Accident Analysis and Prevention 51 (2013) 112–119

Contents lists available at SciVerse ScienceDirect

Accident Analysis and Prevention

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

Assessment of driving expertise using multiple choice questions including static vs. animated presentation of driving scenarios

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ARTICLE INFO

Article history:
Received 19 July 2012
Received in revised form 12 October 2012
Accepted 2 November 2012

Keywords:
Novice drivers
Expertise
Driving assessment
Multiple choice
Animations

ABSTRACT

Novice drivers have a high collision risk compared to more experienced drivers. The optimization of driving assessment's validity should lead to a better identification of those examinees that need further training before solo driving. The aim of the present two studies was to find out whether the integration of animated traffic scenarios can enhance some quality aspects of selected multiple choice items of the official German driving test. For the first study, we developed a static version of a set of multiple choice questions each containing a computerized still picture of a traffic scenario and a dynamic version that included animated instead of still pictures of the same situations. Driving novices ($n = 57$) and experts ($n = 63$) were presented 22 items either in the static or in the dynamic version. Only the novices benefited from the dynamic presentation. Fifty novices and 50 experts participated in a second longitudinal study including three measurements with parallel tests of the dynamic testing materials at intervals of three to four months. The novices, who were currently attending driving school, improved over time whereas the experts' performance remained stable. The results indicate that animation has positive effects on some quality aspects of driving assessment, but the problem of low criterion validity has to be addressed by the means of further approaches.

1. Introduction

In spite of the constantly decreasing number of accidents in road traffic, the accident risk for novice drivers still turns out to be rather high in the beginning phase of solo driving (e.g. Schade, 2001; Lee et al., 2011). A peak of accident risk can be detected within the first six months after getting one's driver's license (Sagberg, 1998; Mayhew et al., 2003). The risk of having a driving accident declines asymptotically within the first two years of solo driving and then reaches a constant level, which remains independent from further driving experience (Schade, 2001). This trend can be interpreted as a learning curve, which manifests itself in the accident liabilities of beginner drivers of every age (Maycock et al., 1991). This fact confirms the hypothesis that driving expertise evolves through experience and is rarely related to the age of an individual. One possibility to face the problem of inexperienced drivers committing fatal crashes could be seen, for example, in optimizing the driving test. Making the driving test more reliable and valid can help to identify those candidates, who are not yet skilled enough to drive safely (Malone et al., 2012). In order to create such valid tests, two demands have to be met: The items should represent contents that are considered to be relevant for driving safely, and the acquisition of the chosen contents has to be assessed appropriately by the means of representative tasks. The identification of some quantifiable aspects of driving expertise, that can explain why some individuals have a higher accident risk than others, is essential in road safety research (Horswill and Mckenna, 2004).

The German driving test is composed of two parts: a theoretical test, which mostly includes multiple choice questions about traffic-related factual knowledge, and a practical test, which consists in guarded driving in real traffic. First efforts have already been made in order to improve some aspects of the theoretical driving test. One attempt, that was realized stepwise from 2008 to 2010, was the adaption of the former paper pencil test to computer based assessment. Presumably, this development will foster objectivity and reliability of the test due to standardized procedure and evaluation. In addition, however computer based assessment might offer some advanced possibilities. One of those is the integration of innovative presentation modes (e.g. animations), which is the feature under investigation within the present study. Based on the described developments, the aim was to investigate whether animated information presentation can improve some quality aspects of the theoretical driving test. The following considerations about some findings of expertise research as well as learning and testing with new media provide a basis for hypothesizing what kind of improvement can be expected from the introduction of animation if multiple choice testing as response mode is conserved.

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0001-4575/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.aap.2012.11.003

1.1. Expertise research and its implications for driving assessment and education

The usual topic of expertise research is extraordinary performance of individuals – the so-called *experts* – in a given domain (Ericsson and Charness, 1994). Further to this understanding of expertise, Dreyfus and Dreyfus (1986) emphasize the ability of expertise concepts to explain skill acquisition in everyday processes such as driving. Ericsson and Lehmann (1996) link expertise development to the process performed by individuals to adapt themselves to adequate fulfillment of everyday task constraints. Therefore, the findings of general expertise research should be reviewed in order to find out whether they can provide a basis for the generation of hypotheses concerning the characteristics as well as the development of driving expertise.

Accident statistics reveal that there definitely are some differences in accident liability which trace back to the drivers' differences in expertise. The key question is which factors contribute to the high accident risk of beginner drivers. Expertise research in the domain of car driving can help to identify these relevant aspects of driving and to find out how to assess them validly. Knowing important skills will potentially help to reduce the beginners' risk in two different ways. On the one hand, education and training can be optimized by focusing on the contents and the skills that have been empirically proven to be essential for driving expertise. An optimized training should result in a good preparation of the beginner drivers for their first time of solo driving and lead to a lower accident liability during that high risk period. On the other hand, driving assessment can be optimized by including tasks which are related to the identified skills. This should have a positive effect on the test's ability to identify those applicants that lack important knowledge and skills, and therefore, need further training.

A basic assumption of the concept of expertise is the existence of a wide difference between expert and novice performance in the experts' favor in a certain domain (Glaser and Chi, 1988). An extensive and well-organized domain-relevant knowledge base is considered to be essential for expertise in a particular domain (e.g. Bédard and Chi, 1992). In some skill acquisition models, the acquirement of factual knowledge is often regarded as the basic phase which is followed by other stages including a transformation of factual knowledge into procedural knowledge (cf. Fitts and Posner, 1967; Anderson, 1982; Rasmussen, 1986). According to this, it is expected that the acquisition of domain-relevant factual knowledge should be essential in the domain of car driving, too. Empirical evidence for this assumption has not been adduced, yet. Although in most domains, there is a strong positive correlation between knowledge and performance, in some domains this relationship might not be that clear. Particularly in many sports, knowing how and when to do a certain action does not necessarily end in correct execution (Thomas and Thomas, 1994). The other way around, there might be automated and routine tasks that can be performed well without having much conscious factual knowledge about the process.

Besides theoretical concepts and empirical findings, methodical approaches used in expertise research can be helpful in order to test whether there is a relationship between expertise and factual traffic knowledge or not. One methodological paradigm, often being used in empirical expertise research, includes comparisons between experts' and novices' action and performance in selected tasks (Gruber, 1994). This contrasting approach can be used in order to reach two different objectives: On the one hand, expert-novice contrasts are appropriate to study what expertise is like in a domain, and, on the other hand, they indicate attributes of adequate test items that are able to reveal the difference in expert and novice performance. The latter can serve as proof of criterion validity of the applied test.

Beyond the cross-sectional approach, longitudinal studies that trace the novices' development seem fruitful in order to understand the nature of expertise in a certain domain. In the domain of car driving this methodological approach could help to investigate whether the gathering of factual knowledge is restricted to the first stage of expertise development.

In order to conduct cross-sectional or longitudinal studies in the field of expertise research, it is indispensable to determine an appropriate quantitative criterion to separate experts and novices. Whereas Simon and Chase (1973) found in their studies with chess players that chess masters had at least ten years of experience in their domain, Ericsson et al. (1993) stated, that the so called "10-year rule" applies to many other domains and can be considered generally as the time amount "of preparation to attain international-level performance" (p. 366). In contrast to this high requirement, we considered minimum two years of solo driving to be sufficient to achieve a critical level of expertise in the domain of car driving. During the first two years of independent driving, the beginner drivers' risk of being involved in a road collision, decreases to a low level (for Germany cf. Schade, 2001). Identifying real beginners is less challenging. Individuals who are at the very beginning of their driving education, and, hence, do not possess any experience in independent driving, can be considered as novices.

1.2. Learning and testing with new media: the roles of expertise and presentation mode

The multiple-choice items of the German official theoretical driving test are criticized (Sturzbecher et al., 2008). The improvement of the theoretical test, while maintaining multiple choice as response mode, is pursued by the additional integration of dynamic presentations of traffic scenarios for each item. Thus, it should be of value to formulate hypotheses about the effects of the introduction of animations.

The application of dynamic presentations seems promising in the domain of car driving. The enhancement of ecological validity can be expected, because animated presentations of traffic scenarios appear more realistic than static pictures. Animations offer impressions of traffic scenarios that are quite similar to the impressions while driving in real traffic: It is not required to infer motion from a text or a static image but movement is perceived directly. According to Salomon (1979), animations offer the opportunity to compensate the novices' limited capability to imagine movements from static representations. Since there have been few researches in the field of assessment by the means of dynamic materials, making use of the findings of the research concerned with learning with dynamic vs. static presentations should be helpful. According to a review of Tversky et al. (2002), dynamic presentations failed to live up to the expectations. If studies revealed any advantages for learning with animated learning materials, these gains could not be attributed to the dynamic presentation mode itself but occurred as a result of the associated availability of additional information. Höffler and Leutner (2007) conducted a meta-analytic study with 26 primary studies that included comparisons of dynamic vs. static studying materials. Comparisons were only included in the meta-analytic study, if the static and the dynamic materials provided the same content information to the learners. The authors intended to identify those conditions that determine whether dynamic displays are more advantageous for learning than static ones. Overall results indicate a moderate advantage for learning, if dynamic presentations are used. The authors emphasize the kind of contents to be crucial: high effect sizes could be found if procedural-motor knowledge had to be developed. These results speak for the application