Accident Analysis and Prevention 52 (2013) 100–110

Contents lists available at SciVerse ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Even highly experienced drivers benefit from a brief hazard perception training intervention

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ARTICLE INFO

Article history:
Received 8 August 2012
Received in revised form
20 September 2012
Accepted 9 December 2012

Keywords:
Driver education
Driver training
Anticipation skill
Hazard detection
Better than average
Driver confidence
Work-related driving

ABSTRACT

We examined the proposal that hazard perception ability is suboptimal even in highly experienced mid-age drivers. First, we replicated previous findings in which police drivers significantly outperformed highly experienced drivers on a validated video-based hazard perception test, indicating that the ability of the experienced participants had not reached ceiling despite decades of driving. Second, we found that the highly experienced drivers' hazard perception test performance could be improved with a mere 20 min of video-based training, and this improvement remained evident after a delay of at least a week. One possible explanation as to why hazard perception skill may be suboptimal even in experienced drivers is a dearth of self-insight, potentially resulting in a lack of motivation to improve this ability. Consistent with this proposal, we found no significant relationships between self-ratings and objective measures of hazard perception ability in this group. We also found significant self-enhancement biases in the self-ratings and that participants who received training did not rate their performance (either in real driving or in the test) as having improved, contrary to what was indicated by their objective performance data.

1. Introduction

1.1. Background

Hazard perception in driving refers to a driver's ability to anticipate potentially dangerous situations on the road ahead (see Jackson et al., 2009 for comment on definitions). This particular ability has generated interest among the road safety community because, to our knowledge, it is the only driving-specific skill found to be associated with crash risk (Pelz and Krupat, 1974; Transport and Road Research Laboratory 1979; Quimby et al., 1986; Congdon, 1999; McKenna and Horswill, 1999; Wells et al., 2008; Darby et al., 2009; Horswill et al., 2010a; Boufous et al., 2011; Cheng et al., 2011). Also, hazard perception test scores tend to mirror patterns of crash risk found in other road safety predictors, such as level of driving experience (Quimby and Watts, 1981; Wallis and Horswill, 2007; Horswill et al., 2008; Borowsky et al., 2009, 2010; Smith et al., 2009; Wetton et al., 2010, 2011; Scialfa et al., 2011), sleepiness (Smith et al., 2009), traumatic brain injury (Preece et al., 2010, 2011), distraction (Horswill and McKenna, 1999; Sagberg and Bjornskau, 2006; Reyes and Lee, 2008), and blood alcohol content (West et al., 1993; Deery and Love, 1996), suggesting that hazard perception may be a key mediator of the relationships between these factors and crash involvement. Hazard perception ability has also been found to decline in older drivers (Quimby and Watts, 1981; Horswill et al., 2008, 2009) and this decline appears to be mediated by factors such as contrast sensitivity, useful field of view, and simple reaction time (Horswill et al., 2008). Note that both contrast sensitivity and useful field of view have been associated with crash risk in older drivers (Owsley et al., 1991).

1.2. Hazard perception as a skill

If we conceptualize hazard perception as a skill then what would we predict? First, we might expect that experienced drivers would become very good at it. Ten years of experience has been cited as the requirement for gaining an international level of expertise in many domains (Ericsson and Lehmann, 1996). Experienced drivers, using typical definitions, would exceed this requirement and hence might be expected to excel in this skill. Indeed, it is the case that hazard perception response times (as measured in video-based tests) are at their fastest between the ages of 45 and 54 years (Quimby and Watts, 1981). A common suggestion is that experienced drivers develop a sophisticated mental representation of the driving environment,

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0001-4575/$ – see front matter
http://dx.doi.org/10.1016/j.aap.2012.12.014

allowing them to make predictions about what will happen next (McKenna and Crick, 1991; Horswill and McKenna, 2004; Underwood, 2007). The implication is that the hazard perception mindset of the experienced driver is what novices should aspire to.

To the contrary, we propose that, while experienced drivers may be superior to novices, their hazard perception performance could still be regarded as under-developed, despite thousands of hours behind the wheel. We present four lines of evidence to support this contention.

First, experienced drivers have been found to be significantly slower at hazard perception than expert drivers, defined as advanced police drivers, who have intensive advanced training as well as extensive experience (McKenna and Crick, 1991). Consistent with this, experienced drivers have been found to have a significantly smaller range of horizontal eye-movements (indicative of a less effective visual search) when viewing driving scenes compared with expert police drivers (Crundall et al., 2003). Also, compared with experts, experienced drivers have been found to yield a lower frequency of sudden-increase electrodermal responses when viewing driving scenes (which is a measure argued to be a physiological proxy for hazard awareness; Crundall et al., 2003). Experienced drivers also appear to spend less time looking at potentially hazardous features such as pedestrians, parked vehicles, and side roads compared with expert drivers (Crundall et al., 2005).

Second, the hazard perception benefit gained from decades of driving experience appears to equate to a relatively trivial amount of direct instruction. For example, McKenna and Crick (1997) found that a 4 h training intervention was able to improve novices' (up to 3 years experience) response times to hazards to approximately the level of a sample of experienced drivers (11–39 years experience). Similar effects have been found for a 20 min video-based intervention (Wallis and Horswill, 2007). This suggests that the rate of learning via driving experience alone must be extremely slow and suggests that experienced drivers' hazard perception skills are likely to be under-developed, given that 20 min of instruction would not be expected to be sufficient to substantially impact any complex skill.

Third, even highly experienced older drivers have been found to benefit from brief hazard perception training. Drivers (aged 65 or over) with between 44 and 71 years of experience improved their responses by about half a second following 20 min of video-based instruction (Horswill et al., 2010b). This is equivalent to 9 m of travel at a speed of 60 kph (37.5 mph) and again suggests that the skill is at a far from optimal level (it is worth noting that this finding may or may not generalize to the experienced mid-age drivers who are the subject of the current study, since older drivers can be considered a special case because their hazard perception ability may be impeded by various age-related factors; Horswill et al., 2008).

Fourth, there is no evidence for ceiling effects in hazard perception skill among experienced drivers, which one might expect if this skill had reached an optimal level (i.e., drivers might be expected to reach broadly similar levels of performance because of overpractice). For example, Wetton et al. (2011) report a standard deviation of 602 ms in hazard response times in an experienced sample (minimum 15 years of experience). This means that a driver one standard deviation below the mean anticipated hazards 1.2 s later than a driver one standard deviation above the mean (i.e., a range comprising of approximately the middle two-thirds of the sample, assuming a normal distribution). This result equates to a distance of 20 m of extra travel along the road given a speed of 60 kph (37.5 mph), which represents considerable variation in road safety terms.

1.3. Why might even experienced drivers be performing hazard perception at a suboptimal level?

If it is true that the hazard perception ability of most experienced drivers is suboptimal, then what is happening? One potential explanation is lack of performance feedback. When learning a skill, one of the most important factors that determine progression is the quality of feedback (Ericsson and Ward, 2007). However, with hazard perception, it could be argued that such feedback is virtually non-existent. Consider a situation in which a driver fails to notice a hazard. Unless a crash occurs as a result of the hazard (a relatively rare event), the driver may never even realize that he or she had been at risk. Even other potential feedback events, such as being forced to perform an emergency maneuver, another driver sounding their horn, or comments from passengers are arguably unlikely to provoke the driver to reason that they ought to attempt to improve their hazard perception skill (a more natural reaction might be to attempt to blame other factors). Even if one argues that drivers receive some level of feedback from every road user they encounter, on most journeys virtually all of this feedback indicates to the driver that their performance is sufficient to avoid a collision as they do not actually crash. A related proposal is that while experienced drivers may have driven a great deal, they rarely engage in *deliberate practice* (defined by Ericsson and Lehmann, 1996 as performing activities designed to improve a skill). One reason why drivers may not employ deliberate practice is that they have no incentive to do so, because the majority already believe that their hazard perception skills are exceptional.

1.4. Do experienced drivers have insight into their own hazard perception skill?

The finding that drivers tend to rate themselves as more skillful than others is well replicated (Svenson, 1981; Dejoy, 1989; Delhomme, 1991; McKenna et al., 1991; Gregersen, 1996; Groeger and Grande, 1996; Horswill et al., 2004, 2012; Waylen et al., 2004; Dogan et al., 2012). For instance, Horswill et al. (2004) found that UK drivers (with a mean of 16 years experience) rated themselves as significantly better than both (a) peers with exactly the same driving characteristics as themselves and (b) the average UK driver, for 18 out of 18 specific components of driving skill. This superiority bias was significantly greater for the hazard perception items (85.6% of the sample thought that they were better at hazard perception than their peers) than for either overall driving skill or items relating to vehicle control skill (though see Sections 3.6.6 and 4.4).

Furthermore, researchers have found little or no relationship between self-assessments of hazard perception and validated objective measures of the skill for older experienced drivers (Horswill et al., 2011, 2012). That is, these drivers appear to have virtually no insight into their own level of hazard perception skill. In the context of skill acquisition, the finding that even highly experienced drivers appear to have no idea how good they are at hazard perception could be regarded as remarkable because one feature of developing expertise is accurate monitoring of performance (Ericsson and Ward, 2007). However, this lack of insight could be a direct result of the lack of performance feedback in driving, as previously discussed.

The proposal that even highly experienced drivers are underachieving at hazard perception has substantial implications for road safety. It suggests that there are millions of drivers underperforming in a skill shown to be associated with crash risk. Out of all the important skills that people learn in life, there are not many others that could be described as influencing the risk of death or injury on a daily basis.

1.5. Can hazard perception be improved through training?

Hazard perception ability appears to be susceptible to remedial interventions. Training strategies have included asking drivers to: (1) produce a running commentary of what they are looking at while driving or viewing videorecorded driving footage (Isler et al., 2009; Crundall et al., 2010; Poulsen et al., 2010; Isler et al., 2011); (2) listen to such a commentary provided by an expert driver as a voiceover on a driving video (McKenna et al., 2006; Wallis and Horswill, 2007; Crundall et al., 2010; Horswill et al., 2010b; Isler et al., 2011; Poulsen et al., 2010); and (3) attempt to predict what will happen next when a video-recorded road scene is unexpectedly paused (McKenna and Crick, 1997; Poulsen et al., 2010). The strategy behind these exercises is to facilitate the development of a more sophisticated mental model of driving, focussing attention toward all the elements of the driving scene that need to be inspected in order to search effectively for hazards. Other training regimes have focused on training eye-scanning patterns, where elements of traffic scenes requiring attention are highlighted to trainees (for example, Chapman et al., 2002; Pradhan et al., 2009). Another approach has been to provide error feedback in a simulator (Wang et al., 2010). Notably, some researchers (Shinar, 2007) have remarked that hazard perception training may be one of the more promising avenues for education-based road safety improvements, especially in the light of the general pessimism surrounding the usefulness of driver education in general. Specific hazard perception training has been found to affect performance in hazard perception tests but also to influence relevant eye-scanning patterns (Pradhan et al., 2009) and examiner-rated visual search (Isler et al., 2011) in real driving, suggesting at least some degree of transfer. However, there is no data yet on whether hazard perception training affects crash risk (mainly because of the practical difficulties associated with conducting such a study).

1.6. The current study

In the present study, we first compared the hazard perception ability of experienced drivers without post-license driver training with equivalently experienced police drivers, all of whom had participated in post-license police driver training. Note that the sole previous attempt to compare the hazard perception response times of these groups (McKenna and Crick, 1991) was made over 20 years ago, was not published in the peer-reviewed literature, and was carried out on a different continent with a different hazard perception test. Next, we made the first published attempt to train members of the group considered to be in their prime with respect to hazard perception performance (that is, highly experienced mid-age drivers) using a brief intervention. We predicted that they may yet benefit from even a simple 20 min video-based intervention found to work on other age groups. Note that McKenna and Crick (1991) found that more protracted advanced driver training (over a period of weeks, including around 10 h of one-on-one on-road instruction from an expert plus additional lectures) did improve the hazard perception of experienced mid-age drivers, but the question is whether this effect can be achieved with a dramatically more truncated intervention.

We also assessed self-ratings of drivers' skill before and after training in order to determine: (1) whether there was any correlation between self-rated and objective hazard perception measures that might indicate that highly experienced mid-age drivers had insight into their ability; (2) whether self-enhancement biases exist in this specific population; and (3) whether changes in self-ratings of skill from pre- to post-training mirrored the objective effects of training. One risk of driver skill training is that, in addition to (or even instead of) improving the target skills, it may also increase driver confidence, which has been associated with risky driving behavior (Horswill et al., 2004). That is, if we found that hazard perception training increased drivers' ratings of their own skill, then this could be cause for concern. On the other hand, it could be that training might provide the feedback missing from everyday driving and hence drivers' self-ratings might decrease toward a more realistic viewpoint (on the assumption that self-ratings are inflated in the first place). Also, while correlations between self-ratings of hazard perception and objective hazard perception measures have been investigated for older age groups (no significant correlations were found: Horswill et al., 2011, 2012), the same has not been done for younger age groups. However, it is possible that experienced mid-age drivers have greater insight than older drivers because they are likely to have greater fluid intelligence and drive more frequently.

Finally we evaluated the face validity of the training intervention via a questionnaire. It is one thing to discover that training is useful but it might be quite another to persuade drivers that it is useful, and data on drivers' views of the training may indicate the extent to which such persuasion is necessary.

2. Materials and methods

2.1. Participants

We recruited 26 currently serving or former police officers as our police driver group (see Table 1 for participant characteristics), via acquaintances and snowballing. All had completed police driver training courses (typically including high speed driver training) but did not have experience of hazard perception tests. The mean length of their police service was 20.92 years (*SD* 8.81). They were not paid.

We also recruited 78 experienced Brisbane drivers who had held an open driving license for a minimum of 10 years but had no police driver training or similar (see Table 1 for participant characteristics). Of these 78 participants, 59 drove as part of their job (they were community-based nursing staff who were required to drive to their clients' residences). These participants were recruited via the company for which they worked, and participated during work hours. An additional 9 experienced drivers were recruited by advertisement and paid 10AUD per testing session. A further 10 were acquaintances of the researchers and were not paid. Experienced drivers were randomly assigned to be either in the trained group ($n = 36$) or the placebo control group ($n = 42$).

The three groups (the police drivers and the two experienced driver groups) did not differ significantly on age, years since they had obtained their open license, or days driving per week (see Table 1 for descriptives). However, the police group drove significantly more kilometers per year, $t(100) = -2.21$, $p = .029$, *Cohen's* $d = 0.50$, and contained a significantly smaller proportion of women, $\chi^2 = 34.56$, $p < .001$, compared with the two experienced groups combined (this issue is addressed in Section 3.3).

2.2. Materials

An ASUS V6000 laptop with a 14″ LCD screen was used for all computer-based tests and training tasks described below.

2.2.1. Simple spatial reaction time test

This computer-based task was used to control for individual differences in the response mode (computer mouse) used in the hazard perception test (Smith et al., 2009; Poulsen et al., 2010; Preece et al., 2010). Participants were asked to use the mouse to click on high contrast rectangles that appeared at random locations on the computer screen. Fifteen rectangles were shown, one at a time, at random intervals. The overall spatial reaction time was

Table 1
Participant characteristics.

	Police drivers with post-license training: *M* (*SD*, range)	Experienced drivers without post-license training: *M* (*SD*, range)
Age (years)	47.04 (8.91, 36–65)	49.27 (8.41, 30–64)
Number of years since obtained open driving license	29.27 (8.99, 17–47)	30.54 (8.33, 11–48)
Number of kilometers driven per year*	27,992 (14,412, 5000–57,200)	19,739 (17,063, 2340–100,000)
Number of days currently driving per week	6.58 (0.81, 4–7)	6.42 (1.03, 1–7)
Gender*	85% male (22 out of 26)	21% male (16 out of 78)

* Differences between the two groups were significant for both these variables, $p < .05$.

calculated as the mean of responses across the trials (discarding any null responses). Internal consistency was high (Cronbach's $\alpha = .93$).

2.2.2. Hazard perception test

This test involved participants viewing video footage of genuine traffic situations filmed from the driver's perspective and displayed on the computer. The task was to use the mouse to click on any road users in the videos that could be predicted to be involved in potential traffic conflicts with the camera car (that is, situations in which the camera car would have to slow or steer to avoid a near miss or collision). For example, in one scenario, the camera car was following another vehicle along a road when a taxi in the distance began maneuvering slowly across their path. We would expect a participant with good hazard perception skill to be scanning down the road, beyond the car immediately in front. Hence, they would see the taxi and be able to predict that the leading vehicle would eventually be forced to slow down or stop, creating a traffic conflict with the camera car. In such a situation, it would be appropriate for the participant to click immediately on either the taxi or the leading vehicle. However, a participant with poor hazard perception might not notice the traffic conflict until the leading vehicle had started braking. Before taking the test for the first time, participants viewed a five and a half minute instruction video explaining the task with examples.

The test item pool comprised 51 traffic video clips in total (one hazard in each). For the experienced drivers, these were randomly assigned to three seventeen-clip tests (a pre-intervention test, a test immediately following training, and a test at least one week following training) on a participant-by-participant basis (that is, each participant viewed the 51 clips in a different random order and each of the three tests contained different clips). For each police driver, a single 17-item hazard perception test was created by random selection from the 51-item pool.

The clips were all from previously validated hazard perception tests (Horswill et al., 2008; Smith et al., 2009; Wetton et al., 2010). Evidence supporting test validity included: (1) an association between test scores and self-reported crash risk in older drivers (Horswill et al., 2010a); (2) the ability of test scores to discriminate between novice and experienced drivers (Smith et al., 2009; Wetton et al., 2010); (3) high correlations with other established hazard perception tests (Wetton et al., 2010); and (4) a predicted decline in test performance with age in older adults, as well as associations between test scores and established crash-related measures (namely, Useful Field of View and contrast sensitivity) in this group (Wetton et al., 2010).

For each clip, custom software calculated the duration from when the traffic conflict was first detectable to when the participant clicked on the road user involved. Each participant's overall score for the hazard perception test was obtained via a four-step process. First, we converted each of the participant's individual response times into a z score (using the M and SD of the relevant clip taken from a previous sample of 49 drivers who had viewed all clips in a random order without any interventions that might affect performance). Second, we calculated the mean of these z scores for each participant. Third, we converted this mean into another z score (using the M and SD of the current sample of z scores, because the mean of z scores is not itself a z score). Finally, we converted this z score back into an overall response latency in seconds to aid interpretation. Any clips to which a participant did not respond were excluded from that participant's mean. This hazard perception test has been shown to have high internal consistency in previous work (with slight variations in the clips used), with Cronbach's α between .87 and .90 (Smith et al., 2009; Horswill et al., 2010b). Note that internal consistency could not be calculated in the present study due to the clip assignment process (because any given clip could appear in any of the three tests presented to the experienced participants, varying by participant).

While response time was the primary test measurement (and clips were chosen to reflect this), we also calculated a measure of the proportion of hazards that participants responded to (note that this tended to be close to ceiling and is therefore of limited value as a behavioral measure).

2.2.3. Self-ratings of driving skill

A questionnaire measuring self-ratings of driving skill, based on Horswill et al. (2004), was used. Participants rated themselves on an eleven point scale (1 = "Bottom 10% of Brisbane drivers"; 6 = "Typical Brisbane driver (50% are more skillful; 50% are less skillful)"; 11 = "Top 10% of Brisbane drivers") for 18 specific components of driving skill (note that all experienced drivers were recruited and tested in Brisbane, Australia). These included 6 items relating to hazard perception ("Awareness and anticipation of pedestrian activity"; "Awareness/anticipation of other road users' behavior"; "Monitoring of junctions/bends"; "Maintaining appropriate speeds for conditions"; "Knowing when to overtake"; "Maintaining appropriate following distances"), and 7 items relating to vehicle control ("Parking"; "Reversing/maneuvering"; "Smooth cornering"; "Appropriate use of gears"; "Hill starts"; "Adapting to conditions"; "Controlled emergency stops"). The remaining five items in the questionnaire were not used in our analysis. The vehicle control measure was intended as a control for the hazard perception measure, allowing us to determine the specificity of any effects on hazard perception self-ratings. Participants also rated their own peer group (defined as, "Brisbane drivers of the same gender, age, occupation, driving training and experience as you") on the same items. Internal consistencies of the hazard perception and vehicle control scales were good (Cronbach's α of hazard perception scales: self-rating/pre-intervention = .90; peer-rating/pre-intervention = .93; self-rating/post-intervention = .95; peer-rating/post-training = .94; Cronbach's α of vehicle control scales: self-rating/pre-intervention = .92; peer-rating/pre-intervention = .95; self-rating/post-training = .96; peer-rating/post-intervention = .94). Participants were also asked to rate their own and their peer group's (peer group was defined as above) performance on the hazard perception test using the same 11 point scale.

2.2.4. Hazard perception training

Participants assigned to the hazard perception training group engaged in two types of exercise (4 examples of each, presented alternately; 19 min total). The first involved them watching a clip of traffic and producing a verbal commentary, indicating both potential hazards and locations that should be monitored for potential hazards. Then the same clip was replayed, accompanied by an expert driver's commentary to allow the participants to compare their performance with the expert's. The expert driver commentaries had been generated by combining the best excerpts from commentaries provided by three expert driving instructors into a script which was recorded as a voice-over by a professional actor (see Poulsen et al., 2010, for further details). When the clip was finished, the researcher provided feedback on how many relevant features were identified by participants compared with the expert commentary (using a checklist transcription of the expert commentary). The second exercise-type involved participants watching traffic footage that cut abruptly to a black screen without warning. Participants were then given 5 s to generate possible incidents that could happen after the point of occlusion. Next, the clip was replayed and participants heard a recording of an "expert" listing potential incidents (with the point of occlusion displayed as a still frame). The expert voice-over was created in the same way as the expert commentaries. Finally the clip was played past the point of occlusion to show what actually happened next (which always included one of the expert's predictions).

2.2.5. Placebo intervention

Participants assigned to the placebo control group viewed the same traffic scenes shown in the training but without the expert commentary or occlusions. They also viewed additional similar traffic scenes in order to make the placebo and training interventions of comparable length (19 min). They were instructed to attend closely to the videos.

2.2.6. Ratings of perceived training effects and the hazard perception test

We created a new questionnaire designed to capture the face validity of the training and placebo interventions. There were five questions (see Fig. 4 for questions) with five response options (1 = not at all; 2 = to a very small extent; 3 = to a small extent; 4 = to a reasonable extent; 5 = to a great extent).

2.3. Procedure

2.3.1. Police drivers

The police drivers were tested at their places of residence. They first gained familiarity with the sensitivity of the computer mouse by clicking in sequence through an array of numbers randomly arranged on the screen. Then they completed the simple spatial reaction time task and a single 17-item hazard perception test (preceded by the instruction video). Finally they answered questions about demographics and driving history.

2.3.2. Experienced drivers

Participants in the two experienced driver groups were tested over two sessions, separated by at least one week ($M_{separation}$ = 8.13 days; $SD_{separation}$ = 4.69 days; range 7–35 days). Each participant was tested at their workplace (fleet drivers), the University, or their place of residence.

The first session took approximately 1 h. As with the police group, participants first completed the computer mouse familiarization task and the simple spatial reaction time test. Next they viewed the hazard perception test instruction video and completed their first 17-item test (pre-intervention test), before answering questions about demographics and driving history. Then they completed the self-ratings of driving skill. Following this, those in the "trained" group engaged in the training package, while those in the control group engaged in the placebo intervention. Following the training or placebo intervention, participants completed a second 17-item hazard perception test (immediate post-training test).

The second session took approximately half an hour. Participants repeated the computer mouse familiarity task, and viewed the hazard perception test instruction video again. They then completed a third 17-item hazard perception test (delayed post-training test) and completed the self-ratings of driving skill questionnaire a second time. Finally, all participants completed the ratings of perceived training effects. Following completion of the study, participants in the placebo control group were offered the opportunity to view the training materials.

3. Results

3.1. Skewness and exclusions testing

All relevant variables were checked for skew and transformed if appropriate. However, in every case (with a single exception indicated below), the transformation did not change the pattern of findings, so results using the untransformed variables are presented unless indicated. Three individuals responded to less than 50% of the hazards, which could raise questions as to the viability of their response time scores. Also, we identified univariate outliers ($z > 3.29$) in the hazard perception and simple spatial reaction time data. Relevant analyses were conducted with and without all these individuals and the pattern of results did not change, so the statistics reported below include their data.

3.2. Testing for heterogeneity in the experienced driver sample

It is plausible that the fleet drivers and non-fleet drivers recruited as part of the experienced driver group might differ in hazard perception ability. However, we found no significant differences in hazard perception response time or hazard perception hit rate for either pre-intervention, immediate post-intervention, or delayed post-intervention (all p's > .1). We therefore combined the fleet and non-fleet drivers for all subsequent analyses.

3.3. Police drivers vs. untrained experienced drivers

We used two ANCOVAs to assess hazard perception differences between the police drivers and the experienced drivers, with simple spatial reaction time entered as a covariate in each. In the first analysis, the dependent variable was hazard perception response time (pre-intervention). We found a significant main effect of expertise, $F(1,101) = 4.99$, $p = .028$, $\eta^2 = .05$, in which the police drivers (estimated marginal M_{police} = 4.32 s, SE_{police} = 0.49 s) responded 1.27 s faster to hazards than the experienced drivers (estimated marginal $M_{experienced}$ = 5.59 s, $SE_{experienced}$ = 0.28 s). The second analysis revealed that the police drivers also responded to a higher proportion of the hazards than the experienced drivers, $F(1,102) = 4.62$, $p = .034$, $\eta^2 = .04$ (estimated marginal M_{police} = 96.60%, SE_{police} = 2.60%; estimated marginal $M_{experienced}$ = 90.10%, $SE_{experienced}$ = 1.50%).

In the light of group differences in kilometers driven and gender ratios, we tested to see whether either of these variables influenced hazard perception response time. There was no significant correlation between kilometers driven per year and hazard perception response time and no significant gender difference in hazard perception response time (p's > .05, both for the entire sample and for each individual experience group). Also, experienced/police driver differences in response time remained significant, $F(1,97) = 5.11$, $p = .026$, $\eta^2 = .05$, after adjusting for both kilometers driven per year and gender.

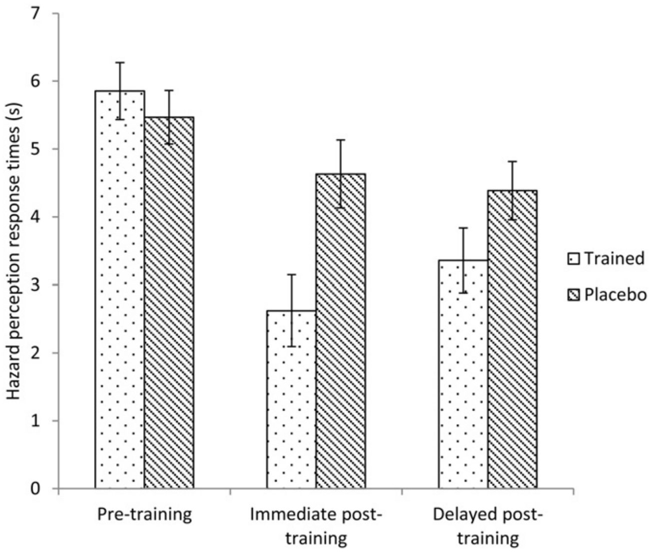

Fig. 1. Hazard perception response times(s) for trained and placebo experienced drivers (error bars are standard errors of the mean).

3.4. The effect of training on experienced drivers' hazard perception scores: immediately and after a delay of at least one week

3.4.1. Immediate effect of training on response time

To determine the effect of training, we carried out an ANCOVA with training group (trained vs. placebo) as the independent variable, hazard perception response time immediately after training as the dependent variable, and two covariates: hazard perception response time before training, and simple spatial reaction time. We found a significant main effect of training group, $F(1,74) = 12.12$, $p = .001$, $\eta^2 = .14$, in which the trained drivers (estimated marginal $M_{\text{trained}} = 2.50$ s, $SE_{\text{trained}} = 0.47$) anticipated traffic conflicts 2.24 s earlier than the placebo drivers (estimated marginal $M_{\text{placebo}} = 4.74$ s, $SE_{\text{placebo}} = 0.44$). Raw means are presented in Fig. 1.[1]

3.4.2. Delayed effect of training on response time

The same analysis was carried out with hazard perception response time one week after training as the dependent variable. Note that the delay was not exactly one week for all participants (see Section 2.3) but there was no significant difference in this delay between the trained and the placebo group, $t(75) = 0.56$, $p = .580$. We found a significant main effect of training, $F(1,73) = 7.08$, $p = .01$, $\eta^2 = .09$, where, in the second session, trained drivers (estimated marginal $M_{\text{trained}} = 3.19$ s, $SE_{\text{trained}} = 0.37$) anticipated traffic conflicts 1.34 s earlier than the placebo drivers (estimated marginal $M_{\text{placebo}} = 4.53$ s, $SE_{\text{placebo}} = 0.34$). Fig. 1 contains the raw means.

3.4.3. Effect of training on hit rates

The analyses on immediate and delayed post-intervention hazard perception ability were also carried out with hazard perception hit rates as the dependent variable (and pre-intervention hit rate as a covariate). No significant main effects of training were found in either case (both p's > .50).

[1] The training effect analyses for hazard perception response time were repeated using a 2 way ANCOVA with group and pre- vs. post-intervention as independent variables, where an interaction would indicate a significant training effect. We found the same pattern of results (i.e. both group × pre vs. post interactions were significant), indicating that the outcomes were robust to using alternative analysis strategies.

3.4.4. Decay of the training effect over time

To determine whether there was any change in the training effect during the time between sessions, we carried out a mixed design ANOVA with training group (trained vs. placebo) and immediate vs. delayed post-intervention test as independent variables, hazard perception response time as the dependent variable, and simple spatial reaction time as a covariate. The interaction between training group and immediate vs. delayed was not significant, $F(1,74) = 1.48$, $p = .227$, indicating that the magnitude of the training effect did not change significantly following the delay.

3.5. Correlations between self-ratings of hazard perception test performance and actual hazard perception test scores among experienced drivers

The Pearson correlations between Session 1 self-ratings of on-road hazard perception ability (based on averaging the 6 hazard perception items in the self-rating questionnaire) and pre-intervention hazard perception ability were not significant (response time: $r = .19$, $p = .123$; hit rate: $r = -.06$, $p = .621$; see Fig. 2 for self-rating means). We also found no significant correlation between self-rated hazard perception test performance and actual hazard perception test performance (response time: $r = .22$,[2] $p = .070$; hit rate: $r = -.05$, $p = .673$).

3.6. Self ratings and "better than average" effects among experienced drivers

3.6.1. Bias scores

Bias scores for hazard perception and vehicle control were calculated by subtracting peer-ratings from self-ratings for each relevant item and then calculating the average of these for the each set of items (Horswill et al., 2004). A positive bias score would therefore indicate that drivers on average rated themselves as better than Brisbane drivers of the same, gender, age, occupation, driving training, and experience as themselves (i.e., their own peer group). Bias scores for self-rated performance on the hazard perception test were also calculated. One sample t-tests indicated that all bias scores, both before and after training, were significantly greater than zero (that is, participants tended to rate themselves as better than peers with the same characteristics as themselves; all p's ≤ .001). Means are presented in Fig. 3.

3.6.2. Self-ratings

Self-ratings of hazard perception ability, vehicle control skill, and performance in the hazard perception test were all significantly greater than the scale's midpoint of 6, which equated to the median driver (all p's < .001). The means are displayed in Fig. 2.

3.6.3. The effect of training on hazard perception self-ratings

Changes in overall hazard perception self-ratings as a result of the training were evaluated using a mixed design ANCOVA. Training group (trained vs. placebo) and pre- vs. post-intervention were entered as independent variables, and self-rated hazard perception ability was the dependent variable (the bias score was not used as the peer-rating definition contained a reference to training, which could have been interpreted as including the training administered in this study). There was a main effect of pre vs. post, $F(1,67) = 4.62$, $p = .035$, $\eta^2 = .06$ (self-ratings were slightly lower following the intervention), no main effect of training group,

[2] Note that the response time correlation reported here used the transformed score (see Section 3.1), where using the untransformed data produced a significant correlation in the reverse direction (higher self-rating equating to worse performance), which was presumably an artifact of the skew in the raw data.

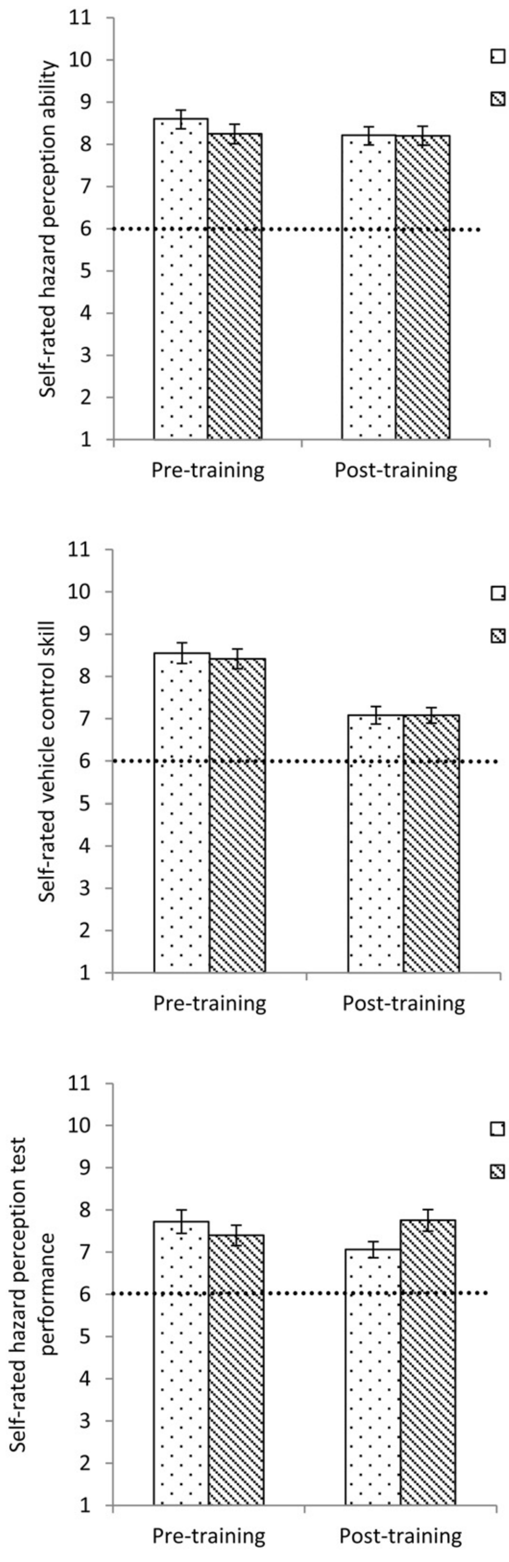

Fig. 2. Self-rated hazard perception ability, vehicle control skill, and hazard perception test performance, compared with the median driver as represented by the scale midpoint of 6 (denoted by dotted line) (error bars are standard errors of the mean).

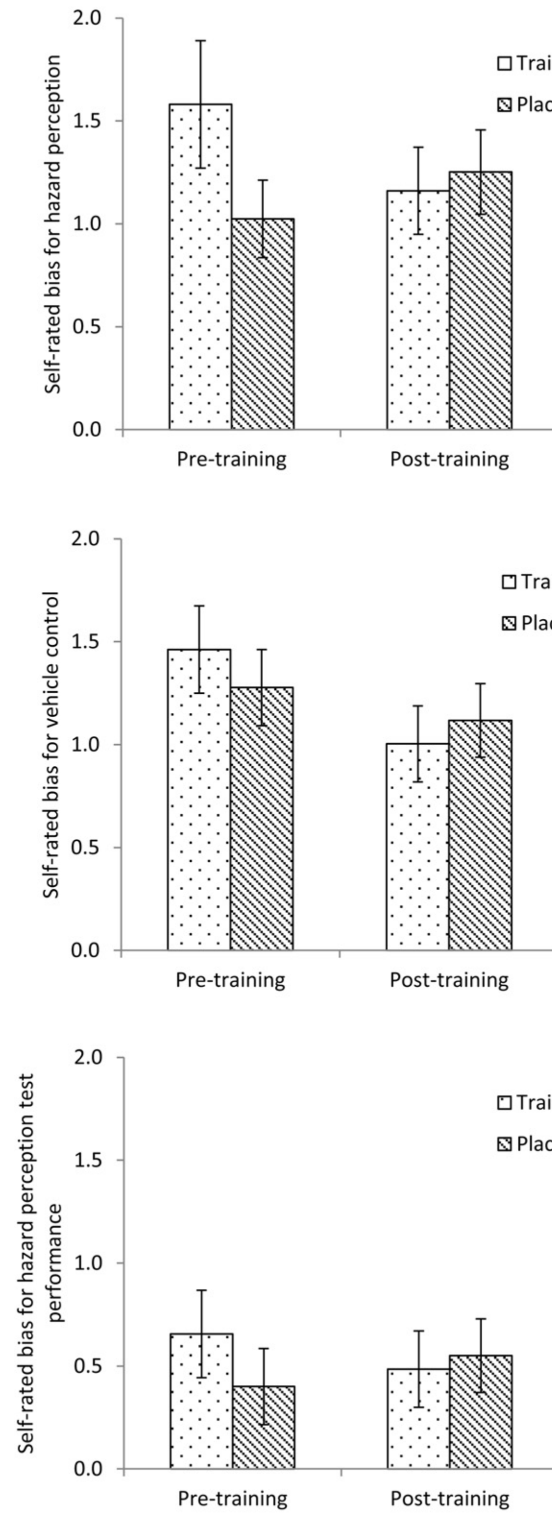

Fig. 3. Bias scores (self-rating minus peer-rating) for hazard perception ability, vehicle control skill, and hazard perception test performance (error bars are standard errors of the mean). A positive score indicates that drivers rated themselves as better than Brisbane drivers of the same gender, age, occupation, driving training, and experience as themselves (i.e., their own peer group).

$F(1,67) = 0.26$, $p = .614$, and no significant interaction, $F(1,67) = 3.16$, $p = .080$ (see Fig. 2).

3.6.4. The effect of training on vehicle control self-ratings

The same pattern of results was found when the same analysis was run on self-ratings of vehicle control skill, but the main effect of pre- vs. post-intervention appeared to be much larger (main effect of pre vs. post: $F(1,67) = 75.74$, $p < .001$, $\eta^2 = .53$; main effect of training: $F(1,67) = 0.02$, $p = .882$; interaction: $F(1,67) = 0.33$, $p = .565$; see Fig. 2).

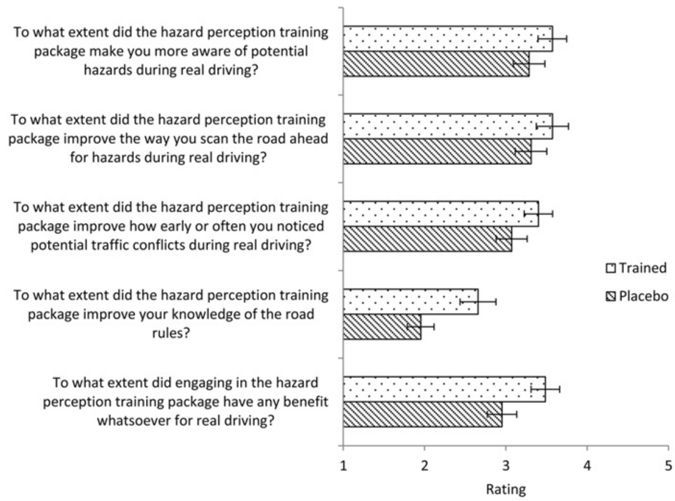

Fig. 4. Mean ratings (error bars indicate standard errors of the mean) for the training evaluation questionnaire (1 = not at all; 2 = to a very small extent; 3 = to a small extent; 4 = to a reasonable extent; 5 = to a great extent).

3.6.5. *The effect of training on self-ratings of performance in the hazard perception test*

This analysis was repeated using self-rated performance in the hazard perception test and a different pattern of outcomes was observed (see Fig. 2). Both main effects were not significant (main effect of time: $F(1,64) = 0.43$, $p = .513$; main effect of training group: $F(1,64) = 0.23$, $p = .637$) but there was a significant interaction, $F(1,64) = 10.79$, $p = .002$, $\eta^2 = .14$. Simple effects analyses revealed that trained participants significantly lowered their self-ratings of hazard perception test performance following the intervention, $t(28) = 2.35$, $p = .026$, *Cohen's* $d = 0.45$, but placebo control participants significantly increased their self-ratings, $t(36) = -2.22$, $p = .033$, *Cohen's* $d = -0.37$.

3.6.6. *The biases for hazard perception and vehicle control compared*

Finally, we wanted to determine whether hazard perception bias was significantly greater than vehicle control bias, as reported by Horswill et al. (2004). Using data from Session 1 only to avoid any manipulation effects, we found no significant difference between the magnitudes of the hazard perception and vehicle control biases, $t(68) = -0.82$, $p = .417$.

3.7. *Ratings of perceived training effects*

Fig. 4 displays the mean responses to the questionnaire in which participants rated the perceived benefits of the intervention. The trained group reported a significantly higher rating than the placebo group for "Knowledge of the road rules" (this was a control item not intended to be related to hazard perception training), $t(75) = 2.62$, $p = .011$, *Cohen's* $d = 0.60$, and "Any benefit whatsoever", $t(75) = 2.10$, $p = .039$, *Cohen's* $d = 0.49$, but there were no group differences for the three items specifically asking about hazard perception ability (all p's > .2).

4. Discussion

This study examined hazard perception ability in highly experienced mid-age drivers, and explored several hypotheses. First, we predicted that police drivers would respond faster to hazards than mid-age experienced drivers in a validated hazard perception test. Second, we predicted that the hazard perception ability of the mid-age experienced drivers could be improved with a brief, video-based intervention. Third, we predicted that the self-ratings of the trained drivers might be affected by the intervention. Fourth, we predicted that the training intervention would display some face validity compared with a placebo. We found support for some of these hypotheses.

4.1. *Hazard perception test scores: effects of training*

The results indicated that the police drivers were significantly faster at anticipating traffic conflicts compared with the experienced driver group, consistent with our proposal that even though the experienced drivers had at least a decade of practice in detecting hazards, their performance was still not optimal.

Those experienced drivers who received the hazard perception training intervention responded significantly faster to hazards than those who received the placebo intervention, both immediately following the intervention and after a delay of at least one week. There was no evidence that the training effect decayed during the delay. Again, this indicates that the hazard perception ability of experienced mid-age drivers can be improved (as measured in a validated video-based measure) via a relatively trivial 20 min intervention, despite these drivers being close to their life-time peak in this skill according to previous data (Quimby and Watts, 1981).

Past experience of driver education effects in the road safety literature warns us to be cautious when extrapolating these findings (Shinar, 2007) and we would be foolhardy to claim that a one-off 20 min intervention would create a permanent improvement in the on-road hazard perception ability of experienced drivers on the basis of our findings. However, the present data is still encouraging as a first step (where subsequent steps would include providing evidence of long term transfer to real driving performance and crash risk). The intervention we employed is straightforward enough for low-cost dissemination on a large scale (the materials are video clips and no driving instructor is required to be present) and therefore, if multiple repeat sessions over a longer timeframe are required for a more lasting effect, then this would not necessarily be problematic. In terms of the likelihood of transfer to real driving, we do have recent data (Wood et al., in press) in which hazard perception test scores correlated with on-road driving performance (as rated by an occupational therapist and a driving instructor) in a sample of older drivers. This, in addition to previous demonstrations of the transfer of computer-based hazard perception training to on-road measures (Pradhan et al., 2009; Isler et al., 2011), provides some grounds for optimism.

4.2. *Effects of training on driver self-ratings of skill*

One concern associated with any driver training is its potential effect on driver confidence. In some cases, driver training designed to improve road safety has been found instead to have the opposite effect (Gregersen and Nyberg, 2003). Gregersen (1996) demonstrated that certain types of driver training may increase driver confidence as well as driver skill. Increased driver confidence has been associated with more risky driving intentions (Horswill et al., 2004), which may counteract the safety benefits associated with improving skill. The present data suggests that this is not a problem for our hazard perception training. Ironically, we found that, while the training improved objectively measured hazard response times, the participants' self-ratings of their hazard perception skill did not increase in line with this (and in fact were significantly decreased among both trained and placebo participants). In relation to perceptions of performance in the test itself, trained (but not placebo) participants also reduced their self-ratings following the training.

The decrease in self-ratings across both groups might indicate that drivers received some degree of feedback during the test itself (even though there is no explicit feedback given, participants may gain a sense for when they are detecting a hazard late, given that most people responded to most hazards). The decrease in self-ratings specific to the trained group could be due to the use of expert modeling as part of the training procedure. During the training, participants could directly compare the expert driver's performance on the two training tasks with their own performance, and were given explicit feedback on their commentary performance relative to the expert. These findings are in contrast to Dogan et al. (2012) who found that providing performance feedback in the form of test scores following a hazard perception test did not affect drivers' self-evaluations. Instead, they reported that drivers, when provided with negative feedback, appeared to question the credibility of the test (and did not adjust their self-ratings to take account of the feedback). Our finding that the training (and associated feedback) modified self-ratings to some degree raises the possibility that self-evaluations potentially could be rendered more accurate if the right form of persuasive feedback could be identified.

It is worth noting that self-ratings of vehicle control skills also decreased significantly following both placebo and hazard perception training. While this was unexpected, one possible explanation is that the overall procedure encouraged some sort of reflective reassessment among participants. From a road safety point of view, this could probably be regarded as a positive outcome in itself.

4.3. Association between subjective and objective measures of hazard perception performance and the face validity of hazard perception training

The non-significant correlations reported between self-ratings of performance and objectively-measured test performance suggest that, like other driver groups (Horswill et al., 2011, 2012), the experienced mid-age drivers in our sample had little insight into either their own level of hazard perception skill or their performance in the test. This finding is consistent with participants' ratings of the face validity of the training, where those who received the training rated the intervention the same as those who received the placebo in terms of its ability to improve their hazard perception skill. One interpretation is that our placebo intervention was in itself considered by participants to be a successful hazard perception intervention (participants reported that both placebo and training affected elements of their hazard perception skill on average between a "small" and a "reasonable" extent; see Fig. 4) but this still leaves us with the conclusion that the pattern of findings for objectively measured hazard perception ability were not reflected in participants' beliefs. Ironically, the trained group did rate the intervention higher than the placebo group at improving their knowledge of the road rules even though this was something that the training was not designed to do. Although the trained group also rated the intervention higher than did the placebo group, in terms of it providing some benefit overall, the benefit they had in mind seems unlikely to have been improved hazard perception skill.

The self-report results are encouraging in the sense that they indicate that our training is unlikely to lead to greater confidence, greater risk taking, and hence increased crash risk. This outcome is consistent with evidence from McKenna et al. (2006) who found that video-based hazard perception commentary training, similar to that used in the present study, decreased risk-taking intentions. However, this finding does present another problem. If drivers cannot tell that their hazard perception ability is being improved by the training (coupled with the finding that they believe that they are superior than others at this skill) then it may be difficult to persuade drivers to engage in this training in the first place. That is, if such a training package were to be made available to all drivers, then we need to consider how it ought to be promoted. If individuals do not believe that the training is of value then this could be a barrier to its uptake.

4.4. "Better than average" effects

It is worth noting that while we replicated the robust "better than average" effects for driver skill found previously in the literature for other driver samples, we failed to replicate the specific finding of Horswill et al. (2004) that hazard perception biases were greater in magnitude than vehicle control biases. One possible explanation for this discrepancy is that drivers in the present study had already completed the hazard perception test and therefore knew that their hazard perception ability had been measured objectively. The accountability associated with this may have decreased their biases enough to eliminate this difference (though not enough to eliminate the bias altogether). In the study by Horswill et al. (2004), the actual hazard perception ability of participants was not measured.

4.5. Practical issues in implementing hazard perception training

We should point out that we are not suggesting that road safety overall is best served by focussing on experienced mid-age drivers to the exclusion of other more risky groups such as novices. However, just because most of the road safety effort probably ought to be aimed at the highest risk groups, this does not mean that we need to ignore experienced mid-age drivers, especially if an effective intervention can be delivered to them at little cost. From a practical point of view, it is likely to be difficult to persuade individual drivers to engage in training voluntarily and also difficult to persuade licencing agencies to mandate such training. However, fleet managers, for instance, might be highly motivated to mandate low-cost training for fleet drivers if an economic benefit was likely (i.e., the possibility of reducing the high cost of employee crashes across an organization). That is, opportunities for implementing the sort of driver training described in this paper may already exist with respect to certain driver groups.

5. Conclusions

We present evidence that even highly experienced drivers are performing at suboptimal levels in hazard perception despite a decade or more of engagement with the task. They were outperformed by police drivers and their performance could be enhanced by a relatively trivial intervention, where benefits were maintained after a delay of at least a week. What is more, participants did not appear to be sensitive to changes in their performance relative to a placebo group and self-ratings of hazard perception performance did not reflect their actual performance. We propose that this type of training may be of benefit for even highly experienced mid-age drivers, though further work is needed to establish whether there is longer term transfer to real driving and to crash risk. However one key obstacle that may need to be overcome first is persuading drivers to engage in the training, especially if the package is not perceived as being more effective than a placebo by those who complete it.

Acknowledgements

The authors thank Bluecare (Queensland) for assisting us to recruit their employees, providing facilities for testing, and paying staff for their time while completing the study. We acknowledge assistance and funding from Queensland Transport to develop the training materials, in particular John Burrill and his colleagues. Some of the data in this paper was presented in a talk for the International Conference on Traffic and Transport Psychology 2012 (Groningen, The Netherlands).

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