The effects of road commentary training on novice drivers' visual search behaviour: A preliminary investigation

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Abstract

One of the major challenges facing novice drivers seems to be adequately scanning, detecting, and responding to hazards which present during the course of everyday driving; a process that involves 'reading the road' and modifying driver behaviour accordingly. Previous studies have indicated that inexperienced drivers tend to utilise only a small proportion of the visual field when driving, and this limited visual search behaviour may play a significant role in the over-representation of young novice drivers' involvement in crashes. This deficiency in visual search is especially evidenced through crashes occurring at intersections, or other densely populated road environments. More recently, road commentary has become of interest within a number of driver education initiatives, and several current studies have indicated that road commentary indeed improves drivers' performance in hazard perception tasks. However, relatively little is known about commentaries influence on the underlying cognitive mechanisms responsible for enhanced situation awareness or hazard awareness, and whether such improvements generalize to a broader range of road scenarios. Using hazard perception and eye-tracking measures, we started to examine how road commentary could influence the way drivers visually accrue and process essential road information. First, our data confirmed that commentary training significantly increased the percentage of hazards identified. But additionally, preliminary eye movement data indicated that road commentary may have influenced visual search behaviour of the participants by 'prompting' them to allocate extra visual attention capacity to hazard rich areas, as evidenced by an increase of their fixation clusters across the visual field. This could help increase situation awareness, and convert to safer driving behaviour and reduced risk-taking.

Introduction

According to the World Health Organisation (2007), vehicle crashes are the single greatest cause of death for young people aged between 15 and 29 years. Internationally, young novice drivers are over-represented in crash and traffic fatality statistics, particular during the first year of unsupervised driving (Preusser & Leaf, 2003; Williams, 2003). While there have been a number of factors identified that contribute to young drivers heightened crash likelihood, deficiencies in higher level skills such as visual search and hazard perception have been suggested as a significant predictor of crash involvement (Underwood, Chapman, Bowden, & Crundall, 2002; Crundell et al., 2004). Although primary driving skills (such as vehicle handling) can be acquired in a relatively short amount of time, novice drivers often lack the 'higher' cognitive skills required to drive safely (Groeger, 2000). These skills include the processing of sensory information from the road environment, and the ability to anticipate the behaviour of other road users and react accordingly (McKenna, Alexander, & Horswill, 2006).

Hazard perception involves the ability to 'read the road', to accrue information about the traffic and road situation, analyse, and ultimately lead to effective responses. Visual search and attention play a critical role in effectively identifying hazards, and inadequate scanning of the visual field has been suggested as contributing to diminished hazard awareness, and consequentially, increased crash likelihood (Underwood, Crundall, & Chapman, 2002; Crundall & Underwood, 1998;

Konstantopoulos, Chapman, & Crundall, 2010, 2012). Chapman, Underwood, and Roberts (2002) found that road commentary training produced different patterns of eye-movement and visual search behaviour in young drivers when combined with hazard anticipation and visual search. They found that the commentary training intervention resulted in greater horizontal breath of search, as well as shorter fixation times during more hazardous road scenarios. In particular, commentary training may assist the development of more efficient search strategies, where visual search is allocated to the areas of the visual field where hazards are more likely to emerge.

Road commentary training has been shown to significantly improve responsiveness to hazards in simulator experiments (Crundall, Andrews, van Loon, & Chapman, 2010) and in regard to on-road assessment (Isler, Starkey, & Sheppard, 2011). Furthermore, road commentary has been demonstrated to improve the number of hazards detected and responses within a very short period of training (Isler, Starkey, & Williamson, 2009), and to increase drivers willingness to rate road situations as hazardous (Wallis & Horswill, 2007). Isler et al., (2009) note that commentary training may "encourage drivers to actively search for hazards and may improve their situation awareness and lead to a better appreciation of the risks involved." (pp. 451)

This research attempted to examine further the effects of road commentary training on novice drivers' visual search behaviour using eye-tracking technology and a laboratory, video-based hazard perception task.

Method

Participants

Sixteen male and four female drivers, holding a New Zealand learner licence, were recruited from two high schools. The average age of the participants was 16.6 years (*SD* = 0.6). The average self-reported time since obtaining learner licence was 11.6 months (*SD* = 11.7) and the average self-reported distance driven per week was reported as 38km (*SD* = 38.9). Participants were given a $10 voucher as appreciation for their involvement in the study.

Apparatus

The experiment used a desk mounted EyeLink™ 1000 eye tracker (1000Hz sampling rate) in order to collect the eye movement data. The experimental trials and different conditions were developed using the Experimental Builder (V1.4) from SR Research Ltd. run by two Dell OptiPlex 760 Minitower desktop computers (3GHz processor, 4GB RAM) running Microsoft Windows 7. One computer deployed the hazard perception task, and the other computer processed the eye-tracker information. The computer displaying the videos was equipped with a 2GB graphics card, and videos were shown using a ViewPIXX 22 inch LCD monitor with a resolution of 1920 x 1200 pixels.

Hazard Perception task

The hazard perception task used for the baseline and post-training assessments involved participants viewing five video traffic scenarios for each assessment (ranging from 20-50 seconds duration), while searching and identifying any immediate hazards that appeared through the course of the videos. Participants were instructed to move a circle on the screen using the mouse, and click on hazards as they identified them. Other instructions given to participants were "Your task will be to identify immediate hazards by clicking on them with the mouse as soon as you detect them. Immediate hazards are hazards such as braking cars, pedestrians walking over the road, cyclists, road workers, etc., which potentially could get into your way so that a driving action would be required (e.g., braking, steering away, etc.)." Each mouse click was accompanied by a 'beep' sound.

This task provided a measure of the percentage of hazards identified by participants for both the baseline and post-training assessment. For each assessment, there were a total of 20 immediate hazards throughout the five video scenarios.

The videos which were used in the experiment were created using footage of New Zealand roads, encompassing a variety of different situations (i.e. school crossings, multiple lane roads), displayed from a drivers perspective including mirrors and dashboard (see Figure 1). The videos were compressed to 1080p resolution, and presented without audio.

Figure 1: A sample scene from the hazard perception task

Road commentary training intervention

The participants selected for training received instructions on how commentary should be performed in the experiment. The training involved participants verbally identifying immediate hazards, and expressing how they might alter their driving behaviour (i.e. "I am approaching a school patrol, so I am watching for children crossing and slowing down").

There were two practice trials. For the first trial, participants were provided with an example of road commentary, performed by a driving expert on a busy urban section of road, and then were required to produce their own commentary on the same section of road. For the second practice trial, participants were required to provide commentary for a second filmed road, and afterward listen to the accompanying expert commentary. Twelve trials of road commentary training followed with the participants providing the road commentary without any expert commentary.

Experimental design and dependent measures

The twenty participants were randomly allocated into one of two equally sized groups, with one group receiving a road commentary training intervention, and the control group receiving no training. The study used a repeated measures design with a baseline assessment of hazard perception, an intervention (either commentary training or no-training), and a post-training hazard perception assessment. The dependent measures used were the percentage of hazards identified, and the number, locations and durations of eye fixations. Fixations were defined as events where the eye was not in a state of saccade or blink. Fixations that were shorter than an interval of 80ms were excluded, as these often preceded multiple short saccades, and were considered as corrective eye-movements not related to acquisition of visual information. Fixations of duration greater than

140ms were considered to relate to sustained focal processing, potentially indicating where drivers visual attention was orientated (e.g. Crundall & Underwood, 1998).

Procedure

Ethics was approved for this experiment by the School of Psychology ethics committee in July 2012. Participants were informed of the experiment, and provided informed consent before participating. The participant was first seated directly facing the computer monitor screen on which the videos were displayed, with their eyes approximately 57cm away from the monitor, and used a chin and forehead rest to keep their head position stationary during the experiment.

The eye-tracker was calibrated for each participant prior to the hazard perception task commencing. The participants first performed two practice trials of the hazard perception task, where participants could become familiar with using the mouse to indicate hazards. Once participants had completed the practice trials, a baseline assessment of hazard perception task was performed. After this, participants who had been allocated to the commentary training group were taken through the road commentary training (as described previously), and then asked to provide a running verbal commentary for each of 12 videos, and audio recording of the commentary was taken. Participants who were in the control (no-training) group were instructed to simply watch the 12 videos as if they were the driver. The post-training hazard perception assessment was the final stage of the experiment.

Results

The effect of commentary training on number of hazards identified

Figure 2 shows the mean percentage of hazards identified for the two groups (no training, with training). Visual inspection of the figure shows that road commentary training improved the percentage of hazards identified, while there was little change visible in the no-training group.

A mixed, repeated measures ANOVA (no training / training as a between subject factor, and baseline / post-training as a repeated measure factor) confirmed the descriptive findings. A significant main effect was found for the repeated measures factor, $F(1,18) = 6.031$, $p < 0.05$, $\eta p2 = 0.251$. This indicated that overall, the percentage of hazards identified in the post-training task (M = 76, SD = 24.04) were significantly greater than the percentage of hazards detected in the baseline task (M = 66.25, SD = 22.53).

The interaction between the repeated measures factor and the between subject factor was also found to be statistically significant, $F(1,18) = 12.802$, $p < 0.01$, $\eta p2 = 0.416$, which suggests that the commentary training had a significant influence in improving hazard perception. While both groups detected a similar percentage of hazards in the baseline trial, the trained group detected significantly more hazards (*M* = 84.9, *SD* = 22.23) following training compared with the no-training group (*M* = 63.9, *SD* = 21.35).

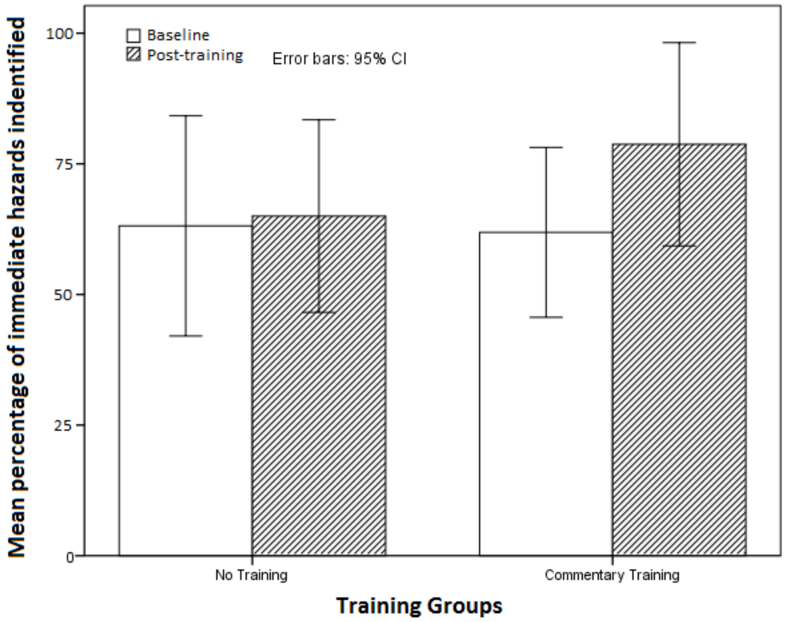

Figure 2: Mean percentage of hazards identified by the two groups for the baseline and post-training assessments

The effect of commentary training on fixation clusters

Using the Eye-link software, fixation maps were generated for each of the baseline and post-training videos for each participant. Figure 3 clearly indicates the road commentary training group showed a greater number of fixation clusters compared to the no-training group. Another, mixed repeated measure ANOVA on the number of fixation clusters observed in the fixation maps confirmed a significant main effect for the repeated measures factor $F(1,18) = 31.547$, $p < 0.01$, $\eta_p^2 = 0.693$.

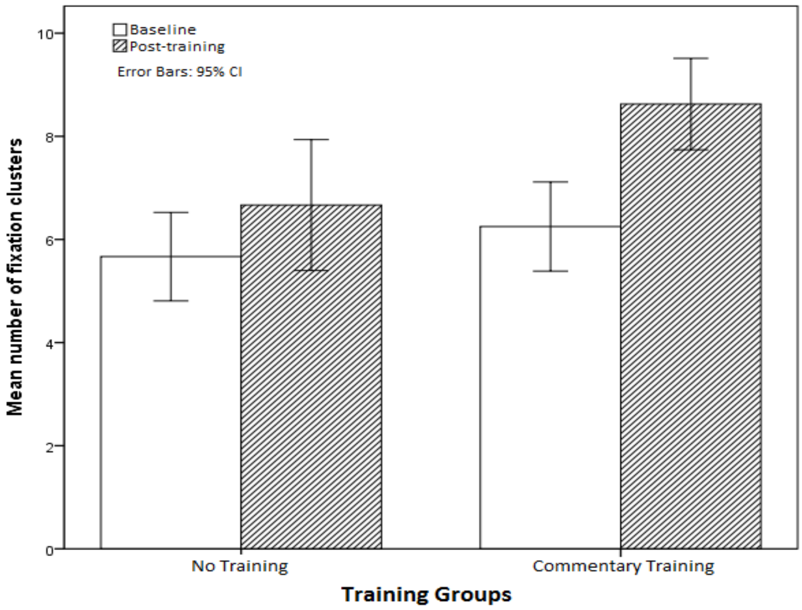

Figure 3: The number of fixation clusters of the two groups for the baseline and post-training assessments

The interaction between the repeated measures factor and the between subject factor was also found to be statistically significant, $F(1,18) = 6.720$, $p < 0.05$, $\eta_p^2 = 0.324$. While both groups had a similar number of fixation clusters in baseline assessment, the commentary group had a greater number of clusters following training (*M* = 8.63, *SD* = 1.061) compared to the no-training group (*M* = 6.67, *SD* = 1.211), which suggests that the commentary training may influence the way drivers search the visual field and acquire information from hazard rich areas.

Fixation maps were calculated using a Gaussian function, with the maximum number of fixation time appearing in red, then the gradient of colour is shown by the number of standard deviations from the maximum value. This allowed images to be generated showing the relative amount of fixation time dedicated to each area of the visual field. Clusters of fixations, which were regions where the most visual attention was dedicated, were counted for both groups of participants at baseline and post-training, and these were analysed using repeated measure ANOVA. Analysis indicated that there was a significant difference between commentary training and non-training group, $F(1,18) = 22.827$, $p < 0.01$, $\eta_p^2 = .647$, with a large effect size.

Both groups had similar numbers of fixation clusters in the baseline assessment (*M* = 6.0, *SD* = 0.894). However, a number of differences were identified between the two training groups in the post-training assessment. Participants who received the commentary training were found to have significantly more fixation regions (total clusters = 68) than the no-training group (total clusters = 43). Furthermore, the breath of search appears to be wider for the commentary group when compared with the no-training group.

Notably, the fixation clusters were located on areas where hazards were most likely to present, such as in the median strip on busy city streets, or parked cars skirting the carriage way on the roads about schools. It could be assumed that these clusters are found in areas which are rich in hazards, and more dedicated fixations on these regions may suggest greater vigilance for detecting hazards. Figure 4 shows typical fixation clusters of two participants from each group. The figure shows that the participant who received road commentary training (right panel) had a greater number of fixation clusters covering a larger region of the visual field.

Figure 4: The fixation clusters of two participants during the post-training assessment. The left panel shows data from a participant in the no-training group, the right panel shows data from a participant after commentary training. Red areas (clusters) represent the areas where the greatest visual search time was dedicated.

Effects of road commentary on fixation on mirrors

To determine if commentary training influenced the visual search of mirrors, the number of fixations within specified regions (wing mirrors, interior mirror, and road ahead) was calculated for each group for the baseline and post-training. The mean percent of fixations on mirrors is shown in Figure 5.

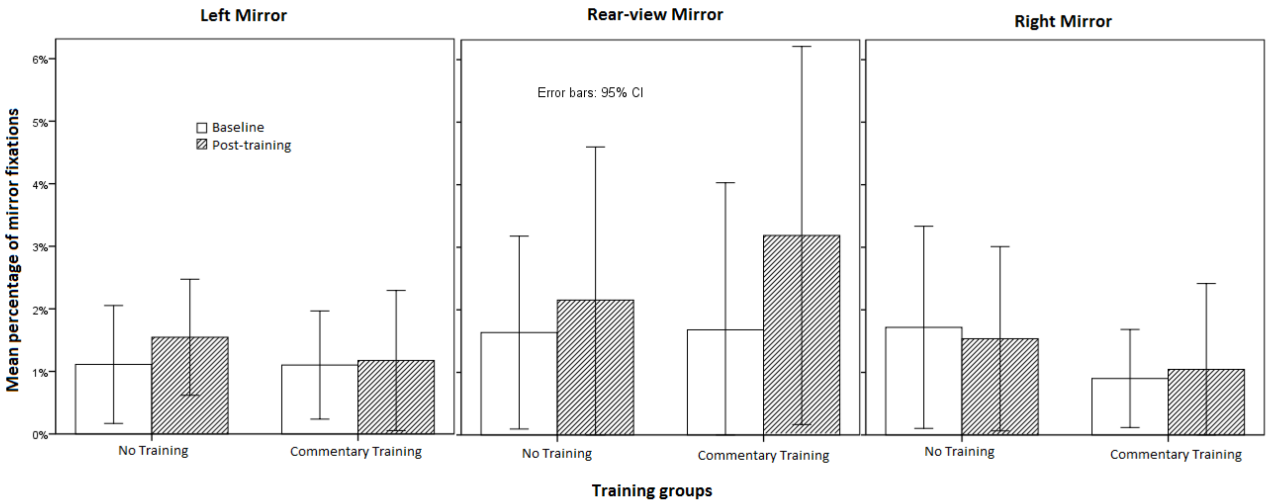

Figure 5: Mean percentage of fixations allocated to rear-view, left and right wing mirrors

The figure shows that while there was generally a small increase in the precent of mirror use between baseline and post-training, this is not a substantial increase. Three mixed, ANOVAs were performed on the percentage of fixations on each of the three mirrors. The analysis confirmed that there was no significant main effect between baseline and post-training regarding the use of the rear view, $F(1,18) = .752$, $p = .40$, $\eta_p^2 = .050$, the left wing mirror, $F(1,18) = .184$, $p = .674$, $\eta_p^2 = .013$, or the right wing mirror, $F(1,18) = 1.127$, $p = .308$, $\eta_p^2 = .074$. This suggests that the use of mirrors in collecting visual information about the driving situation did not change significantly from baseline to post-training assessment. Rather, given that that percentage of mirror use was low compared to the total number of fixations, the majority of visual attention (fixations) remained located about the central visual field.

Discussion

The purpose of this preliminary research was to investigate the effect of commentary training on novice driver's hazard perception and eye-scanning behaviour. First, our data showed that road commentary significantly increased participants' ability to identify hazards on video based traffic simulations. This finding is similar to the reviewed literature, especially that of Isler, Starkey, and Williamson (2009), who found that commentary training increased the number of hazards which young novice drivers' identified in a hazard perception dual-task. The improvement in hazard perception gained through the use of commentary training has been examined in a number of studies, and our findings support its use as part of any driver training programme focussing on higher level driving skills.

Analyses of the fixation data indicated that there were differences between the two training groups in regards to the number of fixation clusters in the post-training assessment, with the commentary training group demonstrating a greater number of fixation clusters following training. These differences indicate that commenting on the road situation may change the way drivers process the visual scene, with commentary training promoting fixations to hazard-rich areas of the visual scene, and dedicating more fixation duration to the areas of the road where hazards might occur.

Additionally, it was observed that the fixation clusters of the commentary training group were distributed more broadly across the visual scene, suggesting these drivers were scanning a greater proportion of the road environment. These findings support those of Chapman, Underwood, and Roberts (2002) found that commentary training produced different patterns of eye-movement and visual search behaviour in young drivers when combined with hazard anticipation and visual search training.

In a study by Crundall and Underwood (1998), it was found that novice drivers who were required to simply watched traffic videos without vehicle control, regardless, demonstrated a pattern of inefficient visual search behaviour. Isler et al (1999) speculated that this was due to either inability to redirect attentional resources to hazard detection task, or that novice drivers lack the skills needed for efficient search of the road scene. The current study may provide some evidence to suggest that commentary training may promote more efficient search for hazards, either through improving search strategy, or through reallocation of attentional resources to the task of detecting and responding to immediate hazards. Though further analysis is needed to determine whether this alteration in fixation is related to improvements in hazard detection schema, or increased vigilance to areas most likely to produce unexpected events

Both groups tended to focus ahead of the vehicle, rather than attending to the mirrors. The way the two groups attended to the mirrors did not show a statistically significant difference between baseline and post-training; this means that participants attended more to the central visual field. Previous studies have shown that young novice drivers typically focus their attention to the centre of the visual field (Konstantopoulos et al, 2010), as this is required for the basic driving task of maintaining lane position and avoiding immediate on-coming hazards (i.e., slowing vehicles). It is worth noting that there was no instruction given regarding hazards occurring in the mirrors, and it could be assumed that the use of mirrors in this experiment may not be representative of actual driving behaviour, as the majority of immediate hazards occur within the centre-field.

Limitations in the current study

Several limitations should be briefly addressed in the current study. Firstly, the small sample size might not be sufficiently large to adequately address the high degree of variability observed within groups. Secondly, the road commentary task used in this experiment did not employ a secondary dual task (as was used in other studies, for example Isler et al., 2009; Crundall et al., 2010). The use of a secondary task created an artificial cognitive demand that represented that task demand of actual driving. In simulator tasks, the secondary task would be steering and vehicle control on the virtual road, where the primary task would be hazard perception. Without the use of a secondary task in this experiment, participants were free to allocate all their cognitive resources to the task of searching for hazards. Therefore, hazard perception performance in this experiment may not have accurately represented the actual hazard perception competency when driving in the real world. Finally, the quality of road commentary was found to vary between individuals within the training group. Some participants found commenting on hazards much more challenging than others. While not within the scope of the present preliminary study, the analysis of the extent and quality of commentary and the use of covariates in future analysis may reveal a more accurate picture when it comes to evaluate the effects of road commentary training.

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