ALTERNATIVE AVENUES IN THE ASSESSMENT OF DRIVING CAPACITIES IN OLDER DRIVERS AND IMPLICATIONS FOR TRAINING

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ABSTRACT

The population aging, combined with the overrepresentation of older drivers in car crashes, engendered a whole body of research destined at finding simple and efficient assessment methods of driving capacities. However, this quest is little more than a utopian dream, given that car crashes and unsafe driving behaviours can result from a plethora of interacting factors. This review highlights the main problems of the current assessment methods and training programs, and presents theoretical and empirical arguments justifying the need of reorienting the research focus. Our discussion is elaborated in light of the fundamental principle of specificity in learning and practice. We also identify overlooked variables that are deterministic when assessing, and training, a complex ability like driving. We especially focus on the role of the sensorimotor transformation process. Finally, we propose alternative methods that are in-line with the recent trends in educational programs that use virtual reality and simulation technologies.

Keywords: Driving, Elderly, Assessment

The current population aging, which is expected to reach a peak in the next decades, is unprecedented, and this situation brings many social, economic and political issues to the table. In developed countries, where automobiles are the primary transportation mode, one important issue arises from epidemiologic data showing that drivers over 65 are more often involved in road crashes than any other road users (United States Census Bureau, 2007). Of course, this observation emerges when data are analyzed on a per mile driven basis. Because road safety is an important public health issue, authorities are in need of proper solutions to face the imminent demographic age shift. This challenges road safety researchers as it requires finding sensible and specific tests that efficiently predict the driving performance of older road users. Unfortunately, as Bédard, Weaver, Darzins, and Porter (2008) state, “we are not there yet”.

There are important problems with the current assessment methods of driving capacities, and by extension, with the training programs that emerge. A whole body of research focuses on finding a “gold standard” test, one that is easy to administer and that has a great predictive value of driving performance. We argue that no single measure taken in isolation can predict driving outcome in a satisfying manner The central focus of the paper is to promote the virtues of a preventive approach where the driving simulator could be used to keep older individuals behind the wheel longer without compromising road safety. The beneficial role of the simulator in the assessment mostly resides in its ability to directly highlight risky behaviours and allow their alterations by practicing and reinforcing the appropriate ones.

TESTING BASIC SENSORY AND COGNITIVE FUNCTIONS

It is worth mentioning that we do not deny the importance of screening older drivers' basic sensory and cognitive functions. Several studies have shown that aging affects vision, attention, memory, and executive functions. In addition, we recognize that other studies also established a relation between each of these functions and driving performance (Anstey, Wood, Lord, & Walker, 2005). However, despite the fact that testing these isolated functions may be helpful as a first screening step, such measures are prone to a lack of sensitivity (i.e. fails to detect at-risk drivers) and specificity (i.e. identifies good drivers as being at-risk) (e.g. Bedard et al., 2008; Bohensky, Charlton, Odel, & Keeffe, 2008). Indeed, normal sensory and cognitive functions do not guarantee safe driving, and below normal functions do not necessarily result in improper driving.

For example, screening for visual acuity is important because, below a given threshold, it is impossible to achieve safe driving (e.g., obviously blind individuals cannot drive safely). Even individuals with healthy vision can sometimes experience how difficult it is to drive when visual information is blurred (e.g., heavy snow falling or rain shower). However, over that threshold, can visual abilities really discriminate between good and bad drivers? And what is the cut-off point? To the first question, Bohensky et al. (2008) say no. They found that static tests of vision are not good predictors of older individuals' driving capacities. Regarding the second question, the same authors conclude that the boundaries set to discriminate between adequate and inadequate visual function for driving are difficult to establish given, notably, the important individual differences in the ability to compensate for visual deficiencies, and the conflicting scientific evidence relating vision testing policies and crash risk reductions in older drivers (Bohensky et al. 2008).

Similar issues arise when it comes to screening for cognitive functions. Remarkably, little is known about the neural underpinnings of the cognitive control of driving. Neuropsychological tests provide important information on functions that are necessary to drive a vehicle and there are links between poor performance on such tests and poor accident records among a sample of elderly male drivers (Daigneault, Joly, & Frigon, 2002). These tests, however, lack sensitivity and do not provide hints on training programs that could be used for helping those drivers still able to drive.

Other in-laboratory tests that are thought to represent more adequately the constraints of driving recently gained in popularity. For example, Owsley, Ball, McGwin, and colleagues (1998) have investigated the efficiency of a Useful Field of View (UFOV) test. The UFOV is defined as the area over which a person can extract information in a single glance without moving the head or eyes. By adding distractors or a secondary task, this test investigates more complex attentional processes as well as visual functions. The statistical association between UFOV performance and various measures of driving safety, notably on-road and in-simulator performance, and state-recorded crashes has been demonstrated (Clay, Wadley, Edwards, Roenker, & Ball, 2005). However, as Bédard et al. (2008) recall, statistical significance and predictive value are different notions. Through a ROC curve analysis, these authors showed that, despite a statistically significant association between UFOV and driving performance, the predictive value of UFOV on driving outcome is relatively poor, with respect to both specificity and sensitivity.

The association between UFOV and driving is difficult to interpret, and provides little information on the nature of the processes involved in driving. Firstly, by definition correlation does not allow for any causal inference. Secondly, we have to keep in mind that, in the end, car crashes directly result from either omission or inappropriate motor actions. Therefore, many variables are in play and the exact cause of UFOV-related crashes remains unclear. Our model emphasizes the fact that some crashes follow an error in the sensorimotor transformation process, leading to the selection of inappropriate motor responses or to the omission of required motor responses (e.g., confounding the brake pedal with the accelerator, not looking at the blind spot when a left deviation is required).

There might somehow be a link between visual attention and sensorimotor transformation abilities. Although the UFOV test is designed to assess visual attention capacities, it is possible that impairment of the attentional component also results in sensorimotor transformation impairment, since attention, sensory processing and motor control are closely related. For instance, results from studies on motor control suggest that balance control is affected by the attentional demands imposed by external tasks and that this is especially true in older people (for a review, see Woollacott & Shumway-Cook, 2001). Thus, it is possible that the UFOV test highlights attentional impairments that translate into the sensorimotor domain.

THE CENTRAL ROLE OF SENSORIMOTOR TRANSFORMATIONS

Handling an automobile vehicle is a good example of a situation that requires a constant transformation of multisensory information into appropriate motor actions. To accomplish such a task, the brain needs to extract and integrate spatio-temporal information streaming from various sensory channels (vision, proprioception, vestibular and timing systems) and based on this array of information, it performs appropriate sensorimotor transformation in order to select appropriate motor actions. Sensorimotor transformations are automatic and are used for directly mapping sensory events into movements. It needs not to be confused with cognitive processing and conscious motor planning. For example, when approaching a red light, the driver's behaviour is not only determined by the ability of the visual system to correctly detect and interpret the signal, or on a conscious interpretation of the situation. It mainly depends on the ability of the brain to automatically select and command the appropriate motor action given that red light.

In the driving literature, many cases of "pedal error" involving older drivers were reported (Cantin, Blouin, Simoneau, & Teasdale, 2004), highlighting the importance of adequate sensorimotor transformations. In such cases, older drivers' perceptions and cognitive processing of the driving situation is generally correct, but an inappropriate motor response is selected (i.e., pushing on accelerator instead of the brake pedal), leading in some cases to fatal crashes.

In addition to pedal error cases, there are more general reasons to believe that the sensorimotor transformation process is affected by aging. Notably, the observation of pervasive age-related declines in the motor and sensory domains and the observation of reduced abilities at executing visuo-motor transformations (Baugh & Marotta, 2009). Nevertheless, the effect of aging on the processing stage that links sensation to action is not that clear and more research is needed in order to understand its nature (Baugh & Marotta, 2009).

However, we do not rule out the importance of the perceptual stage given the fact that some crashes occur because older drivers do not perceive the risk or do too late to generate the appropriate response (Hakamies-Blomqvist, 1993). Rather, we insist on the fact that it cannot account for all crash-related behaviours and that including the transformation component would be a step forward in better understanding the causes of crashes.

TRAINING AT-RISK DRIVERS' ABILITIES BEHIND THE WHEEL

One fundamental principle of human learning is that humans, with practice, can generally improve on specific tasks. It is thus not surprising that most isolated functions identified as potential contributors to driving abilities benefit from specific training (Marmeleiraa, Godinho, & Fernandes, 2009). However, the ability to translate isolated sensory improvements into safe driving is questionable.

As already mentioned, driving implies complex sequences of actions in response to various sensory stimulations. However, learning complex behaviours or sequences of actions implies learning the dynamics between the different portions of the sequence. It was showed that practicing isolated segments of a complex sequence of actions is not an optimal strategy, since it does not allow learning the dynamics between the segments (Ahmed & Wolpert, 2009).

According to a practice specificity approach, if the benefits are to transfer on the road, they must be acquired in a driving-specific context. Indeed, the best training conditions are those allowing the learning of the same underlying processes that will be used in the transfer task (Schmidt & Lee, 2005). That is, a driving training program should involve conditions that are as close as possible from the driving conditions. The practice specificity approach of learning has strong empirical basis (Schmidt & Lee, 2005) and its efficiency has been demonstrated in both motor (Wolf, Winstein, Miller, & al., 2006) and cognitive rehabilitation programs (Calvanio, Levine, & Petrone, 1993).

Other arguments against training programs targeting isolated sensory functions come from research on novice vs. expert differences in sports, showing that performance on isolated sensory functions tests do not account for sports performance differences (Abernethy & Woods, 2001). The efficiency of generalized training programs targeting basic sensory functions to improve sports performance have also been questioned (Aberndthy & Woods, 2001). These finding are not surprising, since it is a fundamental principle of motor learning that specific skills cannot be acquired via a generalized form of training.

Recent research on the efficiency of virtual reality (VR) and simulation-based education programs also support this practice-specificity view. Notably, in a recent review, McGahie, Issenberg, Petrusa, & Scalese (2009) identified 12 features associated to the best practice of simulation-based medical education methods. Simulation fidelity and transfer to practice appeared amongst the most important features. In the same line, Tichon (2007) reports that the transfer of cognitive skills acquired in a VR environment depends importantly on the realistic character of the scenario. McGahie et al. (2009) and Tichon (2007) also both highlight the importance of providing trainees appropriate feedback about their performance, based on objective behavioural measures of performance collected during the training.

With regards to driving skills, recent literature reviews (Hunt & Arbesman, 2008; Korner-Bitensky, Kua, von Zweck, & Van Benthem., 2009) provided inconclusive evidence regarding the effectiveness of interventions targeting isolated sensory functions such as the Useful Field of View training or home exercise programs. Although, some programs using a multi-faceted approach combining physical conditioning and driving education seem capable of moderately improving driving abilities (e.g. Marottoli, Allore, Araujo, et al., 2007), Hunt and Abersman (2008) conclude that learning and retraining driving skills may best be accomplished when learning occurs while actively performing the driving task. Indeed, only the driving task itself can be inclusive of the plethora of sensory-motor functions involved in driving; moreover, consistent with the practice-specificity approach, in this context, sensorimotor transformations are needed and can likely be trained. There are behavioral and neurophysiological support for this suggestion. For instance, cerebellar activity is largely absent when actions are imagined compared to when subjects execute action sequences (Nair, Purcott, Fuchs, Steinberg, & Kelso, 2003), and neural networks during real and imagined movements are not identical (Kilner, Paulignan, & Boussaoud. 2004). This line of research highlights why new and adapted ACTIVE and DRIVING specific training programs are urgently needed to improve driving skills. If inadequate eye-head coordination precedes a driving error (for instance, before a left turn), corrective feedback for this specific action and practice are needed if a decrease of such errors is to be achieved. Currently, Hunt and Arbesman (2008) noted that only a few training programs have been designed to target driving-related behaviours.

Several aspects of driving cannot be optimized in conventional classroom oriented programs. General driving information or 'watch how to do it' procedures are not sufficient to change driving behaviors. The work of Romoser and Fisher (2009) is certainly an important step forward with that regard. Indeed, these authors showed that compared to a passive classroom training, a group of older drivers receiving active simulator training with respect to potential threats at intersections showed an increased likelihood of looking for such threats.

Since individuals who need training are the same that achieve unsafe driving behaviours, it is difficult to provide them with a safe driving context in which they can train these functions. Using a simulator represents a safe way to do so, minimizing the risks while recreating a fairly realistic driving environment (Figure 2). The validity and reproducibility of in-simulator assessment have been proven, and compared to a naturalistic approach, has the advantage of being safer, easier to set up and potentially less costly (Bédard et al., 2010). It has also been demonstrated that what is learned in a driving simulator can be transferred on the road (Wachtel, Romoser, Fisher, Sizov, & Mourant, 2005; Romoser & Fisher, 2009). A promising method of training resides in giving participants driving-specific feedback about their performance and encouraging them to practice and adopt good driving habits, which can include adapted visual screening strategies, better attentional allocation policies, and efficient mnemonic strategies. Specific feeedback also has the advantage of reinforcing proper sensorimotor transformations and allowing the creation of an appropriate mapping between visual inputs and motor outputs. Such in-simulator training is consistent with the practice-specificity approach of learning and is in line with recent ideas regarding the efficiency of stimulator-based and VR education programs. Moreover, in-simulator training is an inclusive approach, allowing a broad range of perceptual and motor functions to be trained, along with important driving-related cognitive skills, that are beyond sensorimotor transformation abilities (e.g., navigation, actions planning, etc.). Finally, it permits practicing the dynamics of the sequences of actions involved while driving a car, thus amplifying the chances of learning transfer.

CONCLUSION

To summarize, we strongly believe that the hallmark of near-optimal driving behaviour depends on the ability of the brain to transform multisensory inputs into appropriate motor actions. Many of the tests that are currently used to identify at-risk drivers target isolate basic sensory functions. Although some of these functions are statistically related to driving outcomes, they are simply too reductionist in their approach. In order to embrace the totality of the multisensory flow of information that the perceptual systems have to deal with when driving, some overlooked variables should be added to the picture, notably, the vestibular function and time perception abilities. More importantly, tests should focus on sensorimotor transformations linking these percepts to appropriate actions.

The task that best reflects driving constraints and its related sensorimotor transformation component is obviously driving itself. With regards to safety issues, in-simulator observation could be the optimal way to understand the causes of crashes. It also seems the best way to target the problematic components of driving behaviour and to plan an appropriate, task-specific training. By achieving the training in a driving-specific context, the sensorimotor transformation component is directly addressed, along with a broad range of driving-specific perceptual demands.

We believe that a change of focus is needed and that the adoption of such a practice-specific approach, that envelopes sensation with action processes would be a step forward to keeping older adults behind the wheel longer without compromising road safety.

RECOMMANDED READINGS

Cantin, V. Lavallière, M., Simoneau, M., & Teasdale, N. (2009). (see references). This article represents a good example of in-simulator research, focussing on driving context-specific measures.

Schmidt R.A., & Lee, T.D. (2005). (2005). (see references). Chapters 9 and 10 of this book offer a complete discussion on the topic of specificity.

Bédard, M., Weaver, B., Darzins, P., & Porter, M.M. (2008). (2008). (see references). This article provides a statistical demonstration of the weak predicting value of traditional visual tests in driving assessment.

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