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The relation between performance in on-road driving, cognitive screening and driving simulator in older healthy drivers

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ABSTRACT

As people age, physical and psychological functions deteriorate which is associated with higher crash risk. In different countries traffic authorities developed screening systems to identify unsafe older drivers. However, until today these screening systems (medical check, road test, cognitive screening) failed. In this context, driving simulators could be helpful in measuring driving performance under controllable and replicable experimental conditions in near-crash situations. However, little is known about the relation between older drivers' performance in an on-road test, cognitive screening and driving simulator performance. In this paper we examined the relation between these three driving related measures in a sample of older participants (mean age = 72.12 yrs.). The results show that performance in an on-road test and the performance in the cognitive tests explained 50% of the variance in the driving simulator performance ($r = .71$). The current analysis indicates that driving simulator data represents on-road driving behaviour and cognitive performance of older drivers. This research presents a substantial potential for driving simulators, for example identifying or retraining unsafe older drivers.

1. Introduction

1.1. Older driver and driving safety

Older adults are the fastest growing driver segment in industrial countries in the next ten years. For 2020 it is estimated that between 33 and 38 million, or 25% of older drivers will be part of the driving population in the US. Highest fatality risk is found in driver aged 80 and older and their involvement is estimated to increase by 155% by 2030 (Lyman, Ferguson, Braver, & Williams, 2002). Nevertheless an increase of fatality risk in older drivers has not been observed. Cheung & McCartt, 2011 showed that fatality risk in drivers aged 75 and older per 100,000 licensed drivers was higher than for drivers aged 35–54 over the period from 1997 to 2008. Interestingly, in the same period the reduction of fatal crash risk in the group aged 80 and older was greater than for the group aged 35–54. Environmental improvements in an emergency, vehicle and traffic safety

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systems (Cheung & McCartt, 2011) lead to the reduction of injured older drivers due to higher frailty (Li, Braver, & Chen, 2003).

Comparison of age dependant crash risk is difficult because the vehicle, exposure, situation and, the most complex, the drivers' behaviour differs in age groups and influence the crash risk (Classen et al., 2007). But physical and psychological functions deteriorate with age and are associated with an increased crash risk in older drivers (Anstey, Wood, Lord, & Walker, 2005; Emerson et al., 2012). Therefore screening systems were developed to identify unsafe older drivers. A recent published study highlighted that so far the screening systems which used medical check-ups, on-road tests and cognitive screenings fail to enhance traffic safety. In the observed time period there was no reduction in fatality of older drivers but an increased involvement in unprotected older road users (Siren & Meng, 2012). Thus, coping with age-dependent decline in driving performance continues to be a substantial challenge for the community (Dobbs, 2008). Therefore it will be of outmost importance to develop techniques and strategies to identify unsafe drivers while keeping traffic safety (Dawson, Uc, Anderson, Johnson, & Rizzo, 2010). As driving cessation reduces well-being in old age (Fonda, Wallace, & Herzog, 2001; Marottoli et al., 2000) there is also a need to develop strategies to maintain driving performance in older drivers (Roenker, Cissell, Ball, Wadley, & Edwards, 2003).

1.2. Driving performance and cognitive performance

Typical age-related changes in driving performance are caused by declines in sensory (vision and auditory), cognitive and physical abilities (Baldock, Thompson, & Mathias, 2008; Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Edwards, Bart, O'Connor, & Cissell, 2009; Owsley & Ball, 1993; Owsley et al., 1998). So far a vast number of computer-based cognitive tasks have been designed to assess driving performance. As mentioned before, the usability of these tests in identifying older unsafe drivers remains uncertain. They disagree from each other and there is either a lack of cut-off scores, or sensitivity and specificity to identify unsafe drivers are unknown (Langford & Koppel, 2006; Mathias & Lucas, 2009; Poschadel et al., 2012). Furthermore there is also a lack of reliable and valid standardized data from on-road assessments reflecting driving performance especially in old age (Selander, Lee, Johansson, & Falkmer, 2011). Therefore some researchers propose a multi-tiered assessment including on-road tests and cognitive tests as well as driving simulator settings (Langford et al., 2008; Lees, Cosman, Lee, Fricke, & Rizzo, 2010).

Risser et al. (2008) analysed the relation between an on-road test and the performance on a computer-based cognitive test battery in a sample of young and middle-aged drivers. The cognitive measures are mathematically combined to one composite measure, which was, based on a trained artificial neural network (logistic regression approaches), statistically related with the on-road test. They identified six cognitive tests (selective and divided attention, field of view, perceptual speed, physical motor speed and fluid intelligence) explaining 50% of the variance in the on-road test (Risser et al., 2008). However, a further study found only weak correlations between cognitive tests and two different on-road tests. Only the UFOV was significantly correlated with both on-road tests with a maximal variance of 21%. The authors of this study argue that the lack of validity and reliability of the on-road test driving measures are pivotal for the weak correlation (Selander et al., 2011).

Mathias and Lucas (2009) focused in their meta-analysis on the relation between age dependent decline in cognition and driving performance. Performances in different cognitive tests were related to driving performance in on-road driving, simulator driving and driving offences. Only test scores of UFOV test met their study criteria for predicting older drivers driving performance. The predicting variance of the UFOV was 43% for the on-road driving performance, 36% for the simulator performance and 20% for the driving offences. However, they did not assess the direct relation between the on-road test and driving simulator performance.

1.3. Potential of driving simulators

A study using simulated driving scenarios employed hundred-twenty-nine older participants (60–88 years old) in a relatively simple driving simulator and validated driving simulator performance by an on-road test conducted on a predefined route (Lee, Cameron, & Lee, 2003). The on-road test performance was rated by driving experts while the driving simulator performance was rated half by an experimental assistant and half by automatically obtained measures recorded by the simulator software (driving speed, use of indicator, decision and judgement, confidence on high speed and attention task). The on-road test predicted 67% of the variance in the simulator performance. Both measures were negatively associated with chronological age ($-.25 \leqslant r \geqslant -.66$). Another study examined differences in cognitive performance and driving simulator performance in 20 younger (25–42 years) and 20 older drivers (65–83 years). 12 older drivers were excluded because of Simulator Adaptation Syndrome (SAS). Comparisons of challenging traffic events (car overtaking, pedestrian crossing, incursion of a parked car) during simulator driving showed higher crash risk for the older driver group. In addition, participants who crashed scored lower on the cognitive tests (reaction time, choice reaction time, and UFOV). The comparison of older non-crashers with older crasher showed a lower performance on the divided attention and selective attention UFOV subtests for the older crashers. These findings suggest a problematic role of older drivers' cognitive capacity in demanding traffic situations (Bélanger, Gagnon, & Yamin, 2010).

Driving simulators seem to be a useful alternative to on-road tests since they offer the potential to design standardized driving scenarios which are the basis to obtain good measures. A study with older healthy participant and participants with