Hazard perception in older drivers

Charles T. Scialfa*, Micheline C. Deschênes, Jennifer D. Ference and Jessica Boone

Department of Psychology,
University of Calgary,
Calgary, Alberta, T2 N 1N4, Canada
E-mail: scialfa@ucalgary.ca
E-mail: m.deschenes@shaw.ca
E-mail: jennifer.ference@gmail.com
E-mail: Jessica.boone@shell.com
*Corresponding author

Mark S. Horswill and Mark Wetton

Department of Psychology,
University of Queensland,
Brisbane 4072, Australia
E-mail: m.horswill@psy.uq.edu.au
E-mail: m.wetton@psy.uq.edu.au

Abstract: We have developed a hazard perception test (HPT) that presents short video scenes to observers and requires them to identify a traffic conflict that could lead to a collision between the 'camera' vehicle and another road user. In the present study, we compared the performance of young, experienced drivers (M = 21.30 years of age) with that of healthy, older drivers (M = 70.88 years of age). Although an average hazard perception test score based on all scenes did not produce systematic age effects, older adults were systematically slower on a composite hazard perception test score used previously with novice drivers (Scialfa et al., 2011b). Age differences in hazard perception test latencies were mediated by contrast sensitivity, but not simple reaction time. The findings suggest that a brief hazard perception test could potentially be used in the assessment of drivers across the adult lifespan.

Keywords: hazard perception; driving; age differences; collision risk.


Biographical notes: Charles T. Scialfa has served as a faculty member in the Department of Psychology at the University of Calgary. His research focuses on visual perception, attention, and human factors, with a special emphasis on ageing. Studies related to driving have played a growing role in his research programme. In particular, recent work has examined the ability to predict driving difficulty among novices and older adults using relatively new tests including a North American hazard perception test.
Micheline C. Deschênes has been a Clinical Vision Scientist for more than 20 years. Her research interests are in the fields of clinical electrophysiology of vision and ocular blood flow, specifically in relation to age-related ocular conditions such as glaucoma and age-related macular degeneration. For the last two years she has been a coordinator for several clinical trials and research projects in a private eye facility in Calgary, the Calgary Retina Consultants.

Jennifer D. Ference is a graduate student at the University of Calgary in the Clinical Psychology programme. At present, her research focus is on infant speech perception, with a special interest in the emergence of autism spectrum disorders. Prior to this, she worked as a Research Assistant for several years on projects related to visual perception, attention, ageing, depression, and hazard perception.

Jessica Boone received her undergraduate degree in Psychology in 2010. Since that time, she has worked in the oil and gas industry in western Canada.

Mark S. Horswill is currently an Associate Professor at the School of Psychology, the University of Queensland, Australia, which he joined in 2002. He obtained his PhD on Driving Behaviour from the University of Reading in 1994. He headed a team that developed the hazard perception test for Queensland Transport, which became part of the new driver licensing procedure in Queensland, Australia, in July 2008. His research interests include hazard perception training for different driver groups, behavioural factors affecting crash risk, and medical human factors.

Mark Wetton is completing his PhD at the University of Queensland, Australia. His research focuses on drivers’ hazard perception, with particular interests in the development of valid hazard perception tests, and hazard perception training. He was involved in developing the Queensland Transport Hazard Perception Test used for driver licensing in Queensland.

1 Introduction

Driving safety demands that we quickly and reliably respond to hazards in the roadway environment. Whether a hazard is defined as another driver behaving erratically or an unexpected object in the roadway, hazard avoidance is a critical component to safe driving and failures to respond appropriately to hazards increase driver risk. This relationship is seen in collision statistics (Insurance Institute for Highway Safety, 2010; Wells et al., 2008).

If problems in hazard perception are a major reason for collisions in the general driving population, they are particularly challenging for older drivers, who contribute disproportionately to driving injuries and fatalities when exposure is controlled (National Highway and Traffic Safety Administration, 2008; Stutts et al., 2009). Transport Canada (2001) report that more than one-half of mature drivers (53%) killed in a collision struck another vehicle, while an additional 10% hit a non-moving object and 7% struck a pedestrian. US data (e.g., Preusser et al., 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 et al., 2009).
There are a number of mechanisms that could predispose older adults to deficits in the perception of hazards. At the sensory-perceptual level, there are well-known declines in spatial vision, including acuity, contrast sensitivity and clinically measured visual fields (see Scialfa and Kline, 2007; for a review). Many older drivers operate with a reduced useful field of view (Ball et al., 2006), experience problems with visual search (Scialfa et al., 1998), and do not perform well under the conditions of divided attention that often characterise driving (McPhee et al., 2004). Because of age-related slowing on visuospatial tasks (Jenkins et al., 2000), hazard perception may be impaired and responses to identified hazards delayed, leading to an increase in collision risk. Consistent with these facts, Horswill et al. (2010) reported that poor performance on a 22-item measure of hazard perception time was associated with self-reported collision involvement in the previous five years in a sample of drivers aged 65 yrs. and older.

Other experimental studies of age-related declines in hazard perception have produced mixed results. Some data indicate that older drivers fixate hazards at least as well as other drivers (Pradhan et al., 2005; Underwood et al., 2005), yet they have been shown to search the roadway environment less thoroughly (Lavalliere et al., 2007; Renge et al., 2005). Age deficits in hazard identification have been reported by Renge et al. (2005), Borowsky et al. (2010), and Horswill et al (2008, 2009; Study 2). In contrast, Ota (1997), Renge et al. (2008) and Underwood et al. (2005) found no difference among younger and older groups of drivers on hazard perception tests. Where age deficits are obtained, they are often eliminated after controlling for perceptual and cognitive factors such as contrast sensitivity and the useful field of view (Horswill et al., 2008, 2009; Study 2).

The investigation described below was carried out to determine if experienced, healthy older drivers demonstrate difficulties in hazard perception when compared with experienced, young adult drivers. To date there has been no North American assessment of age-related differences in hazard perception for a large number of varied scenes of known reliability (Horswill and McKenna, 2004; Scialfa et al., 2011b). If hazard perception tests are to become part of the licensure process, as has occurred in other jurisdictions, then the stimuli used must be appropriate for North American drivers (e.g., right-side driving). As well, the hazards that are challenging for younger drivers who lack an appropriate mental model (e.g., Scialfa et al., 2011a; Underwood et al., 2002) may differ from those that pose problems for older people, who have rich schemas for hazards developed over years of driving (Borowsky et al., 2009). In comparison to some earlier work using very brief tests (Pradhan et al., 2005; Renge et al., 2005, 2008; Ota, 1997), we asked drivers to respond to almost 100 diverse traffic scenes. Additionally, by collecting data on measures of sensory function and simple spatial reaction time, we were able to determine if any age-related deficits were mediated by well-known changes in abilities that underlay safe driving (Stutts et al., 2009).

2 Methods

2.1 Participants

This study was approved by the Conjoint Faculty Research Ethics Board at the University of Calgary. There were 173 drivers who participated in the current study. The larger group of experienced, younger drivers consisted of 146 adults with two or more years of
driving experience. They were students in the Calgary, Alberta area. As compensation for their involvement, they received either $25 or partial course credit. The comparison group was made up of 27 licensed individuals aged 65 and older. These people were community-dwelling adults who were driving at the time of assessment and who had not been hospitalised in the past year for a serious illness or medical condition. They did not demonstrate signs of age-related macular degeneration on the Amsler grid test (Amsler, 1953). They were recruited from service and recreational organisations in Calgary area. They were given $25 in return for their participation.

Demographic data on these groups are shown in Table 1. It can be seen that both groups were well educated and drove regularly. Age differences in visual acuity and contrast sensitivity are consistent with normal age-related changes in spatial vision (Scialfa and Kline, 2007). Self-reported health was not provided by younger adults but older adults, on average, rated their health as 4.35 (SD = .69) on a five-point Likert scale and their mini-mental state examination (MMSE) scores (Folstein et al., 1975) were 29 or better.

Table 1  Mean demographic and outcome data (SD) for younger and older groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Younger adults</th>
<th>Older adults</th>
<th>t-value (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>21.30 (1.86)</td>
<td>70.88 (5.31)</td>
<td>88.14 (&lt; .001)</td>
</tr>
<tr>
<td>Males/females</td>
<td>75/71</td>
<td>15/12</td>
<td>N.A.</td>
</tr>
<tr>
<td>Years of education</td>
<td>14.66 (1.81)</td>
<td>14.07 (2.60)</td>
<td>1.44 (.150)</td>
</tr>
<tr>
<td>Years of driving</td>
<td>5.81 (2.28)</td>
<td>50.28 (8.16)</td>
<td>55.69 (&lt; .001)</td>
</tr>
<tr>
<td>Km driven per year</td>
<td>17,822 (13,781)</td>
<td>16,838 (6,995)</td>
<td>.36 (.718)</td>
</tr>
<tr>
<td>Acuity (LogMAR)</td>
<td>–.12 (.10)</td>
<td>.20 (.15)</td>
<td>13.55 (&lt; .001)</td>
</tr>
<tr>
<td>CS (1.5 cpd)*</td>
<td>87.23 (33.23)</td>
<td>57.89 (22.10)</td>
<td>4.33 (&lt; .001)</td>
</tr>
<tr>
<td>CS (3.0 cpd)</td>
<td>161.02 (37.87)</td>
<td>101.81 (45.63)</td>
<td>7.11 (&lt; .001)</td>
</tr>
<tr>
<td>CS (6.0 cpd)</td>
<td>193.09 (54.62)</td>
<td>104.42 (49.38)</td>
<td>36.78 (&lt; .001)</td>
</tr>
<tr>
<td>CS (12 cpd)</td>
<td>128.15 (90.71)</td>
<td>65.69 (33.46)</td>
<td>102.87 (&lt; .001)</td>
</tr>
<tr>
<td>CS (18 cpd)</td>
<td>47.73 (22.04)</td>
<td>18.42 (15.47)</td>
<td>45.31 (&lt; .001)</td>
</tr>
<tr>
<td>50 Scene HPT (sec)</td>
<td>2.68 (.54)</td>
<td>2.90 (.79)</td>
<td>1.52 (.130)</td>
</tr>
<tr>
<td>50 scene hits</td>
<td>47.30 (2.99)</td>
<td>45.26 (5.72)</td>
<td>2.75 (.007)</td>
</tr>
<tr>
<td>18 scene HPT (sec)</td>
<td>2.72 (.59)</td>
<td>3.04 (.81)</td>
<td>2.43 (.019)</td>
</tr>
<tr>
<td>18 scene hits</td>
<td>17.10 (1.39)</td>
<td>16.00 (2.43)</td>
<td>3.28 (.001)</td>
</tr>
<tr>
<td>False alarms</td>
<td>.91 (1.35)</td>
<td>1.85 (2.46)</td>
<td>2.86 (.005)</td>
</tr>
<tr>
<td>Reaction time (ms)</td>
<td>717 (130)</td>
<td>799 (161)</td>
<td>2.84 (.005)</td>
</tr>
</tbody>
</table>

Note: *Vistech contrast sensitivity.

2.2  Materials and apparatus

The primary measures gathered were the accuracy and reaction time for a number of potentially hazardous driving scenarios. The hazard perception test was modelled after that used by the UK and some Australian states (e.g., Horswill et al., 2009), which has been demonstrated to be a reliable and valid measure of collision risk in both novice and older drivers (Horswill et al., 2010; Wells et al., 2008). The version used in this study and
described below has recently been found to reliably discriminate novice and experienced young drivers (Scialfa et al., 2011b).

A series of 95 silent driving scenes lasting between 10 to 62 s were filmed in Vancouver, B.C., Canada, and surrounding areas using a Sony Handycam Camcorder, model HDR-SR11 in AVCHD 16M (FH) format at a resolution of 1,920 × 1,080/60i. The camera was mounted inside a 2005 Subaru Impreza and secured to the inside door window on the passenger side of the vehicle. An extendable arm allowed the videotaped scenes to give a ‘driver’s eye’ view. Filming occurred in March and April, 2009, during daylight hours, generally under clear skies and dry roadway conditions in a variety of frequently encountered environments (e.g., residential, limited-access freeway). Each driving scene was edited from original files using Sony Vegas Movie Studio Platinum software (version 9.0a) at a resolution of 1,280 × 720.

<table>
<thead>
<tr>
<th>Type</th>
<th>All 64 traffic conflict scenes</th>
<th>18 traffic conflict scenes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving vehicle in same direction as the camera car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal/turn right</td>
<td>7 (10.9)</td>
<td>1 (5.6)</td>
</tr>
<tr>
<td>Signal/turn left</td>
<td>4 (6.3)</td>
<td>1 (5.6)</td>
</tr>
<tr>
<td>Parking</td>
<td>3 (4.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Slowing</td>
<td>13 (20.3)</td>
<td>3 (16.7)</td>
</tr>
<tr>
<td>Turning/merging into CC* lane</td>
<td>9 (14.1)</td>
<td>4 (22.2)</td>
</tr>
<tr>
<td>Stopped in CC lane</td>
<td>6 (9.4)</td>
<td>2 (11.2)</td>
</tr>
<tr>
<td>Parked in CC lane</td>
<td>5 (7.8)</td>
<td>2 (11.2)</td>
</tr>
<tr>
<td>Moving vehicle in different direction of the camera car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossing CC path from the left</td>
<td>2 (3.1)</td>
<td>1 (5.6)</td>
</tr>
<tr>
<td>Crossing CC path from the right</td>
<td>1 (1.6)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Head-on</td>
<td>2 (3.1)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrians</td>
<td>3 (4.7)</td>
<td>2 (11.2)</td>
</tr>
<tr>
<td>Cyclists</td>
<td>5 (7.8)</td>
<td>2 (11.2)</td>
</tr>
<tr>
<td>Road work</td>
<td>3 (4.6)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Object on the road</td>
<td>1 (1.6)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

Note: *CC = camera car.

Out of the 95 driving scenes, 64 (67%) contained a traffic conflict, defined as a situation in which the camera car was required to take evasive action such as slowing, stopping, or steering to avoid a collision with a road user or stationary object. At onset the object in the traffic conflict had a height between 1 and 10 deg \( (M = 3.0\) deg) and width between 1.6 and 14.8 deg \( (M = 4.4\) deg) at the nominal viewing distance of 50 cm. The eccentricity of the object relative to screen centre ranged between \(-.9\) and 3.4 deg on the vertical axis \( (M = 1.0\) deg) and between \(-16.2\) and 10.9 deg on the horizontal axis \( (M = -1\) deg). Thus, objects in traffic conflicts were quite varied in their size and location.
but, on average, did not require excellent acuity or peripheral vision. Examples included a braking lead vehicle, pedestrian incursion, and construction equipment in the driving lane. The traffic conflicts were diverse and broadly representative of the conflicts that are most commonly associated with collisions in adult drivers (McKnight and McKnight, 2003; Preusser et al., 1998). Information regarding the type of traffic conflicts can be found in Table 2. Thirty-one scenes (33%) did not contain a traffic conflict and were included in the series to increase uncertainty about hazard presence, as would be the case in normal driving.

The presentation of the driving scenes took place in daytime light levels. The driving scenes were presented in three counterbalanced, 20-minute segments, each with a fixed, random order of scenes. The segments were separated by mandatory, brief rest periods. Custom software defined the onset, offset, and spatial extent of the traffic conflicts of each scene (see Marrington et al., 2008). This same software was used to present driving scenes to participants and record the spatial coordinates of their responses and their reaction times. A touch-sensitive 17-inch LCD desktop monitor (Elo TouchSystems 1729L) with a resolution of 1,280 × 1,024 set at a viewing distance of approximately 50 cm was used to present the hazard perception test and collect responses. A small yellow circle appeared at the point of finger contact on the monitor to provide visual feedback that participants’ responses had been registered, but did not give them any information about speed or accuracy of responses.

A simple spatial reaction time test was administered to all participants, in order to control for any individual differences in general speed of response. In this test, 16 high-contrast black boxes of differing sizes appeared at random intervals and locations on the monitor. The size of the boxes ranged from 2.75 cm × 2.8 cm to 13 cm × 14 cm and were chosen to represent the 25th, 50th, 75th, and 100th percentiles of the height and width at first appearance of the hazards in the hazard perception test. Participants were instructed to touch these boxes as quickly and accurately as possible. A yellow circle appeared at the point of contact to provide visual feedback that participants’ responses had been registered.

Several large studies have indicated that decreased visual acuity is associated with an increased risk of self-reported crashes, but these findings are not always obtained (e.g., Margolis et al., 2002). In fact, in a review by Anstey et al. (2005), driving outcome measures including subjective reports, on-road assessments and collision data were found to be quite inconsistent in their relation with the visual functioning of drivers. These findings may simply indicate that the complexity of driving is influenced not only by visual factors, but also by other variables such as cognitive functioning. Given that findings on visual functioning and driving have thus far been inconsistent in the literature, we felt the inclusion of some visual tests could provide useful information related to driving performance. Visual acuity was assessed at a distance of 40 cm with a Landolt C chart that measured acuity in .05 logMAR steps from 20/200 to 20/10. Contrast sensitivity at 1.5 to 18 cycles per degree was measured with the VISTECH 6500. Macular health was measured with the Amsler grid test.

The MMSE has a maximum score of 30, with lower scores indicating more impairment. Its predictive power for driving is inconsistent. Some research has found no association between MMSE scores and self-reported (Marottoli et al., 1998) or state recorded collisions (Margolis et al., 2002). Other research indicates substantial correlations with mental state tests and various measures of driving performance (Odenheimer et al., 1994; Owsley et al., 1991).
2.3 Procedure

Participants were tested in a single session lasting between 1 and 2 hrs. Upon arrival, the study was described in detail and participants provided written informed consent. Next, they were shown the touch screen monitor and simple touch screen practice tasks were completed before moving on to the spatial RT task. Immediately after, participants received instructions for the hazard perception test and were given the sample driving scenes. They were told,

“You will be shown video clips of traffic situations filmed from a driver’s point of view. We want you to watch the videos as if you are the driver.”

“While watching the videos, your task is to ANTICIPATE potential traffic conflicts BEFORE they occur.”

“A traffic conflict is a situation in which a collision (or near collision) between you and another road user would occur unless you took evasive action (such as slowing or steering).”

“Your job is to touch any road user (or users) that could be involved in a POTENTIAL traffic conflict with your vehicle. In this task, ‘road users’ include moving vehicles, stationary vehicles, cyclists and pedestrians.”

“We will be measuring your reaction time, so you need to predict the potential traffic conflicts as early as you can. If possible, try to touch the screen BEFORE you would actually need to take evasive action.”

Throughout the sample scenes, the researcher provided feedback regarding the participants’ responses to the scenes and repetition of the definition of a traffic conflict was often necessary. At this point, participants were given the hazard perception test. After completion of the hazard perception test, the vision tests were administered.

3 Results

We defined outliers as those individuals who either failed to complete any test or whose aggregate RTs for traffic conflict scenes deviated from their age group by more than 2.5 SDs. One older adult was identified as an outlier and their data were excluded from further analyses. Missing responses were not replaced and so RTs for traffic conflict scenes were based only on those scenes generating a correct response, where a correct response was defined as touching the screen at a location corresponding to the pre-determined coordinates of the hazard. For the reliability estimates reported below, this reduced the number of observations entering into the analysis, which would generally serve to decrease estimates of reliability.

Even though two research assistants were able to identify and classify hazards in each of the 64 scenes containing a traffic conflict, not all of these hazards were identified by every driver. Although failing to identify a hazard is clearly important to driving safety, analysis and interpretation of hazard perception RT data is difficult when drivers frequently fail to identify the same hazard and, in consequence, many studies of hazard perception test use tests wherein most viewers eventually identify the hazard. Following Scialfa et al. (2011b), we only included scenes in further analysis if the hit rate among younger drivers was greater than 85%. Out of the 64 driving scenes that contained a traffic conflict, 50 met this criterion.
C.T. Scialfa et al.

Table 3  Description of 18 scenes discriminating older and younger drivers

<table>
<thead>
<tr>
<th>Driving environment</th>
<th>Lighting</th>
<th>Traffic conflict onset time (sec.)</th>
<th>Size at onset (deg²)</th>
<th>Vertical eccentricity at onset (deg)</th>
<th>Horizontal eccentricity at onset (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Sunny</td>
<td>17</td>
<td>60.26</td>
<td>1.98</td>
<td>0.78</td>
</tr>
<tr>
<td>Residential</td>
<td>Sunny</td>
<td>22</td>
<td>9.42</td>
<td>0.67</td>
<td>7.81</td>
</tr>
<tr>
<td>Commercial/residential</td>
<td>Sunny</td>
<td>24</td>
<td>4.13</td>
<td>1.25</td>
<td>1.63</td>
</tr>
<tr>
<td>Residential</td>
<td>Sunny</td>
<td>30</td>
<td>18.14</td>
<td>0.84</td>
<td>10.93</td>
</tr>
<tr>
<td>Freeway</td>
<td>Cloudy</td>
<td>11</td>
<td>49.29</td>
<td>0.11</td>
<td>5.25</td>
</tr>
<tr>
<td>Forested parkland</td>
<td>Sunny</td>
<td>21</td>
<td>5.06</td>
<td>0.68</td>
<td>0.18</td>
</tr>
<tr>
<td>Commercial</td>
<td>Sunny</td>
<td>9</td>
<td>7.42</td>
<td>0.81</td>
<td>0.78</td>
</tr>
<tr>
<td>Commercial</td>
<td>Cloudy</td>
<td>0</td>
<td>6.25</td>
<td>0.50</td>
<td>4.20</td>
</tr>
<tr>
<td>Commercial</td>
<td>Sunny</td>
<td>17</td>
<td>6.24</td>
<td>1.34</td>
<td>3.43</td>
</tr>
<tr>
<td>Commercial/residential</td>
<td>Cloudy</td>
<td>16</td>
<td>35.54</td>
<td>0.73</td>
<td>4.67</td>
</tr>
<tr>
<td>Commercial</td>
<td>Cloudy</td>
<td>6</td>
<td>6.52</td>
<td>0.36</td>
<td>0.44</td>
</tr>
<tr>
<td>Commercial</td>
<td>Cloudy</td>
<td>11</td>
<td>30.88</td>
<td>1.51</td>
<td>8.55</td>
</tr>
<tr>
<td>Residential</td>
<td>Sunny</td>
<td>19</td>
<td>3.01</td>
<td>0.02</td>
<td>0.54</td>
</tr>
<tr>
<td>Commercial</td>
<td>Sunny</td>
<td>8</td>
<td>5.23</td>
<td>0.50</td>
<td>1.24</td>
</tr>
<tr>
<td>Commercial</td>
<td>Cloudy</td>
<td>16</td>
<td>21.62</td>
<td>2.00</td>
<td>2.24</td>
</tr>
<tr>
<td>Commercial</td>
<td>Sunny</td>
<td>7</td>
<td>35.21</td>
<td>2.59</td>
<td>1.10</td>
</tr>
<tr>
<td>Residential</td>
<td>Sunny</td>
<td>33</td>
<td>16.51</td>
<td>1.40</td>
<td>0.20</td>
</tr>
<tr>
<td>Residential</td>
<td>Cloudy</td>
<td>17</td>
<td>7.44</td>
<td>1.69</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Scene description

- Lead car signals to turn left, then brakes, and CC\* has to brake
- CC stops to let pedestrian cross at intersection
- Lead car signals to change lanes to avoid parked car in CC lane
- Cyclist crossing as CC executes a right-hand exit
- Bus in lane to the right merges into CC lane
- Postal truck parked on the side of the road
- Lead car brakes and takes a right-hand turn
- Pedestrian crossing at authorised cross-walk
- Cyclist in CC lane
- Pick-up truck merges into CC lane to avoid car stopped in lane
- Bus turning into lane to right of CC comes into the CC lane
- Car in left lane signals to move into CC lane
- Postal truck parked in CC lane
- Car parked in CC lane
- Lead car brakes due to jay-walking pedestrian
- Lead car brakes for pedestrians at intersection
- Lead car brakes for to police truck parked in CC lane
- Oncoming car cuts CC path and turns right

Note: CC = camera car.
The reliability of single items is generally quite low and several studies have shown that hazard perception test scores based on multiple items have better reliability and predictive success (Horswill and McKenna, 2004; Scialfa et al., 2011b). We computed a composite hazard perception test score from the 50 scenes that met the 85% hit rate criterion for young, experienced drivers, creating an instrument with a reliability (Cronbach’s alpha) of .85. The mean hazard perception test scores, along with hit rate and false alarm rate for scenes without traffic conflicts and SSRT are shown in Table 1. Older adults were more likely to indicate a hazard when there was no objective hazard present and to miss a hazard that younger drivers identified (see Table 1). There was a trend toward slower hazard perception test scores for older adults on this composite, but it was non-significant. As expected, older adults were significantly slower on the SSRT.

Scialfa et al. (2011b) reported that 18 scenes of the many traffic conflict scenes they presented were able to discriminate young novice from young experienced drivers, with a Cronbach’s alpha of .75. It is not necessary that hazards posing problems for novices are also problematic for older drivers, but to assess the more general utility of that set, we created a new hazard perception test score and also calculated hit rates based only on those 18 scenes, which are described in Table 3. Older adults \( (M = 3.04\) sec) were slower on average than younger adults \( (M = 2.72\) sec), a difference that was significant, \( t (171) = 2.36, p = .019 \). The hit rate for these scenes was also significantly lower, \( t (171) = 3.28, p = .001 \) in the older adults \( (M = 16.00) \) compared with the younger adults \( (M = 17.10) \).

Horswill et al. (2008) provided evidence that some of their observed age deficits in hazard perception test scores were mediated by age-related reductions in contrast sensitivity and information processing speed. Along these lines, we computed a composite contrast sensitivity score across all measured spatial frequencies and then used several analyses of covariance to determine if there were age effects on hazard perception test and hit rate after controlling for these other age-related variables.

When both contrast sensitivity and simple reaction time were controlled, there were no age differences in HPT, \( F(1, 167) = 1.30, p = .255 \). Controlling only for simple reaction time the age effects remained significant, \( F(1, 169) = 5.39, p = .021 \). Controlling only for contrast sensitivity, the age effects were eliminated, \( F(1, 169) = 1.08, p = .300 \). These results are consistent with the view that age differences in hazard perception are mediated by spatial vision, but not by generalised slowing of responses.

When we controlled for both contrast sensitivity and simple reaction time, age differences in hit rate for the 18 scenes used by Scialfa et al. (2011b) remained significant, \( F(1, 167) = 6.54, p = .011 \). Thus, age differences in the accuracy of identifying hazards were independent of general slowing and spatial vision.

Given this relation between contrast sensitivity and age differences hazard perception test scores, one might expect that older adults would be particularly disadvantaged with those hazards that are smaller or presented at greater distances from screen centre. This was not the case, however. Among all 50 scenes that met the 85% hit rate criterion for younger adults, those scenes producing the largest age-related slowing were not different from others in size or eccentricity \( (p's > .25) \).
4 Discussion

Collision risk is a serious concern of drivers and governments alike, and this concern has focused on novice and older drivers because of their disproportionate involvement in collisions, (National Highway and Traffic Safety Administration, 2008; Stutts et al., 2009; but see Hakamies-Blomqvist, 2004). For both groups, deficits in hazard perception are associated with a greater risk of collisions (Horswill et al., 2010; Wells et al., 2008). Fortunately, the assessment of and training in hazard perception is developing rapidly (Fisher et al., 2006; Horswill and McKenna, 2004; Horswill et al., 2010; Pradhan et al., 2005; Scialfa et al., 2011b) and, in fact, the assessment of hazard perception is being seen more often as a part of the licensure process (e.g., Queensland Department of Transportation and Main Roads, 2009).

In the present study, we asked younger and older experienced drivers to identify a large number of hazards in video sequences of commonly encountered driving scenarios (e.g., lead vehicle suddenly braking). Although individual scenes rarely revealed significant age-related slowing, older adults were slower to respond in more than 2/3 of the scenes, suggesting that the age differences generalise across driving scenarios. Consistent with previous work (Horswill et al., 2009; Scialfa et al., 2011b), we found that hazard perception test performance based on a subset of scenes that discriminate novice from experienced drivers can also discriminate older and younger drivers. These results hold the promise that a brief assessment, taking less than 20 minutes to administer, could be useful in mass testing of drivers who, as a consequence of poor hazard perception, are at greater risk for a collision (Horswill et al., 2010).

The age-related increase in hazard perception latency is not simply a reflection of generalised slowing. Performance on the 18-scene hazard perception test differed between younger and older drivers, even when simple spatial reaction time was controlled. Neither are the observed age differences due to a reluctance to identify a hazard. The age differences in false alarm rate suggest, if anything, that older adults are more likely to identify a scenario as hazardous (see also Underwood et al., 2005) and yet are less accurate at identifying hazards and are slower to do so. Lack of experience cannot account for these results, because older adults were much more experienced than the younger drivers. In addition, it is unlikely that older adults have an impoverished mental model of driving hazards (Borowsky et al., 2009). The hazards we presented were similar to those encountered in real driving and the eye movements of older adults indicate that they are adept at searching the forward driving environment for regions of greater potential hazard (Pradhan et al., 2005; Underwood et al., 2005).

Horswill et al. (2008) also reported that older drivers with a mean age of 73 yrs. differed from younger adults in hazard perception test latencies. Horswill, et al. (2009) found no age differences between a group aged 69 yrs. on average and a middle-aged group, but there was a significant age-related slowing compared with a group that was, on average, 79 yrs. old.

Methodology could account for this seeming inconsistency. The results reported here use a composite hazard perception test score that has been used previously (Scialfa et al., 2011b) to successfully discriminate novice and experienced drivers. Both studies by Horswill and colleagues incorporated new scenes that had not been validated. Their approach was taken to increase the number of scenes and thus the reliability of the test, but their new scenes may not have been as good at identifying those who have difficulties in hazard perception. If a person failed to respond to a hazard scene, Horswill et al.
replaced that missing value with a mean for the scene, creating a conservative bias in the composite hazard perception test score. We have calculated average hazard perception test only for scenes to which a person responded. As well, Horswill and colleagues have not generally incorporated hit rate into their analyses. Focusing on latency simplifies analysis, but including information about hits may be particularly useful in explaining increased collision risk because responding to a hazard slowly may be less critical than failing to respond at all.

Despite these differences in outcome, it is important to point out that in previous work as well as our own, the age differences in hazard perception may be mediated by spatial vision. Thus, our results support the general conclusion that visual health is systematically related to age differences in hazard perception. This does not mean that hazard perception tests are unimportant simply because they correlate with other age-related variables that could be used for collision risk evaluation. Hazard perception tests have obvious face and content validity that are not shared with basic measures of sensory function or speed of response. As well, it remains for future work to determine which abilities contribute uniquely to variance in on-road performance or collision risk.

There are several directions for additional research. One is to replicate these findings in a larger and representative sample of older drivers. A second, given the influence of contrast sensitivity on hazard perception test scores found here, is to assess the relation between more precisely measured contrast sensitivity and the power spectra of scenes at hazard onset. A third is to determine if special sub-populations of older adults, particularly those suffering from physical or cognitive impairment, perform poorly on tests of hazard perception relative to their healthy age peers. Finally, it is critical to ascertain, as has been done in other countries with different driving demands and driver populations, if hazard perception is related to on-road performance and collision risk.

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References


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