COMPARATIVE EVALUATION OF TRAINING METHODS IN IMPROVING DRIVERS' UNDERSTANDING ABOUT THE FUNCTIONALITIES AND POTENTIAL LIMITATIONS OF ADAS

Villy Portouli (CERTH/HIT, Greece), Evangelos Bekiaris (CERTH/HIT, Greece), Sofie Boets (IBSR, Belgium), Per Henriksson (VIT, Sweden)

vportou@certh.gr

ABSTRACT: A common study was undertaken to evaluate the effectiveness as regards knowledge acquisition of three different methodologies for drivers' training on new in-vehicle technologies, a standard paper manual, a multimedia software tool and a driving simulator. 93 persons from three countries were assigned to three groups, the first being trained on four systems by a paper manual, the second group being trained by a software tool and the third being trained by a software tool and acquiring practical experience of the system on a driving simulator. The analysis focused on the correctness of answers given by the participants on multiple-choice questions. The software group answered better than the other groups in one of the four systems (Lane Departure Warning), but no clear effect of the additional training via the simulator was found. However, people trained with the software and the simulator feel better trained than the rest. Based on the analysis performed, we can conclude that the use of software tools and driving simulators for training drivers in the use of new assistance systems should be further explored.

1 Introduction

1.1 Background

Within Task Force F of the HUMANIST project a new methodology for training all drivers on the use of new in-vehicle assistance systems has been developed [1,2]. The work has focused on the use of information technology for this training, thus a multimedia training tool (MMT) and specific scenarios for a driving simulator have been realised, the latter aiming to acquaint the driver with operational specificities of in-vehicle assistance systems.

The assumption is that the use of MMT for training in in-vehicle assistance systems and the users' familiarisation with such systems in a driving simulator will improve the users' knowledge on in-vehicle assistance systems potential benefits and limitations [2,3]. It is supposed that drivers usually do not read detailed manuals and hence, if such a structured curriculum does not exist, they may misinterpret the in-vehicle assistance systems functionality which may even result in adverse safety effects, i.e. due to overconfidence in the system or due to risk homeostasis effects. These potential effects have been analysed in detail in ADVISORS project Deliverable 3/8.1 [4].

1.2 Objectives of the study

A common study was performed by three partners of the HUMANIST Consortium, CERTH, IBSR/BIVV and VTI. The objective of the study was to evaluate the effectiveness of three training/ learning methods in improving drivers' understanding about the functionalities and potential limitations of Advanced Driver Assistance Systems (ADAS), In-vehicle Information Systems (IVICS) and Driving Support Systems (DSS).

The three training methods that were tested are training/learning by:

- Group A: reading a paper manual,
- Group B: using a specific developed multimedia training tool (MMT),
- Group C: using the MMT in addition to hand-on experience of each system.

By comparing the first two groups, one can identify differences between a simple manual and the MMT. By comparing the second and third group, one can identify the effect of a simulator compared to the use of an MMT only. The simulator can not be used as stand-alone training method, as its aim is only to emphasise the limitations of each system and not to demonstrate all of its functionalities.

Four systems have been chosen for consideration [5].

Table 1. Systems included in the study

System	Type
Adaptive Cruise Control (ACC)	ADAS
Lane Departure Warning (LDW)	ADAS
Navigation system & Route Guidance	IVICS
Anti-lock braking system (ABS)	DSS

2 Method

2.1 Experimental design

The independent variable was, *the training method used,* with three levels (A: training by reading manual, B: training by using the multimedia training tool, C: training by using the multimedia training tool and providing in addition hand-on experience). For each training method, all the above mentioned systems were learned. Providing that, training by reading a manual constitutes the existing standard training method, this condition was considered as reference (control condition) for the evaluation of the second condition. Comparison between second and third condition allowed reviewing any effects caused by the use of the driving simulator.

2.2 Participants

93 drivers from three countries, 33 from Greece, 30 from Sweden and 30 from Belgium, were randomly assigned in the three experimental conditions, balancing between gender. Subjects were found through advertisements and calls. The selection strategy was random selection of novice drivers (having had a driving license for less than three years), who had at least a sufficient level of English understanding, trying to have equal men and women drivers in each group. The sample can be considered as representative of the novice drivers population as far as gender is concerned. The sample size is rather small, and this was due to time and resources limitations, thus the results presented in the following sections should be considered as indicative.

The characteristics per group are given below.

Table 2. Participants' sample

	Mean Age (years)	Male	Female	Mean driving experience (years)	Mean Annual Mileage (km)
Group C	27.26	15	16	7.77	9984
Group B	27.10	15	15	7.56	8297
Group A	27.63	15	17	6.51	7536

Table 3. Participants' experience with the systems surveyed

	ABS	ACC	LDW	Navigation system	Driving simulator
Group C	22	2	1	8	3
Group B	25	2	0	8	1
Group A	19	2	0	8	0

The group participants were matched as regards PC skills, level of English understanding and educational background. No pre-test for these background variables was used, due to time and resources constraints. English understanding was assessed, based on the subjects' statement. Subjects with not sufficient English understanding were not able to participate anyway, as they were not able to read and understand the manual. The majority of the participants were of university level background, and only few were of basic education. The participants were assigned to each group, so as to match their educational background per group, however this fact should be kept in mind in the following sections.

Table 4. Group matching

	PC use			Level of English understanding		Educational background		
	Expert	Average	Novice	High	Sufficient	University degree	High school	Basic
Group C	5	25	1	14	17	19	9	3
Group B	5	24	1	11	19	15	14	1
Group A	6	21	4	15	17	19	11	2

2.3 Apparatus

All the educative information that was provided to the participants was the same, irrespectively of the training used. However, depending on the learning/training method, different kind of apparatus/equipment was necessary.

In condition A (control condition), participants were given a printed manual providing all relative information in regard to the selected ADAS/IVICS. The manual was in the form of text, containing a detailed description of systems' functionality, benefits and limitations in the systems' use depending on road/weather/traffic conditions, as well as, some indicative interfaces providing information about the type of warnings/messages that drivers might receive from the system and the type of actions that drivers are supposed to undertake.

In condition B, namely, learning by using the multimedia training tool, participants were trained on the selected system, not only through text information but also through videos and simulated examples (e.g. sounds) projected on a PC screen [2]. In essence, the same information provided into the manual was also provided to the text of the MMT. In addition to these, there were videos and simulated examples.

In condition C, namely, learning by using the multimedia training tool and providing hand-on experience, participants were given the additional opportunity to have a realistic experience on how systems would work in practice, by driving a driving simulator. Moreover, in this condition they were experiencing situations where system limitations appear. The simulators used in the three sites were of the same manufacturer, so exactly the same scenarios have been used in each site.

The manual and the multimedia training tool were developed in the English language, as this was the official language of the project, within the framework of which the present survey was conducted. There were not enough resources available to have the material translated into the native language of each of the three countries.

For the evaluation of training methods' effectiveness, a set of four questionnaires with multiple choice questions (one set for each system with 5-7 questions per system) was administrated to participants.

User ID: _____
Date: _____
Group: ? 1 ? 2 ? 3

Questionnaire for LDW

Please answer the following questions. Only one answer is correct.

1. When the LDW system is active, steering is:
   ? Controlled by the system to follow a trace
   ? Controlled by the system to keep the position in the lane
   ? Controlled by the system according to the traffic flow
   ? Controlled by the driver according to the received LDW information

2. In which of the following situations will the LDW warn you properly?
   ? If the vehicle in the adjacent lane is coming towards you
   ? If you are drifting to another lane without using your direction indicator
   ? If you are drifting to another lane, even if you are using your direction indicator
   ? If you are drifting to another lane where another vehicle is already occupying it.

3. Which one of the following road types would be the most appropriate for LDW?
   ? Rural roads
   ? Urban roads
   ? Highway
   ? Peri-urban roads (i.e. ring-road)

4. Which preconditions in the road infrastructure should be met in order to get the LDW to work properly?
   ? Good road surface
   ? Good lane markers with a specific range of lane widths
   ? Open road with good lane markers
   ? None

5. What should you do if you get an LDW warning?
   ? Return immediately to your original lane
   ? Return to your original lane if you did not want to change lane, but keep on to the next lane if you purposely did it
   ? Operate your change lane indicator and continue the manoeuvre
   ? Return to your original lane if you did not want to change lane, but keep on to the next lane if you purposely did it checking that there is no other car at the adjacent lane that did not foresee your lane change manoeuvre.

6. Which of the following is not an effect of the LDW?
   ? Enhance driver comfort
   ? Enhance traffic safety
   ? Reduce driver responsibility
   ? Improve steering performance

Fig.1. Questionnaire used for the Lane Departure Warning system

2.4 Procedure

Participants were seated in a quiet room and were administrated by the experimenter an entry questionnaire asking general questions about their characteristics (e.g. age, gender, driving experience, previous experience with ADAS/IVICS/DSS).

After a brief description of the scope of the experiment, all participants were given sufficient time to become familiar with the information provided about the systems, either by reading the manual or by using the multimedia training tool for each one of the systems. The participants were asked to read carefully the manual or to browse themselves all the pages of the MMT reading all the information included and activating all multimedia content. The experiment leader asked the participants whether they felt confident that they had understood well the manual or the MMT. According to their answer, they were either given more time for the study or they proceeded further. No assistance was provided by the experimenter in regard to better understanding the context of the information provided. But since all material was written in English, the experimenter was however allowed to translate expressions into the native language of the participant.

In the multimedia training + practice condition, apart from training by using the multimedia training tool, participants were also provided with a realistic experience on how systems would work in practice by driving in the driving simulator. Initially, there was a warm-up scenario, so that the participants were familiarised with the driving simulator. As two environments were used in the scenarios, highway and rural road, the participants were driving for 5 minutes in each environment. Then, there were four categories of scenarios, those related to ACC, LDW, ABS and the navigation system. The experiment leader was giving the following instructions to the participants:

Navigation scenarios: Drive following the traffic rules. Try to follow the navigation system instructions so as to reach destination. Do not overtake.

ABS scenarios: Drive normally without overtaking.

ACC scenarios: Drive in the right lane, without changing lane.

LDW scenarios: Driver in the right lane, imitate that you are drifting towards the road marker (lane exit) without using indicators.

For each category there were the following scenarios, one showing the normal functionality of the system and a second showing a limitation of the system:

Navigation scenarios

- Normal functionality
- With roadworks

ABS scenarios

- Vehicle braking in good weather with ABS
- Vehicle braking in bad weather with ABS

ACC scenarios

- Slow vehicle ahead
- Sudden cut in

LDW scenarios

- Good weather
- Bad weather

2.5 Analysis of results

The analysed measures are the correct answers of the participants to the questionnaires after the end of each training. We have compared the number of correct and wrong answers in all questions among group A (learning due to the use of a manual) and group B (learning due to the use of the MMT). Then, we have compared the number of correct and wrong answers among group B (learning due to the use of the MMT) and group C (use of MMT and experience in a driving simulator), summing up for each system only the questions that are of relevance for the simulator, namely Q1 and Q6 for ACC, Q2 and Q4 for LDW, Q3 and Q5 for navigation system, Q1 and Q2 for ABS. The chi2 test was used for both comparisons.

The graphs below depict the participants' performance in each question separately. The reason is that we wanted also to analyse also the understandability and usefulness of each question. If the majority of people had failed or respond worse in one question than in the rest questions, this could be due to the phrasing of the question itself, moreover since the training material and the questionnaires were not in the participants' native language.

Country effects were not analysed, as the sample size was very limited, to acquire meaningful results.

3 Results

The percentages of correct answers per system and per group are given below. Significant differences were found for the Navigation system ($p<0.05$, effect size=0.86), where participants in the Manual group answered more correctly than participants in the MMT group and for the LDW system ($p<0.05$, effect size=0.71), where we note the opposite, participants in the MMT group answered more correctly than participants in the Manual group.

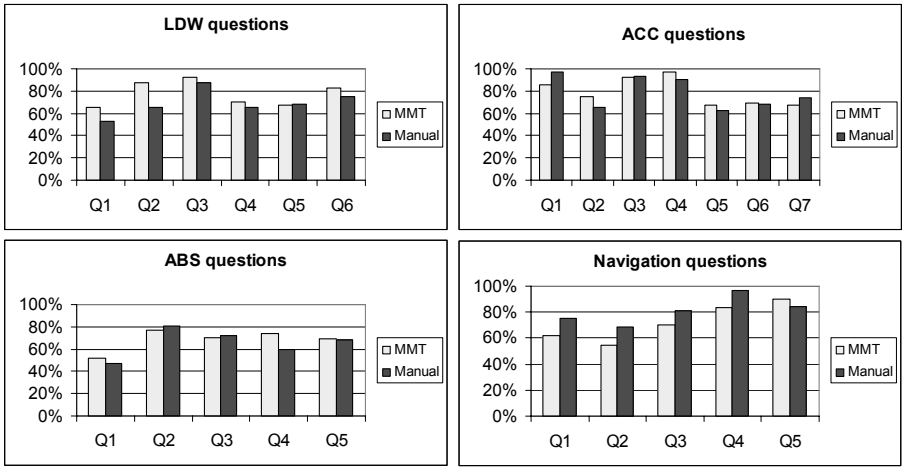

Fig.2. Correctness of answers per system among Groups A and B

No effect of the driving simulator was found for any system, according to the analysis of correct answers in the questions which were relevant to the simulator scenario applied.

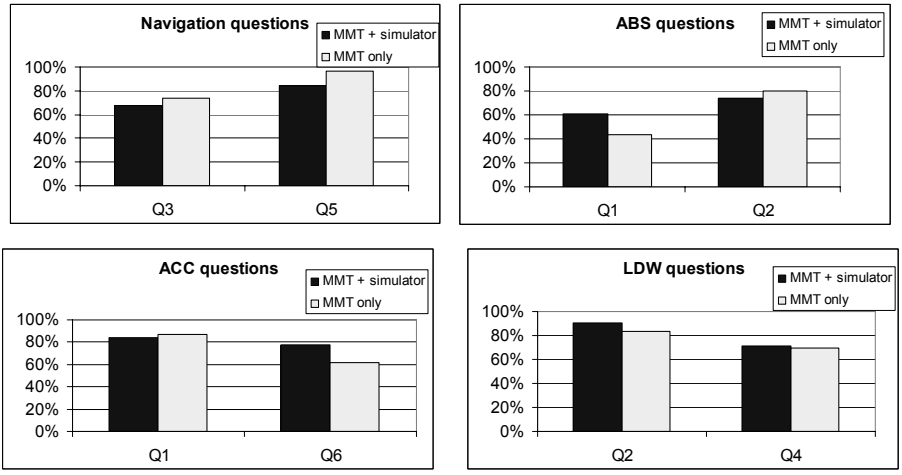

Fig.3. Correctness of answers per system among groups B and C (only relevant questions)

The participants' answers to the question if they think that they have learnt to use the system after the training are given below. The chi2 test was used to evaluate the distribution of answers in each group. Answers were given in a 5 rate scale, surely no: -2, rather no: -1, neutral: 0, rather yes: +1, surely yes: +2. There were effects found for the LDW ($p<0.01$) and for the ABS ($p<0.05$), where in both cases participants in the simulator group are more convinced that they have learnt to use the system than participants in the other two groups. The figure below have derived after we have transformed the qualitative answers into numbers and calculated the mean for each group and system.

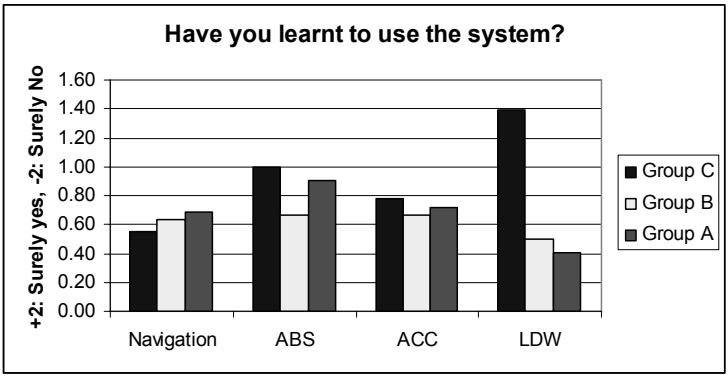

Fig.4. Participants' feelings about learning effectiveness per system among Groups

The participants answers to the question if they think that they need additional training before using the system are given below. There were significant effects found for the LDW system ($p<0.01$), where participants in the simulator group

are more confident that they do not need additional training participants in the other two groups. Effects were also found for the Navigation system ($p<0.05$), where participants in the MMT group are more confident that they do not need additional training participants in the other two groups.

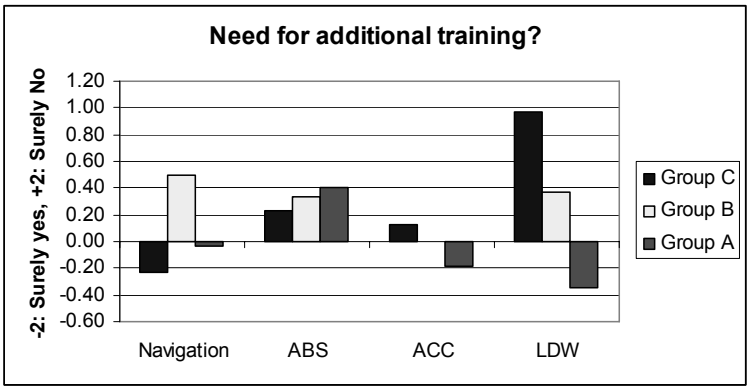

Fig.5. Participants' feelings about need for additional training per system among Groups

4 Conclusions

Compared to training with only a paper manual, the MMT showed advantages in the case of only one of the four systems studied, the Lane Departure Warning system. However, no clear effect of the additional training via the driving simulator on the correctness of answers was found for any of the systems.

However, people trained with both the MMT and the simulator feel better trained in the case of LDW and ABS. Moreover, in the case of LDW, people trained with the MMT and the simulator feel that they need less additional training than the people trained with the MMT only or with the manual.

These results are rather inconclusive as regards the potential of the MMT and of the driving simulator to improve acquisition of knowledge by the participants, as regards the functionalities and limitations of new systems, although positive effects were found for the MMT in one of the four systems. Further development of the MMT and of the scenarios employed in the driving simulator, or selection of different scenarios, showing more clearly the limitations of the system, could lead to higher impacts on knowledge acquisition. The language issue could have also played a role in this.

It must be noted that the evaluation of the training effectiveness was based on number of correct answers in a paper quiz, that is the acquisition of knowledge by the participants was analysed. Results could be different if evaluation was based on actual driving assessment in real road or on simulator, namely if we had analysed the skills acquisition, and if long-term effects could be studied.

Moreover, the sample mainly consisted of people having a university degree, of whom it can be expected that they can easily learn well by only reading a paper

manual. Results could be different if more people with lower educational background were included in the sample.

As a conclusion, we may say that further research is needed, with bigger sample size coming from various educational backgrounds and with analysis of actual driving behaviour, in order to clarify if there is a positive impact from the use of a MMT and of a driving simulator in the training of drivers. Emphasis should be put on analysing possible negative side impacts of these tools, like creation of overconfidence, as possibly implied by the participants' subjective perceptions in the present study.

5 References

[1] Bekiaris, E., Georgopoulos, P., and Mousadakou, A.: 'Multimedia training tool for road safety and traffic behaviour training'. Road Safety training in high schools (6th Grade), Hellenic Ministry of Transport & Communications, April 2006.

[2] Simoes, A., and Nikolaou, S.: 'Deliverable F.2 Inventory of drivers' needs for training regarding ITS according to driving tasks affected'. Report of Task Force F, HUMANIST Network of Excellence, January 2006.

[3] Twisk, D., and Nikolaou, S.: 'Deliverable F.1 Inventory of ITS functionalities according to driving task models'. Report of Task Force F, HUMANIST Network of Excellence, January 2005.

[4] Bekiaris, E., Papakonstantinou, Ch., Stevens, A., Parkes, A., Boverie, S., Nilsson, L., Brookhuis, K., Van Wees, K., Wiethoff, M., Damiani, S., Lilli, F., Ernst, A., Heino, A., and Widlroither, H.: 'Deliverable 3/8.1 Compendium of existing Insurance schemes and Laws, risk analysis of ADA systems and expected driver behavioural changes. User awareness enhancement, dissemination report and market Analysis and ADAS marketing strategy'. ADVISORS Project, March 2001.

[5] Heijer, T., Oei, H.L., Wiethoff, M., Boverie, S., Penttinen, M., Schirokoff, A., Kulmala, R., Heinrich, J., Ernst, A.C., Sneek, N., Heeren, H., Stevens, A., Bekiaris, E., and Damiani, S.: 'Deliverable 1/2.1 Problem identification, User Needs and Inventory of ADAS'. ADVISORS Project, July 2001.