THE DEVELOPMENT OF A COGNITIVE SKILLS TRAINING TO SUPPORT DRIVER EDUCATION: EXPERIMENTAL VALIDATION OF THEORETICAL UNDERPINNINGS

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Summary: Crash numbers of novice drivers are, despite best efforts of all involved institutions, alarmingly high. One central explanation refers to deficits in cognitive skills such as hazard perception, which have a tremendous influence on accident involvement of younger drivers. Conventional forms of driver training have largely failed to build up skills that go beyond a rather descriptive knowledge of how to drive. Computer based trainings (CBTs) are assumed to provide new ways of tackling this problem. There are already CBTs available that address relevant issues and are presumed to be effective. However, their evaluations lack evidence for the superiority of the specific features of multimedia based interventions over other forms of training. This shortcoming, in addition to the fact that all available relevant CBTs have been developed within contexts that differs significantly from European conditions in terms of the "average" driving environment as well as the respective educational schemes, has prompted us to develop a new CBT that is intended to complement the existing driver training program by addressing critical cognitive skills. In a first step, we tested the CBTs theoretical validity by comparing the performance in the training itself between learner drivers and experienced drivers. The results show that experienced drivers achieve higher scores in the CBT. We conclude that our application does indeed address relevant cognitive skills that are associated with driving experience.

INTRODUCTION

Accident statistics reveal an extremely high risk for novice drivers to be involved in traffic crashes, much higher than for experienced drivers. The Organisation for Economic Co-operation and Development (OECD) states that "Traffic crashes are the single greatest killer of persons aged 15-24 in OECD countries, accounting for 35% of all deaths, or approximately 25,000 people annually in recent years." (OECD, 2006, p. 27). Although they represent only 10% of the population, 27% of all traffic fatalities occur in the group of young drivers. In Germany, every fifth road fatality or injury occurs among people aged 18-24, although this group accounts for only one twelfth of the overall population (Statistisches Bundesamt, 2008). Vehicle occupants and motorcyclists represent roughly 91% of road fatalities in this age group, a much higher portion than in any other cohort. It is clear that young, inexperienced drivers are at increased risk on the road and at the same time are also a major hazard for other road users.

One of the reasons of the high accident involvement of novice drivers are deficits especially in driving relevant cognitive skills. There is a vast amount of research pointing to the fact that experience is a major factor in the development of the critical skill of hazard perception (e.g. Crick & McKenna, 1992; Mills, Hall, McDonald, & Rolls, 1998; Whelan et al., 2004). An additional problem is calibration, which is the balancing of task demands and capabilities (Kuiken & Twisk, 2001). Novice drivers often do not perceive and evaluate specific driving situations as being risky (Finn & Bragg, 1986), and at the same time overestimate their driving skills (Matthews & Moran, 1986; Groeger & Brown, 1989). This combination of deficits leads to fatal errors when it comes to adjusting the task demands (speed, following distance etc.) to the resources available.

One of the possibilities to address these issues is computer based training (CBT). The rise of multimedia applications has provided new ways of delivering content to the learner. One of the most important aspects is the possibility to include animated content, be it actual video footage or other kinds of moving pictures. Learner drivers can experience potentially critical situations without actually endangering themselves or others. As there is much more realism to such animated depictions compared to static images in a textbook, this can be considered a true benefit of CBTs. The adaptability of such training to a trainees needs, both in the training in general (e.g. in setting different levels of difficulty depending on pre-test results) as well as in a specific item (e.g. repeating questions when answered wrong, giving feedback depending on answer), constitutes another major advantage over learning from a textbook or following a lecture. Compared to driving simulators, however, CBTs do not rely on expensive equipment, and therefore have the potential to be used by a broad public.

On an international level, there are a few CBTs available that try to exploit these possibilities. Applications like Driver ZED (Blank & McCord, 1998), DriveSmart (Regan, Triggs, & Wallace, 1999) or CDDrives (Cockerton & Isler, 2003; Isler & Cockerton, 2003) employ real life video footage and require the users to answer multiple choice questions, to react to hazards by pressing buttons, or to mark hazardous areas in the scenery. Evaluations of these applications (Fisher et al., 2002; Regan, Triggs, & Godley, 2000) show that there are indeed measurable effects. However, it has to be noted that all those applications were developed and tested in countries where driver education differs fundamentally from most of the institutionalized European driver education schemes, in driving environments that differ significantly from the European context. Therefore, it might prove difficult to directly translate the effects to the European context (at least without further exploration). Additionally, although the available evaluations provide evidence for the general effectiveness of the tools, they are not able to answer questions about the specific potential of multimedia applications, as no comparison is made to non-multimedia types of training. Therefore, we felt the necessity to develop and test a new cognitive training application that addresses these issues. This paper reports on an initial analysis in which a comparison between learner and experienced drivers with respect to performance on the CBT was conducted. Further steps (on which no results will be reported here) include a driving simulator study in which the CBT’s effects are compared to a paper based version (with similar content) as well as a control condition.

MULTIMEDIA TRAINING APPLICATION

Background

Central in the development of the new cognitive training application was the integration of multimedia elements while still staying low cost. To proof that such an application can contribute to driver education, we decided on anticipatory behaviour, and more specifically hazard perception and glance behaviour as relevant skills to address, rather than try to design a complete educational package. We focused especially on the proceduralisation of knowledge that has already been acquired during theoretical lessons, providing a link between those lessons and actual driving. Since there is the need for individual application of the acquired knowledge and skills in contexts close to reality, we wanted to employ a problem based approach when we constructed the multimedia training. Core element should be traffic situations that could be potentially harmful, and in which the driver should act (or stop acting) in a certain way to prevent an accident (which is the problem to solve). The situations should be displayed by exploiting the most obvious advantage of multimedia applications - moving pictures. Rather than just by showing a single image of a ball lying on the street hinting at children that might run across (which is an item out of the German theoretical examination), the criticality of the situation should develop out of its dynamic depiction. In addition, we wanted to employ some form of adaptive (e.g. related to the respective mistake) feedback, to go beyond the character a pure “drill and practice” type of learning (Bodendorf, 1993). This shall help to stimulate a deeper form of elaboration and information processing in the learner driver.

The application

The application consists mainly of three parts: (1) a pre-test on theoretical knowledge, (2) an instructional phase, and (3) the actual training. The pre-test comprises 23 items that are part of the set of questions used in the official theoretical examination in Germany. The main objective of this pre-test is the activation of previous knowledge in the participant. However, data is recorded as a control variable as well. In the instructional phase, the relevance of the training and its contents are expressed. Knowledge that is essential for the successful completion of the training is given, which concerns the operation of the application as well as important previous knowledge connected to the issues the training tries to address.

The actual training uses short clips of traffic scenes, embedded in a Flash environment, to present information. Instead of using real life video footage, we generated artificial animations that in many aspects are comparable to a driving simulating, however with much higher visual quality (see Figure 1 for an example). We chose to do so because that strategy allowed us to have absolute control of any variable we might want to manipulate in the video. The video sequences are 50-70 sec in length. The participants watch them from the driver’s point of view. They are instructed to observe the evolving situations as if they were driving. This experience is supported by a “navigation system” which informs the “driver” about the route (e.g. “turn left”).

Scenes were constructed to reflect various aspects of the driving task. They can be broadly classified in two categories – (1) hazard indicators in vertically distant positions (e.g. something ahead in the driver’s lane) and (2) hazard indicators in horizontal positions (e.g. something on an intersecting road). For situations in which the critical information is placed in a vertically distant position (“information far ahead”), driving scenarios that are displayed include car following situations, passing/overtaking or being overtaken. When the critical information has to be found in a horizontal position (“information left & right”), driving scenarios are again car following situations, but also passing straight through intersections, or turning left or right. The two categories are rather artificial, as usually the hazard indicator only is indicative of a critical situation when put in relation to other information. However, the categories reflect one crucial handicap of novice drivers – the close focus on an area directly in front of the vehicle, neglecting the farther vertical and horizontal areas (e.g. Mourant & Rockwell, 1972).

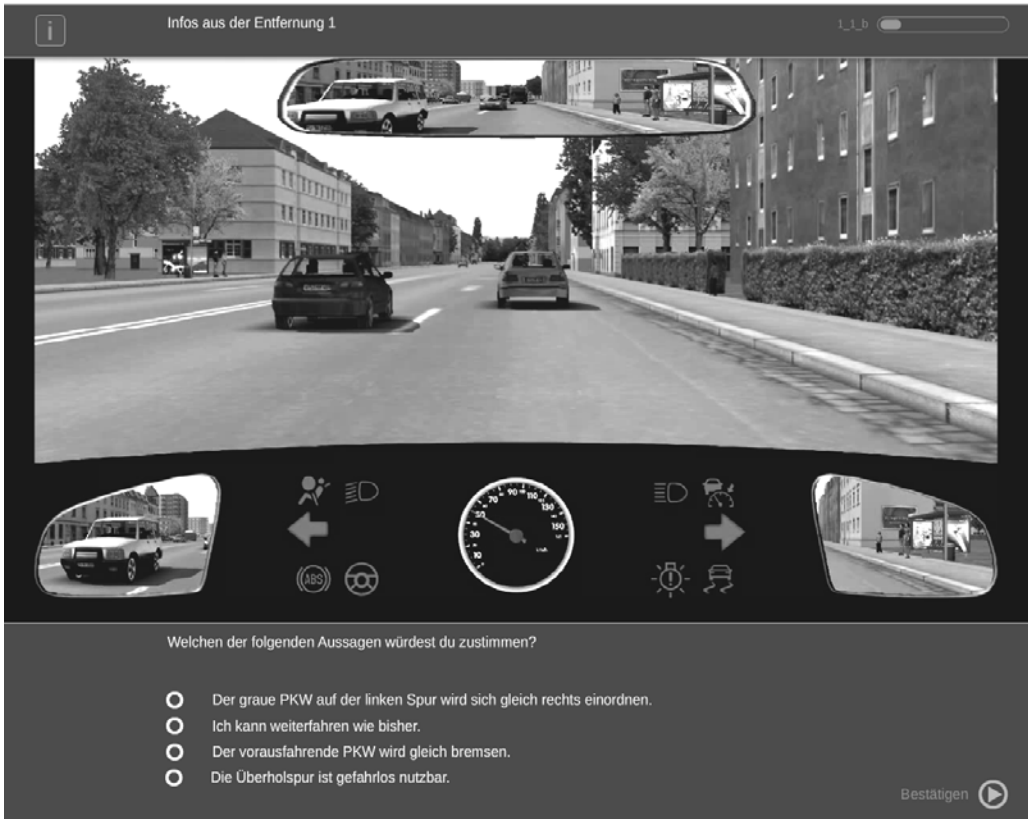

Figure 1. Screenshot out of the training application

Another important aspect of the tool is the repetition of driving situations and potential risks. So, although no specific scene is displayed twice, the elements that constitute the scenes are repeatedly experienced. The training is composed of two different sessions, both containing 13 video sequences. Each of the video sequences contains two or three scenes. The scenes are stopped at various positions and questions are presented. Most questions are in multiple-choice format, some also require the participants to mark certain relevant areas in the stopped video. Depending on whether the given answer is correct or not, participants receive feedback, followed by either the continuation of the sequence or the repetition of the previous segment of the scene (in case of a wrong answer). Questions in the first session vary – they deal with the sole observation of the traffic environment as well as the understanding and prediction of the situations. In the second session, the format is more standardised. Once a scene is stopped, the first question is always: "Is there a need for action?". If so, this is followed by a multiple choice question asking what this action would be, followed by a third question on why this action is necessary. At the end of each session, the CBT gives a general feedback on the participants' performance, highlighting issues that should be addressed in further training.

Experimental validation

In a first step, we tried to assess whether our implementation of a cognitive skills training indeed adresses the deficits of novice drivers that were identified previously. Assuming that the scenes we used fulfill the requirements, one should expect that for novice drivers, the situations depicted in the scenes represent something unfamiliar. In comparison, experienced drivers should already have knowledge (and the respective skills) to deal with situations like the ones presented. Thanks to the question based format of the application, this difference in familiarity or experience with the situations should be reflected in different rates of correct and false answers to these questions. Experienced drivers should, on average, answer more questions correctly than novice drivers.

METHOD

Participants

The learner driver group consisted of students at driving schools. Only students without other licenses previously acquired (e.g. motorcycle) and with a maximum of four practical driving lessons were allowed to take part. We recruited 21 participants (11 female, 10 male) with an average age of 18.1 years (*SD* = 2.5 years) for this group. The experienced driver group was required to have an overall driving experience of at least 20,000 km, and was limited to a maximum age of 30 years. We recruited 21 participants (12 female, 9 male) with an average age of 23.7 years (*SD* = 2.8 years) and an average driving experience of 79,762 km (*SD* = 60,980 km) for this group.

Material

Our main tool was the training application as described above, which was presented on a 19” flat screen. In addition, we administered questionnaires to gather demographic data and find out about the participants motivation, expectations, etc.

RESULTS

As anticipated, the learner driver group reported to expect a higher utility of participation for their own driving skills than the experienced drivers. The theory test yielded no differences between the two groups. We therefore assumed that the groups’ descriptive knowledge about rules and proper behaviour on the road were comparable.

Table 1 shows the relative frequencies of correct answers for the categories “information left & right” and “information far ahead” for the respective training sessions. As mean values show, experienced drivers outperformed learner drivers in any of the categories. Comparisons through t-tests for independent groups revealed significant differences for all category-session-combinations with the exception of “information far ahead” for session 1. Also, when computing one single score for all shown situations (“all scenes combined”) to allow for a statement on the overall performance, we found a significant difference between experienced drivers and learner drivers.

Table 1. Participants' performance (relative frequency of correct answers) in the training application

	Learner drivers		Experienced drivers			
	M	*SD*	*M*	*SD*	*t (df=40)*	*p*
scenes "information left & right" (session 1)	.47	.11	.55	.12	2.277	.028*****
scenes "information left & right" (session 2)	.50	.12	.57	.09	2.138	.039*****
scenes "information far ahead" (session 1)	.48	.11	.50	.11	.793	.432
scenes "information far ahead" (session 2)	.47	.05	.51	.06	2.311	.026*****
scenes "information left & right" (sessions combined)	.49	.09	.56	.08	2.838	.007*****
scenes "information far ahead" (sessions combined)	.48	.06	.51	.07	1.557	.127
all scenes combined	.49	.07	.53	.06	2.433	.020*****

***** $p < .05$

DISCUSSION

The results of our experimental study support the hypothesis that experienced drivers would perform better on the cognitive skills training than inexperienced drivers. This strengthens our claim that the training adresses relevant skills that are fully developed only in experienced drivers. While this result is encouraging, the next logical step is the experimental evaluation of the applications effects on driver behaviour. First results of a simulator study (Petzoldt et al., 2010) point to the fact that there are indeed positive effects of the training compared to a control group without training, as well as in comparison to a group with a paper based training which comprised the same contents as the multimedia training. Taking this into account, it appears that CBTs, given that they are designed to specifically adress learner drivers deficits, and that they rigorously exploit the advantages of multimedia, can be effective tools for driver training.

ACKNOWLEDGMENTS

The research presented in this paper was sponsored by the Bundesanstalt fuer Strassenwesen (BASt; German Federal Highway Research Institute) as project FE82.306/2006 - "Unterstuetzung der Fahrausbildung durch Fahrsimulatoren und Lernsoftware" ("Supporting driver education with driving simulators and computer based training"). The tool used for creating the video sequences included in the multimedia training was provided by TUEV/DEKRA arge tp 21.

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