Transportation Research Part F 17 (2013) 63–74

Contents lists available at SciVerse ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

Calibration as side effect? Computer-based learning in driver education and the adequacy of driving-task-related self-assessments

Thomas Weiss [a,*], Tibor Petzoldt [b], Maria Bannert [c], Josef Krems [b]

[a] Chemnitz University of Technology, Educational Media, Reichenhainer Str. 41, D-09126 Chemnitz, Germany
[b] Chemnitz University of Technology, General Psychology, D-09107 Chemnitz, Germany
[c] University of Wuerzburg, Instructional Media, Oswald-Kuelpe-Weg 82, D-97070 Wuerzburg, Germany

ARTICLE INFO

Article history:
Received 16 August 2011
Received in revised form 23 July 2012
Accepted 21 October 2012

Keywords:
Driver education
Novice drivers
Computer-based learning
Calibration
Self-assessment
Hazard perception

ABSTRACT

To reduce the high risk of young, novice drivers being involved in traffic accidents, there have been several attempts to utilize computers for driver education. Previous studies have shown promising results concerning the benefits of using computers for the acquisition of driving-task-related cognitive skills. However, these studies' findings are inconclusive regarding whether using computers for driver education affects drivers' calibration skills. Underdeveloped calibration skills are considered to be an important reason explaining why young, novice drivers are at a higher risk of being involved in an accident relative to other drivers. To examine the effects of computer-based learning in driver education on drivers' calibration skills, we provided student drivers ($N = 38$) with two different types of learning material (computer-based vs. paper-based, approximately 90 min in duration). Two days later, we presented them with a driving simulator task. Right before the test, the participants were asked to predict the likelihood that they would be able to successfully implement their newly acquired competencies. We chose "anticipatory recognition of hazardous traffic situations" as the learning objective to examine both facets of calibration: accuracy of assessing driving tasks (situational or risk awareness) and accuracy of driving-task-related self-assessments (self-efficacy, state awareness). The analysis of participant's gaze data confirmed our expectation that student drivers who used computer-based learning material would not only detect situation-specific hazard cues sooner but would also demonstrate better comprehension of the information they perceived. Contrary to our expectations, the computer-based learning did not lead to more accurate predictions of test performance. However, it increased the insecurities of the participants, thereby reducing the risk that these student drivers would overestimate their own competence. Because using computers helps student drivers to develop better hazard-perception skills and more defensive self-efficacy expectations, the implementation of computers in driver education is more likely to support safe behavioral patterns in traffic than conventional methods.

1. Introduction

1.1. Accident risk of novice drivers and computer-based learning

The high risk of novice drivers being involved in traffic accidents (OECD, 2006) has resulted in various attempts to optimize driver education. Among other approaches, there has been an emphasis on utilizing computers to facilitate the

* Corresponding author. Address: Tieckstrasse 4, D-01099 Dresden, Germany. Tel.: +49 179 958 6248; fax: +49 371 531 27529.
E-mail addresses: thomas.weiss@phil.tu-chemnitz.de (T. Weiss), tibor.petzoldt@psychologie.tu-chemnitz.de (T. Petzoldt), maria.bannert@uni-wuerzburg.de (M. Bannert), josef.krems@psychologie.tu-chemnitz.de (J. Krems).

1369-8478/$ - see front matter
http://dx.doi.org/10.1016/j.trf.2012.10.001

acquisition of driving-task-related competences (e.g., Regan, Triggs, & Godley, 2000). This effort is based on the assumption that the higher accident risk of novice drivers (when compared to experienced drivers) is largely due to the limited automation of driving routines, which especially in complex traffic situations results in a higher mental workload and decreases available resources (Leutner & Bruenken, 2002). Conventional driver education does not seem to be able to provide the amount of exercise and practical experience being essential for the automation of driving skills. Whereas in theoretical lessons, individual practice is limited to learning activities with a rather low physical and functional fidelity (that is, ecological validity; Wallace, Haworth, & Regan, 2005), the quality of driving lessons in real traffic depends on the representativeness of driving tasks and driving situations that normally arise by chance. Due to these limitations, a systematic proceduralization can only be guaranteed for psychomotor skills (e.g., vehicle handling, steering, shifting gears) on the operational level of the driving task, but not for perceptual and cognitive skills (such as scanning, hazard perception and navigation) on the strategic and tactical level (Anderson, 1982; De Craen, 2010; Deery, 1999; Michon, 1985).

Computer programs may compensate for these shortcomings. By using dynamic representations and interactive elements, they enable learning activities with a comparatively high ecological validity. They can even off the real traffic facilitate encounters with realistic driving scenarios, which is an essential precondition for allowing student drivers to adequately practice driving-task-related skills (Weiss, Petzoldt, Bannert, & Krems, 2009).

A number of studies evaluating computer-based learning applications for driver education have shown promising results concerning the benefits of using computers to acquire driving-task-related cognitive skills (Pradhan, Fisher, & Pollatsek, 2005; Regan et al., 2000; Wang, Zhang, & Salvendy, 2010). However, none of these studies explicitly focused on the specific characteristics of computers or drew systematic comparisons to conventionally designed learning materials. With regard to the development of driving-task-related cognitive skills, conventional learning materials primarily consisted of textbooks, work sheets, diapositives or videotapes. Therefore, no conclusive statement can be made about the specific contribution of computers to improving student drivers' acquisition of those skills.

Furthermore, it has to be taken into account that insufficient acquisition and automation of relevant skills is only one plausible reason for the higher accident risks associated with novice drivers (Engstroem, Gregersen, Hernetkoski, Keskinen, & Nyberg, 2003; Fuller, 2002; Gregersen & Bjurulf, 1996). It has been noted that as the driving task is self-paced, the level of task demands is at least partially under the driver's control. By reducing speed or increasing headway, novice drivers have the opportunity to decrease task demands and adjust them to the lower degree of automated driving to which they are accustomed (De Craen, Twisk, Hagenzieker, Elffers, & Brookhuis, 2008). The adaptation of behavior based on the comparison between a person's capabilities and the demands of the current task is called *calibration* (De Craen et al., 2008; Hacker, Bol, & Keener, 2008; Mengelkamp & Bannert, 2010; Mitsopoulos, Triggs, & Regan, 2006). Novice drivers tend to drive at higher speeds and with shorter headways than experienced drivers, indicating inadequate calibration (De Craen et al., 2008; Engstroem et al., 2003). Empirical findings suggest that novice drivers are, in fact, less adequately calibrated than experienced drivers and that novice drivers are overconfident rather than insecure (Davidse, Vlakveld, Doumen, & De Craen, 2010; De Craen et al., 2008; Horswill, Waylen, & Tofield, 2004). Because inadequate calibration and overconfidence, in particular, are associated with a greater risk of being involved in traffic accidents (Brown & Groeger, 1988; De Craen et al., 2008), an estimation of the effectiveness of computers in driver education has to include the examination of this method's possible effects on the *adequacy of driving-related calibration*, which was the goal of the present study.

Both age- and experience-related factors have been shown to be responsible for the poor calibration of young, novice drivers (Deery, 1999; Vlakveld, 2005). In our study, we mainly focused on the effectiveness of innovative learning material for driver education and thus on the facilitation of adequate (learning) *experiences*. Therefore, age-related factors (such as lifestyle, aggression, sensation-seeking or risk-acceptance) will not be discussed in this paper.

1.2. Calibration, self-assessments and computer-based learning

The adequacy of one's driving-task-related behavioral adaptations (calibration) depends on one's ability to correctly assess driving tasks (resulting in the development of situational or risk awareness; Davidse, Vlakveld, Doumen, & De Craen, 2010; Horswill & McKenna, 2004) and accurately self-assess one's individual capabilities (resulting in state awareness; Davidse et al., 2010; De Craen et al., 2008; see Fig. 1). Thus, an inadequate calibration can be the result of insufficient risk awareness, insufficient state awareness or both. Because empirical findings indicate that experienced drivers outperform novice drivers with respect to both facets of the calibration process (De Craen et al., 2008; Deery, 1999; Horswill & McKenna, 2004; Kuiken & Twisk, 2001), both of these facets should be considered when testing the possible benefits of using computers to educate student drivers.

Students' development of driving-task-related cognitive skills (such as scanning, hazard perception and anticipation) has already been shown to benefit from computer-based learning environments (Pradhan et al., 2005; Regan et al., 2000). It is not yet clear whether this is attributable to the application of innovative didactic strategies rather than to the inherent characteristics of a computer-based education. However, students' improved cognitive skills should accompany an improved assessment of driving tasks (risk awareness) and indirectly contribute to the quality of calibration (McKenna, Horswill, & Alexander, 2006).

To understand the possible impact of computer-based learning on the accuracy of self-assessments, it is helpful to consider the nature of self-assessments and the way they are generated. Self-assessed (subjective) skills are the result of experience- and theory-based metacognitive judgments (Koriat, Nussinson, Bless, & Shaked, 2008). Therefore, these skills are not