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Improving Older Drivers’ Hazard Perception Ability

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One reason that older drivers may have elevated crash risk is because they anticipate hazardous situations less well than middle-aged drivers. Hazard perception ability has been found to be amenable to training in young drivers. This article reports an experiment in which video-based hazard perception training was given to drivers who were between the ages of 65 and 94 years. Trained participants were significantly faster at anticipating traffic hazards compared with an untrained control group, and this benefit was present even after the authors controlled for pretraining ability. If future research shows these effects to be robust, the implications for driver training and safety are significant.

Keywords: driving, anticipatory skill, older adults, useful field of view, Stroop test

One reason that drivers over 65 years of age have a greater number of crashes per mile driven (Cerrelli, 1998) compared with their middle-aged counterparts may be because of a decline in their hazard perception ability. Drivers over the age of 65 have been found to be worse than middle-aged drivers at anticipating hazardous situations on the road ahead (Quimby & Watts, 1981; Renz et al., 2005), and this skill has been found to be associated with crash risk (Hull & Christie, 1992; McKenna & Horswill, 1999; Pelz & Krupat, 1974; Quimby, Maycock, Carter, Dixon, & Wall, 1986; Wells, Tong, Sexton, Grayson, & Jones, 2008).

Drivers’ hazard perception response latencies have been found to become faster from the initial stages of driving up until 55 years of age. After this age, their responses slow down again (Quimby & Watts, 1981). It has been argued that the initial age- and experience-related decrease in response times occurs as drivers gain experience in the traffic environment and learn better how to anticipate dangerous situations (Horswill & McKenna, 2004). One proposal is that initially novice drivers simply react to startling events, but as they gain experience, they develop more proactive strategies to anticipate hazards and learn to look for cues that may signal the onset of a dangerous situation (Horswill & McKenna, 2004). This type of anticipatory ability has been shown to be an important discriminator of novice and experienced/expert groups in a range of different skills (Rowe & McKenna, 2001). However, this skill has been found to be resource intensive (McKenna & Farrand, 1999), such that when experienced drivers engage in a demanding secondary task, their hazard perception latencies are slowed to the level of novices.

The slowing of response times after age 55 is likely to be driven by different mechanisms from those that mediate the changes from novice to experienced driver for the simple reason that drivers do not become less experienced with age. Cross-sectional hierarchical regression analyses (Horswill et al., 2008) suggest that the age-related slowing in hazard perception latency can be accounted for by a combination of cognitive, sensory, and motor declines. Underlying factors may include (a) reduced cognitive resources impeding the implementation of the resource-intensive proactive search strategy for hazards, (b) sensory declines, most notably contrast sensitivity, affecting the ability to see objects (Scialfa, Kline & Wood, 2002), and (c) generalized slowing (Cerella, 1990; McDow & Shaw, 2000; Schneider & Pichora-Fuller, 2000).

A key intervention to reduce crash risk among older drivers is to encourage individuals to limit their driving exposure or even cease driving altogether. However, there are substantial negative impacts to stopping driving, such as increases in depression (Marottoli et al., 1997). An alternative strategy is to find ways of training older drivers to counteract their deficits.

Hazard perception ability has been found to be amenable to a number of training interventions in young drivers (Chapman, Underwood, & Roberts, 2002; Pollatsek, Fisher, & Pradhan, 2006; Grayson & Sexton, 2002; McGowan & Bambury, 2004; McPherson & Kenel, 1968). For example, McKenna, Horswill, and Alexander...
(2006) found that even a 20-min video-based intervention significantly improved response times in a hazard perception test.

This article focuses on the question of whether such training could help drivers 65 years or older. On the one hand, it could be argued that because most older drivers will have had decades of driving experience, such interventions, which tend to involve advice on how to anticipate hazards, are unlikely to affect them. That is, it could be argued that older drivers’ strategies for detecting hazards are as well developed as they are likely to become and that the reason that their hazard perception latency is slower is not a suboptimal search strategy but rather problems in implementing that strategy (e.g., they fail to see objects they are searching for due to sensory declines).

On the other hand, there is evidence that strategy-based training can improve the hazard perception latency of even highly experienced drivers. McKenna and Crick (1991) found that expert drivers (advanced police drivers who had received hazard perception training) were significantly faster at responding to hazards than drivers with equivalently high levels of experience but no specific training. They also found that the hazard perception latencies of experienced drivers could be significantly improved by training. This suggests that even highly experienced drivers have not maximized their hazard perception ability despite decades of exposure and hundreds of thousands of miles of driving to the extent that even a relatively simple intervention can still improve their skill.

So why does experienced drivers’ substantial engagement in the activity fail to lead to maximal performance in hazard perception? Ericsson, Krampe, and Tesch-Romer (1993) have argued skill develops only through deliberate practice, defined as activities in which the performer is explicitly attempting to improve their level of skill. As most drivers consider themselves more skilled than average (McKenna, 1993; Svenson, 1981), particularly with respect to hazard perception (Horswill, Waylen, and Tofield, 2004), they have little incentive to improve their skill. In addition, performance feedback for hazard perception, specifically knowledge of results (information regarding performance outcomes), is arguably inconsistent and infrequent. Researchers have described this type of feedback as extremely important to motor skill development (Blandin, Toussaint, & Shea, 2008). An example of the paucity of this type of feedback in hazard perception would be a case in which a driver fails to detect a potential hazard but an accident does not result; the feedback may well be nil (i.e., the driver may not even be aware he or she was in danger). To give another example, if crash involvement is regarded as one of the mechanisms by which drivers gain feedback on crash avoidance, then the average driver has been estimated to have one accident in every 10 years of driving (Evans, 1991), which is extremely rare in the context of learning.

In terms of the present study, these lines of reasoning raise the possibility that the hazard perception ability of even highly experienced older drivers could be improved through training. That is, while novice drivers’ search strategies are primitive, experienced drivers’ strategies are still far from optimal. An implication is that older drivers may be able to compensate for cognitive, sensory, and motor declines by employing the superior anticipation strategies of expert drivers.

In the present experiment, we trained drivers 65 years or older using the technique described by McKenna et al. (2006), in which participants listen to an expert driver’s commentary on a series of hazardous traffic situations. Verbal protocols have been known to facilitate learning in certain conditions. Berry (1990) has argued that these protocols work by focusing a participant’s attention on the critical features of a task (in this case, the cues that precede a hazardous traffic situation). However, protocols were found to be more effective if accompanied by instruction in what the critical features were. The idea of listening to an expert’s commentary is to combine the instructional element with the ongoing verbal protocol in order to give recipients insight into the expert’s search strategy. In principle, this may allow older drivers to learn and employ this superior search strategy to improve their hazard perception latency despite high levels of driving experience and despite the possible presence of cognitive, sensory, and motor deficits.

Method

Participants

Twenty-eight currently licensed drivers who were 65 years or older were recruited from a sample of community-dwelling individuals. These participants had indicated their willingness to take part in research at the University of Queensland in a previously administered postal questionnaire (sent to a representative sample of the older adult population). Note that 65 years was chosen as a cutoff on the basis of the widely used recommendations for the definition of older adults proposed by Suzman and Riley (1985). One participant was excluded for falling asleep during the session, two others were excluded due to incomplete data, and a fourth was excluded to maintain counterbalancing (see Procedure section for details). The mean age of the remaining 24 drivers was 75.33 years (SD 7.83, range 65–94); the mean time since they had passed their driving test was 53.52 years (SD 6.29, range 44–71; one participant did not respond to this item). The 14 women and 10 men reported driving an average of 7,733 kilometers per year (SD 5,232, range 250–20,000). None of the participants were found to have scores for depression, anxiety, or cognitive status in the clinical range (see Table 1 for descriptives, and see Control Variables section for a list of the measures used with references containing the relevant clinical cutoffs). Participants gave written consent to take part in the experiment and were not paid. They were told that the aim of the study was to determine whether a new training program would help older drivers improve their ability to detect traffic hazards.

Materials

Hazard perception test. We used a previously developed hazard perception test in which participants viewed video footage of a driver’s eye view of unstaged hazardous traffic situations. Videos were presented on a 15-in. (381-mm) touch screen (3M Microtouch M150; 3M Co., St. Paul, MN) with purpose-made software on a standard PC computer. Participants wore headphones to minimize the distracting effects of local environmental noise. Participants were instructed to touch any road user (e.g., cars, cyclists, pedestrians) who was likely to become involved in a traffic conflict with the camera car as early as possible. A traffic conflict was defined as a situation in which the camera car was required to brake or steer to avoid a collision. Instructions were
given via a 5-min video, which was developed to ensure participants understood the test requirements. The scenes included in the current tests were taken from previously validated tests (Horswill et al., 2008; Wetton et al., 2009): Responses to these scenes were found to discriminate between novice and experienced drivers and correlated with another hazard perception test that had previously been found to correlate with crash risk. We created two alternate versions of the test by randomly assigning scenes into two sets. Test 1 had 22 conflicts (14-min long), and Test 2 had 19 conflicts (16-min long). Response time to each traffic conflict was calculated as the time elapsed between the first possible moment the relevant road user was visible and the point at which the participant touched the road user. Note that because this test was designed to be a latency rather than a hit rate measure, conflicts were chosen such that nearly all participants would be expected to respond eventually. Cronbach’s alpha for the hazard perception tests in the present sample was .89 for Test 1 and .87 for Test 2, and the alternative forms reliability correlation between Test 1 and Test 2 was .72.

**Hazard perception training video and control.** The training package was the same as that used by Wallis and Horswill (2007), which was based on the materials developed by McKenna et al. (2006). A 17-min video of real driving, depicting a variety of hazardous situations was presented to participants. Those in the trained group also heard an expert driving instructor giving a running commentary on the footage, indicating what he was paying attention to and giving general advice about anticipating hazards. The following excerpt from the commentary is typical: “Scanning ahead. Looking over the crest of the hill. Car turning left. Approaching traffic. More cars coming toward us. Cars on the right. Checking amongst the trees.” Before hearing the commentary, those in the trained group were given written instructions, explaining the training and giving additional advice (e.g., “While you are watching the video consider: what can be seen; what cannot be seen; what may reasonably be expected to happen?”). Those in the untrained group viewed the video sequences but without hearing the commentary (control video). They were given instructions beforehand, telling them to pay attention to the video “as if they were the driver of the vehicle depicted” but were not given any advice on hazard perception.

**Control variables.** Participants completed several motor, vision, and cognitive tests in order to ensure there were no differences in cognitive function between the experimental groups and to screen for individuals with clinical disorders. To measure the ability to use the touch screen together with simple reaction time, we used a spatial simple reaction time test. Participants were required to touch 15 high-contrast rectangles that appeared one at a time at random intervals and at random locations on the screen. Response times were calculated and averaged to give an overall score. Binocular static visual acuity was measured with the National Vision Research Institute (Melbourne, Australia) logMAR (logarithm of the minimum angle of resolution) chart, and binocular letter-contrast sensitivity was measured with the Pelli–Robson Letter-Sensitivity Chart (Pelli, Robson, & Wilkins, 1988). A Useful Field of View test developed by Wood and Troutbeck (1995) was administered on a Sony VPL-CS5 data projector (Sony Corp., Tokyo, Japan). Participants were required to detect the presence of a central target and indicate the position of a peripheral target. The task was completed with and without an array of visual distracters. To assess cognitive status, we used the Modified Mini-Mental State Examination (3MS; Teng & Chui, 1987), the California Older Adults Stroop Test (COAST; Pachana, Thompson, Marcopulos, & Yoash-Gantz, 2004), and the Trail-Making Tests A and B (Strauss, Sherman, & Spreen, 2006). Participants also completed the Geriatric Anxiety Inventory (Pachana et al., 2007), the Geriatric Depression Scale (Yesavage et al., 1983), and the State–Trait Anxiety Inventory (Spilberger, 1983). Note that the clinical cutoffs used for the cognitive status, anxiety, and depression measures are contained in the references given. Finally, participants provided demographic details as well as information about their driving history.

### Table 1

Control Variable Descriptives

<table>
<thead>
<tr>
<th>Variable</th>
<th>Trained group</th>
<th></th>
<th>Untrained group</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>Range</td>
<td>M</td>
</tr>
<tr>
<td>Age (years)</td>
<td>74.33</td>
<td>7.56</td>
<td>67–94</td>
<td>76.33</td>
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<tr>
<td>Simple spatial reaction time (seconds)</td>
<td>1.00</td>
<td>0.20</td>
<td>0.67–1.43</td>
<td>1.04</td>
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<td>UFOV</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No distractors (out of 24)</td>
<td>23.33</td>
<td>0.89</td>
<td>21–24</td>
<td>22.08</td>
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<td>Distractors (out of 24)</td>
<td>18.00</td>
<td>5.34</td>
<td>6–24</td>
<td>17.58</td>
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<td>3MS (out of 100)</td>
<td>92.25</td>
<td>5.33</td>
<td>82–99</td>
<td>87.25</td>
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<td>COAST (seconds to complete color/word task)</td>
<td>72.42</td>
<td>27.97</td>
<td>42–142</td>
<td>69.17</td>
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<tr>
<td>Trail-Making Tests</td>
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<td></td>
<td></td>
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<td>A (seconds)</td>
<td>31.92</td>
<td>8.31</td>
<td>23–54</td>
<td>62.25</td>
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<td>B (seconds)</td>
<td>102.33</td>
<td>49.33</td>
<td>48–234</td>
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<td>GDS</td>
<td>1.33</td>
<td>1.56</td>
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<td>GAI</td>
<td>0.33</td>
<td>0.89</td>
<td>0–3</td>
<td>0.50</td>
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<td>STAI</td>
<td>55.75</td>
<td>14.78</td>
<td>43–87</td>
<td>55.36</td>
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<td>LogMar visual acuity</td>
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<td>0.33</td>
<td>0.30–0.94</td>
<td>–0.12</td>
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<tr>
<td>Pelli–Robson Contrast Sensitivity</td>
<td>1.64</td>
<td>0.04</td>
<td>1.5–1.70</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Note. UFOV = Useful Field of View Test; 3MS = Modified Mini-Mental State Examination; COAST = California Older Adults Stroop Test; GDS = Geriatric Depression Scale; GAI = Geriatric Anxiety Inventory; STAI = State–Trait Anxiety Inventory.
Procedure

The experiment was granted ethical approval by the University of Queensland. Participants were tested at the university where they were randomly allocated to one of the experimental conditions on arrival (subject to the limitation that equal numbers were to be maintained across the groups), resulting in 12 individuals (seven women and five men) in both the trained and untrained groups. All participants first completed the Useful Field of View test, followed by the 3MS, the COAST, the Trail-Making Tests (A and B), and the Geriatric Anxiety Inventory. Participants were then given a break before completing the pretraining hazard perception test. The two alternate forms of the hazard perception test were counterbalanced across two experimental conditions (trained vs. untrained). All participants viewed the test instruction video before the pretraining test. The tests of visual acuity and contrast sensitivity were then given. Next, participants in the trained group viewed the training video, and participants in the untrained group viewed the control video. Then, all participants completed the Geriatric Depression Scale and the State–Trait Anxiety Inventory and provided demographic and driving history information before being given another break. Finally, the participants completed the posttraining hazard perception test (approximately 10–15 min after completing the training) and were debriefed. For ethical reasons, those in the untrained group were given the opportunity to view some or all of the training materials if they wished (three participants took advantage of this). The full procedure took about 2 hr, including breaks.

Statistical Analysis

All analyses were performed using SPSS Statistics Version 17.0. Alpha was set at 5%. The response times from both versions of the hazard perception test were calculated and averaged. We replaced misses with an overall mean from the missed hazard (not group means) as a conservative strategy designed to favor the null hypothesis. The response times for Test 2 were standardized to have the same mean and standard deviation as Test 1. We evaluated the training effect by carrying out a mixed-design analysis of variance (ANOVA), with hazard perception latency as the dependent variable, pre- versus postintervention as a repeated-measures independent variable, and training group as an independent samples variable. We predicted that the training effect would be revealed as a significant interaction between pre- versus postintervention and training group.

Results

No significant differences between the trained and untrained groups were found for any of the control variables. Descriptive statistics for the control variables can be seen in Table 1. Participants’ mean miss rate for hazards across both tests was 4.1%; the mean miss rate across both tests was 3.4% for the training group and 4.9% for the untrained group.

A mixed-design ANOVA was carried out, with hazard perception latency as the dependent variable, pre- versus postintervention as a repeated-measures independent variable, and training group as an independent samples variable (assumptions for ANOVA were met). A significant interaction between pre- versus postintervention and training group was found, $F(1, 22) = 7.18$, mean squared error (MSE) = .157, $p = .014$, $\eta^2_p = .25$. Simple effects indicated that the hazard perception latencies of the trained group improved between pre- and postintervention, $t(11) = 2.98$, $p = .013$, but the latencies of the untrained group did not improve, $t(11) = -.57$, $p = .580$. There was no difference in hazard perception latencies between the trained and untrained groups for the preintervention test, $t(22) = 1.70$, $p = .103$, but for the postintervention test, the
trained group was significantly faster, \( t(22) = 3.27, p = .003 \). This pattern of effects indicates that the training significantly improved hazard perception skill relative to the control intervention, which did not significantly affect performance. The means are displayed in Figure 1 and Table 2. Note that a significant main effect of training group, \( F(1, 22) = 7.28, MSE = 1.07, p = .013, \eta^2_p = .25 \), and a marginal main effect of pre- versus postintervention, \( F(1, 22) = 3.86, MSE = .157, p = .062, \eta^2_p = .15 \), were found, but these effects are not relevant to the hypothesis.

When we performed the repeated-measures analysis again with simple spatial reaction time as a covariate, the pattern of significant effects was the same, with no significant effects of simple spatial reaction time relative to any other variable. This indicates that the training results could not be accounted for simple spatial reaction time effects.

**Discussion**

In this experiment, we improved older drivers’ hazard perception latencies by a considerable degree using a brief and simple intervention. This is consistent with our prediction that exposing even highly experienced older drivers to alternative strategies for anticipating hazards can lead to performance improvements. Those in the trained group were responding to traffic conflicts 513 ms earlier than they had prior to the training (the response times of the untrained group were unchanged following the intervention, with a nonsignificant trend in the opposite direction). The time difference as a result of the training would equate to a distance of approximately 8.9 meters on the road if one was travelling at 60 kph, which could plausibly be the difference between having and not having a crash.

It should be noted that it is unlikely that these results are due to purely motivational factors, given previous work by McKenna and Crick (1997) in which they contrasted different hazard perception training interventions and found significant performance improvements only when anticipatory skills were trained compared with when other potential aspects of hazard perception were trained. This specificity suggests that increased motivation alone is unlikely to account for the training effect observed.

A number of caveats should be considered when interpreting the results. First, there is always the possibility that the training is improving latencies in our hazard perception tests but does not improve latencies in real-world driving (despite the validity evidence for the hazard perception tests) and hence does not impact crash risk. In future studies, investigators could attempt to measure whether this effect generalizes. Second, in the present experiment, we tested the effects of the training within a short time frame. It could be that these effects are not long lasting enough to translate into meaningful road safety benefits. In future studies, follow-up testing could be used to determine whether the training effects are long lasting (it could be, for example, that a number of training sessions might be required to have a long-term effect).

It is worth noting that other researchers have had success in improving the driving performance of older drivers in the long term through perceptual training aimed at improving useful field of view (Roenker, Cissell, Ball, Watdley, & Edwards, 2003). It is possible that this alternative type of training might improve hazard perception independent of our strategy-based training (especially given the relationship between useful field of view and hazard perception found by Horswill et al., 2008), and an optimal intervention for older drivers could well involve a combination of both approaches.

We have looked at the possibility of training driving-specific abilities in an attempt to reduce crash risk in this age group, and these initial findings are promising. There is no reason that older adults cannot learn new strategies for dealing with such everyday situations despite those in our sample having an average of over half a century of driving experience. This could allow individuals to maintain their driving independence longer without compromising road safety.

**References**


