoP. The Guidelines [9] consist of 24 principles organised into five groups: Installation Principles, Information Presentation Principles, Principles on Interactions with Displays/Controls, System Behaviour Principles, and Principles on Information about the System.

The USA's National Highway Transportation Safety Administration (NHTSA) has worked with the auto industry and the cell phone industry to develop a set of guidelines [10] for visual-manual interfaces for in-vehicle technologies. These are based on the ESoP/Alliance guidelines and introduce some specific assessment procedures. The NHTSA plan to publish guidelines for portable devices and for voice interfaces in future years.

The NHTSA guidelines seek to provide specific acceptance criteria for the given design principles, as opposed to the more generic criteria given within the ESoP. Whilst this does lead to more definitive assessment, it does rely on the testing of participants to determine levels of distraction (suggesting

the use of 24 people to test). This introduces issues of participant homogeneity and sample sizes and, as NHTSA notes, this may mean that outcomes may differ between different test groups.

2.2.3 Japan: JAMA

The Japanese Auto Manufacturers Association (JAMA) Guidelines [11] consist of four basic principles and 25 specific requirements that apply to the driver interface of each device to ensure safe operation while driving. Specific requirements are grouped into the following areas: Installation of Display Systems, Functions of Display Systems, Display System Operation While Vehicle in Motion, and Presentation of Information to Users. Additionally, there are three annexes: Display Monitor Location, Content and Display of Visual Information While Vehicle in Motion, and Operation of Display Monitors While Vehicle in Motion. There is, as well, one appendix: Explanation of the guideline for in-vehicle display systems.

2.3 Warning Guidelines

Guidelines on establishing requirements for high-priority warning signals have been under development for more than five years by the UNECE/WP29/ITS Informal Group [12]. There has also been work in standardisation groups to identify how to prioritise warnings when multiple messages need to be presented and one 'Technical specification' (TS) has been produced:

- ISO/TS 16951: Road Vehicles – Ergonomic aspects of transport information and control systems – Procedures for determining priority of on-board messages presented to drivers

In addition, two Technical Reports are relevant that contain a mixture of general guidance information, where supported by technical consensus, and discussion of areas for further research:

- ISO/PDTR 16352: Road Vehicles – Ergonomic aspects of transport information and control systems – MMI of warning systems in vehicles
- ISO/PDTR 12204: Road Vehicles – Ergonomic aspects of transport information and control systems – Introduction to integrating safety critical and time critical warning signals

2.4 Driver Assistance Systems Guidelines

To help promote acceptance of Advanced Driver Assistance Systems (ADAS), a key issue is ensuring controllability and this has been addressed through guidelines. Controllability is determined by the possibility and driver's capability to perceive the criticality of a situation; the driver's capability to decide on appropriate countermeasures (such as overriding or switching off the system) and the driver's ability to perform any chosen countermeasures (taking account of the driver's reaction time, sensory-motor speed and accuracy). Drivers will expect controllability to exist in all their interactions with assistance systems:

- during normal use within system limits
- at and beyond system limits
- during and after system failures

The European project RESPONSE developed a Code of Practice for defining, designing and validating ADAS. The Code describes current procedures used by the vehicle industry to develop safe ADAS with particular emphasis on the human factors requirements for 'controllability'.

Another European project, ADVISORS, attempted to integrate the RESPONSE Code within a wider framework of user-centred design taking account of the usability of information, warning and assistance systems [13]. There is also activity by the International Harmonized Research Activities – Intelligent Transport Systems (IHRA-ITS) Working Group to develop a set of high-level principles for the design of driver assistance systems [14].

3 METHODS RELATED TO USABILITY MEASUREMENT

As discussed earlier, when assessing usability of IVIS it is not necessarily the inherent usability of the product/system in isolation that is of interest; it is usually more important to gauge the usability of the system within the wider context of the driving task as a whole. As such, metrics of usability need to focus on overall driver performance associated with system use. Also, as

shown in the previous section, various guidelines have been produced that provide designers and assessors with principles that are shown to help promote better system performance. Methods for assessing IVIS usability can therefore take two different approaches:

1. Evaluate actual driver performance when using the product/system in a realistic context of use
2. Evaluate how well a product/system meets the design principles in the relevant guidelines

With regard to approach 1 (measuring actual performance) a method for testing the usability of in-car systems can be seen to be a combination of three factors [15]:

1. Which environment the method is used in (road, test track, simulator, laboratory etc.) The decision will be based partly on the available resources; on-road testing is usually far more expensive than laboratory testing, for example. More importantly, from a scientific point of view, is to do with the validity of the testing, and there is usually a trade-off between achieving good ecological or internal validity. For instance, road trials may have high ecological validity (we are confident that the testing is representative of the real world), but may have poor internal validity (it may not be clear what the exact reasons are for any observed behaviours). Laboratory testing, conversely, will typically demonstrate good cause-effect relationships, but it is not always clear if such relationships are relevant or occur in practice in the real world.
2. Which task manipulations occur (multiple task, single task loading, no tasks given etc.) When testing IVIS, there is usually a need to, at least partially, recreate relevant operational tasks, in order to make usual judgements on usability and performance. The broadness of this representation will depend on the research/evaluation needs.
3. Which dependent variables (operationalised as metrics) are of interest. Choosing very specific metrics (such as eyes-off-road time) can give very objective performance measures that allow clear comparison between conditions. Conversely, choosing much broader metrics (such as questionnaire self-assessment of task difficulty) are

typically much more subjective and less focussed, but may give a better overall picture of performance, typically a combination of measures will be used and will depend on the research questions to be answered.

As noted by Rogers et al. [16], in deciding on any method, the design team must consider the overall goals of the work, specific questions to be addressed, the practical and ethical issues, and how data will need to be analysed and reported. Due to the unique combinations of complex tasks demands when driving, a number of bespoke research methods have arisen that are typically used in assessments within a driving context. In preparation for the NHTSA guidelines, Ranney et al. [17] assessed several different methods for testing distraction potential of devices. The following are some commonly used methods for testing usability:

- Road trials – Participants drive a real vehicle, usually on the public roads but potentially on a test track. Typically a wide range of more generic metrics are used in order to understand what will usually be a complex set of observed behaviours, causal/contributory factors and driving environments.
- Simulator trials – participants drive in a simulated environment in which the environment is carefully controlled and where test activities are tightly controlled. The key for simulator trials is the repeatability of the experiments. Specific objective measures allow useful comparisons between participants and between test scenarios.
- Occlusion - This is a standardised laboratory-based method [18] which focuses on the visual demand of in-vehicle systems. It involves the use of special goggles that mimic periodic glancing behaviour typically adopted by drivers when attempting to perform a secondary visual task. Common performance metrics are: time taken to complete task, number of glances (related) and number of errors made.

- Peripheral detection – This method is often performed as part of a simulator study and requires participants to respond to changes in their periphery. This may be the presence of lights or movement of shapes. Speed and accuracy of responses are used as metrics and as an indication of mental workload and distraction associated with secondary tasks.
- Lane change task - This standardised method [19] uses a basic PC simulated environment in which drivers are requested to make various lane change manoeuvres whilst engaging with an in-vehicle system. The extent to which the profile of manoeuvre made by a driver varies from the optimum manoeuvre (the normative model) is considered to be a measure of the quality of their driving.
- Keystroke Level Model (KLM) - The KLM method is a form of task analysis in which system tasks with a given user-interface are broken down into their underlying physical and mental operations; e.g., pressing buttons, moving hand between controls, scanning for information. Time values are associated with each operator and summed to give a prediction of task times. In an extension of the KLM method, Pettitt, Burnett and Stevens [20] have developed new rules that enable designers to develop predictions for a range of visual demand measures.

The second main option for evaluating IVIS is to develop checklists based on the design principles laid down in the guidelines (e.g. ESoP, NHTSA and JAMA guidelines). To this end a functional IVIS usability checklist has been developed [21], based on an existing checklist produced for the UK Government in the late 1990's, and incorporates requirements taken from the ESoP.

The structure of the checklist is such that each specific topic comprises an initial question, supplemented by optional sub-questions requiring True/False answers and then a response box identifying if there are concerns/issues about the interface design in relation to the question (Figure 1).

Is the driver's view of the road scene free from obstruction by the IVIS?	
The swept windscreen area is fully clear.	True/False/NA
The view of the mirrors is not restricted.	True/False/NA
The side windows are fully clear.	True/False/NA
None <input type="checkbox"/>	Minor <input type="checkbox"/>
Serious <input type="checkbox"/>	N/A <input type="checkbox"/>

Fig. 1 Example question from the TRL Checklist

A key issue in developing the Checklist was the extent to which questions are sufficiently "elemental" such that they can be answered by observation and without judgment (i.e. such that all reasonable observers would agree on the same answer). For just three Checklist questions derived from the ESoP principles, it was proposed that further work on measurements and criteria needs to be established:

- Is the IVIS securely fitted?
- Is the IVIS visual display positioned close to the driver's normal line of sight?
- Are presented messages visually simple?

A future challenge is to consider whether the checklist can be developed to include a rating system, whereby differing systems can be compared in terms of their overall usability. There are, however, a number of difficult issues that would need to be addressed:

- Elements - Which elements are included within the rating? (E.g. all Checklist questions)
- Scoring* - How are the individual elements scored? (E.g. +3/0/-3 or 1-10)
- Weighting - How are the individual elements weighted? (E.g. all

even, high and low weights, individual weights)

- Combining - How are the scores and weights combined?
- Rating - How is the final number converted into the consumer rating?

*An additional issue related to scoring is determining how to account for features that may be absent. Is it “better” to have a feature, even if poorly designed, than for that feature to be absent; and how should the scoring reflect this?

4 CONCLUSIONS

This paper has discussed how usability can usefully be considered in terms of perceived usefulness and ease of use, which contribute to a drivers’ judgement of the acceptability of in-vehicle technology and their desire to use it. It has considered the importance of context in terms of assessing usability, particularly from a safety perspective.

The paper has reviewed a range of regulations, standards and design guidelines that aim to encourage better-designed in-vehicle technology that should also help to promote driver acceptance. Although basic human factors principles are established, the rapid development of in-vehicle technology presents a challenge for updating regulations and detailed design guidance.

Finally, the paper has explored a range of methods through which usability can be evaluated. The technique, the equipment used and the testing environment need to be carefully chosen depending on the in-vehicle system and the evaluation question being addressed. Some questions remain in terms of producing usability ratings suitable for the public domain; nevertheless, it can be concluded that usability can be measured and that usability is a key contributor to drivers’ acceptance of in-vehicle technology.

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