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Predicting on-road driving performance and safety in healthy older adults

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ABSTRACT

Introduction: This study evaluated the ability to predict the on-road driving of older drivers using a battery of laboratory-based instruments. *Methods*: The Roadwise Review, a brief Hazard Perception Test and several tests of vision were given to 65 cognitively healthy, licensed older drivers ($M = 74$ years, $SD = 9$ years). They also participated in a standardized driving assessment of approximately 18 km, along a mixed residential and commercial route. *Results*: Raw scores on the Roadwise Review did not predict accumulated points, or automatic disqualifications, but could predict who would pass or fail the on-road evaluation. The number of serious problems (excluding head and neck flexibility) that were identified by the Roadwise Review was a significant predictor of automatic disqualifications, and a significant predictor of passing or failing the on-road assessment. The Hazard Perception Test approached significance when predicting accumulated points and was a significant predictor of automatic disqualifications, as well as pass/fail outcomes. *Conclusions*: The best model for predicting passing or failing the on-road assessment included the Hazard Perception Test, color vision, and, a measure of walking speed from the Roadwise Review, which yielded a sensitivity of 82% and a specificity of 69% (AROC = .80). Future work will need to determine how these tests can be used with other information (e.g., medical history) to yield better diagnoses of fitness to drive, particularly among those who are medically at risk.

1. Introduction

Older drivers have one of the highest collision rates per distance driven, despite the fact that they tend to drive less and in lower-risk situations (see Evans, 2004 for a review). Many older adults are quite safe "behind the wheel" (Hakamies-Blomqvist, Raitanen, & O'Neill, 2002), but because of the myriad number of age-related health declines that affect driving, there are some older adults who pose a risk to themselves and others if they continue operating a motor vehicle. Thus, it is important to be able to accurately predict who is safe to drive and who is not. The past several years have seen the introduction and evaluation of many tools to identify older drivers whose performance is an indication of driving difficulties (Dobbs & Schopflocher, 2010; Staplin, Lococo, Gish, & Decina, 2003; Wood, Horswill, Lacherez, & Anstey, 2013). The purpose of the present research was to determine if several of these tests, alone or in combination, could predict the on-road driving safety of a sample of healthy, currently driving older adults and to do so using several measures of driving safety.

The DrivingHealth® Inventory (DHI) was developed from the Maryland Pilot Older Driver Study with the goal of identifying those measures that could be used to predict collision involvement in older adults (Staplin, Gish, & Wagner, 2003; Staplin, Lococo, Gish, & Decina, 2003). It includes tests of spatial vision, strength and flexibility, working memory, attention, and visual search. The American Automobile Association and the Canadian Automobile Association have distributed this battery as the Roadwise Review, which is marketed as a self-assessment tool that evaluates physical, visual, and cognitive abilities related to safe driving.

Both the DHI and the commercially distributed Roadwise Review have shown inconsistent predictive utility. Edwards et al. (2008) found that older adults who reported a collision in the previous two years performed worse on the DHI than older adults without a collision. On the other hand, Scialfa, Ference, Boone, Tay, and Hudson (2010) concluded that the Roadwise Review was unable to predict self-reported driving difficulties or retrospective collision involvement. Similarly, Bédard, Riendeau, Weaver, and Clarkson (2011), reported that the Roadwise Review has limited congruence with on-road evaluations of driving ability.

One relatively new driver-screening instrument in North America is the Hazard Perception Test (HPT) (Horswill, Anstey, Hatherly, & Wood, 2010; Scialfa et al., 2011). Whether a hazard is defined as another driver behaving erratically or an unexpected object in the roadway, it is self-evident that hazard avoidance is a critical component to safe driving and, conversely, failures to respond appropriately to hazards increase driver risk. This relationship is seen in collision statistics (Wells, Tong,

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Sexton, Grayson, & Jones, 2008). For example, the Insurance Institute for Highway Safety (2010) found that approximately 20% of all deaths in motor vehicle crashes involved fixed roadway hazards. Transport Canada (2001) reported that more than one-half of mature drivers (53%) killed in a collision were struck by another vehicle, while an additional 10% hit a non-moving object and 7% struck a pedestrian. U.S. data (e.g., Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998) indicate that intersections are particularly problematic for older drivers. It is likely that inadequate perception of hazards plays a significant role in these collisions (Stutts, Martell, & Staplin, 2009).

Hazard Perception Tests (HPTs) have been used for driving assessment at both ends of the driver age spectrum (Horswill et al., 2010; Pollatsek, Fisher, & Pradhan, 2006; Scialfa, Borkenhagen, et al., 2012; Scialfa, Deschênes, et al., 2012; Scialfa et al., 2011). There are various versions of HPTs, but all of them are designed to measure one's ability to detect and respond to hazards in the driving environment using reaction time as the primary dependent measure. Older drivers are slower than their younger counterparts at hazard perception (Horswill et al., 2008; Scialfa, Deschênes, et al., 2012) and HPTs have been associated with crash involvement in various adult samples (Darby, Murray, & Raeside, 2009; McKenna & Horswill, 1999; Wells et al., 2008), including older adults (Horswill et al., 2010).

Recently, Wood et al. (2013) used a Multi-factorial Model of Driving Safety (Anstey, Horswill, Wood, & Hatherly, 2012) to predict on-road driving performance in older adults. The screening battery included tests of spatial vision, strength, attention, and driving history, along with a brief (i.e., 22-scene) HPT. On-road performance was assessed on a 10-point scale by trained evaluators as participants drove a standardized 19.4 km city and suburban route. Their HPT was able to discriminate between those who passed or failed the on-road assessment. It also contributed to the accuracy of predicting passing or failing the on-road test which, together with measures of vision, RT and driving distance yielded a sensitivity of 85% and a specificity of 78%.

Efforts to predict driving fitness are complicated by uncertainty regarding the best means of assessing performance. Even if one accepts the view that on-road performance is the preferred outcome measure, there still remain large differences of opinion as to how a driver's on-road performance should be assessed and quantified. Many jurisdictions use a point system where the points are assigned for unsafe driving behaviors in various categories (e.g., parking, speed maintenance, and intersection negotiation). It has been argued (Dobbs, Heller, & Schopflocher, 1998) that evaluating older adults in this way does not differentiate between common errors committed even by many drivers and more hazardous errors that are indicative of declines in driving fitness. Additionally, whether based on total points or hazardous errors, these more quantitative scoring approaches are difficult to use in clinical settings, where dichotomous decisions (e.g., pass/fail) are more common. On the other hand, a pass/fail system is inadequate if one of the goals of assessment is to provide remediation and/or training that necessarily is behavior-specific. Wood et al. (2013) based their analysis on whether a driver passed or failed the on-road assessment. Bédard et al. (2011) used both accumulated points and pass/fail outcome to assess driving performance.

There were three primary goals to the present research. The first was to assess the predictive validity of the Roadwise Review in a healthy sample of older adults, where the outcome variable was on-road performance evaluated in a standardized fashion mirroring governmentally administered license examinations. Additionally, given the growing evidence that hazard perception suffers in older adults, and that HPTs are valid measures of driving safety, a second goal was to assess the capacity of a brief HPT to predict on-road driving. Our third goal was to examine which combinations of Roadwise Review subtests, HPT, and other tests would best predict on-road performance. In light of questions surrounding how driving should be assessed, we operationalized on-road performance using serious or hazardous violations, as well as total points and global pass/fail assessments. This is a novel approach to the study of on-road driving performance in healthy older adults in two ways: It is the first time that the Roadwise Review and the HPT have been examined in combination. Second, we used three different indicators of on-road performance.

2. Methods

2.1. Participants

A convenience sample was obtained from sixty-six individuals (38 females, 27 males) who held a valid driver's license and were recruited from community organizations, such as local senior's centers, as well as from advertisements seeking older drivers in a local senior's newspaper. Seventy-four percent ($N = 53$) drove between 5000 and 20,000 km per year. Twenty percent ($N = 13$) reported involvement in one or more collisions over the last two years.

Participants were required to have corrected or uncorrected high contrast far visual acuity of 20/50 or better in order to take part in the on-road assessment. If they did not meet this criterion when assessed using the relatively crude Roadwise Review acuity test, we administered a second, more precise measure of distance acuity to determine that they were eligible to take the on-road evaluation.

Of those participants originally recruited, one individual was excluded because he was under the age of 55 years. Summary demographic data are presented in Table 1.

Table 1
Descriptive statistics for demographic data, Roadwise Review, HPT, and on-road evaluation (N = 65).

Variables	Min	Max	*M*	*SD*
Demographics				
Age	56	89	73.58	9.01
Education (in years starting with grade 1)	8	22	16.06	3.31
Self reported health ratings (scales of 1 to 5)	3.00	5.00	4.17	.65
MMSE	27.00	30.00	28.89	1.05
Roadwise Review (raw scores)				
Leg strength & general mobility (LS&GM)	4.00	9.00	5.80	1.22
Head/neck flexibility (HN/F)[a]	1	2	1.53	.50
High contrast visual acuity (HCVA)[b]	1	2	1.02	.12
Low contrast visual acuity (LCVA)[b]	1	3	1.13	.38
Visualizing missing information (VMI)	0	10	2.50	2.16
Visual information processing speed (UFOV)	100.00	410.00	171.26	92.76
Visual search (VS)	47.00	261.00	107.25	40.38
Working memory (WM)	0	2	.25	.50
Roadwise Review number of problem areas				
Serious problems	0	4	.83	.93
Serious problems (no HN/F)	0	3	.35	.72
Combined serious and mild problems	0	6	2.32	1.71
Combined serious and mild problems (no HN/F)	0	5	1.85	1.45
HPT				
Reaction time	1.70	6.55	3.24	1.04
On-road evaluation demerit points by category				
Controls	.00	25.00	2.62	5.38
Parking/starting/backing	.00	25.00	1.54	4.41
Lane driving/changing/position	10.00	100.00	37.08	18.83
Intersections/turns/RR	.00	120.00	20.62	17.58
Traffic lights/signs	.00	80.00	4.85	11.86
Right of way	.00	20.00	1.62	4.25
Speed	.00	40.00	8.00	11.07
Total demerit points	30	180	73.92	32.14
Total number of disqualifications	0	9	1.60	2.04
Vision tests				
Landolt C near acuity test	1.00	4.50	1.67	.63
D15 color vision [c]	1.00	2.00	1.84	.36
Vistech 1.5 contrast sensitivity	12.00	170.00	48.11	26.51
Vistech 3.0 contrast sensitivity	15.00	220.00	97.20	51.07
Vistech 6.0 contrast sensitivity	5.00	260.00	83.22	55.06
Vistech 12. contrast sensitivity	5.00	88.00	31.63	23.78
Vistech 18. contrast sensitivity	.00	40.00	9.20	8.10

[a] 1 = no impairment, 2 = impairment.
[b] 1 = 20/40 or better, 2 = 20/40–20/80, 3 = 20/80 or worse.
[c] 1 = impairment, 2 = no impairment.