“Weapon Focus” & Drivers Visual Search Strategy!

One of the most difficult problems in driver training is the challenge of exposing learner drivers to hazardous situations in a realistic but safe manner. While the introduction of hazard perception test in the British driving test has substantially increased awareness of hazards among both learners and trainers, there are still limited opportunities for learner drivers to experience real hazards while actually driving, and there are questions about the value of learning to respond to hazards in a purely video-based task. When training we must endeavour to ensure our trainees are observant and continuously scanning all areas of their environment fully to detect hazards early in order to take appropriate action. Apart from the necessity of having good eyesight for driving, it’s also equally important to use your eyesight properly to look in all the right places if you are to remain safe on the road. Ideally, when driving, a driver or trainee should be physically relaxed but must always remain mentally and visually alert. Our eyesight is the most important of our senses when driving so, we must be acutely conscious of our “situational awareness” at all times. This paper explores the typical visual search strategy of drivers and how inexperienced drivers are less inclined than experienced drivers to adjust their visual search to the complexity of the environment and to changing task demands. Finally, a conclusion is given: novices tend to allocate their *visual attention to information close to the vehicle. Inexperienced drivers are less inclined than experienced drivers to adjust their visual search to the complexity of the environment and to changing task demands.*

Harrington Driver Training Services

"Weapon Focus"& Drivers Visual Search Strategy!

Tom Harrington LL B F Inst. MTD (September 2020)

Introduction

To drive a vehicle safely, we are required to perceive visual stimulus, quickly and accurately of pedestrians cyclists, motorcyclists and other vehicles, Since visual sensitivity generally decreases with increasing the retinal eccentricity, ***(e.g., Millodot, 1965;*** [1] ***Osaka***, 1976), [2] eye movements play an important role in perceiving the visual stimulus during car driving by capturing a peripheral stimulus on the fovea. [3] Several studies measured eye movements during driving and found that frequencies of saccades [4] and fixation durations decreased with increasing the number of the visual objects. ***(Chapman & Underwood, 1998***; [5] ***Miura, 1992***). [6] It appears there are few studies conducted examining eye movements during driving with conditions controlled experimentally (e.g., driving in a road situation). However, some studies have explored the visual behaviour of car drivers. [7] A comparison of drivers' eye movements in filmed and simulated dangerous driving situations is the most important considerations in such studies and is the way in which visual behaviours are modified in dangerous or stressful driving situations. [8] The idea that attention is altered in stressful situations has a long history in psychology. ***Easterbrook (1959)*** [9] proposed the general idea that arousal causes a narrowing in the range of cues attended to by an organism. Applied cognitive psychologists have extended this idea to 'weapon focus' [10] in which a witness to crime may look at the weapon, but fail to remember the face of an assailant. Participants who were asked to watch situations where a shop customer holds either a gun or a cheque found that viewers fixated more on the gun than they did on the cheque.

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[1] Millodot, M. (1965). *Foveal and extra-foveal acuity with and without stabilized retinal images.* The British Journal of Physiological Optics, 23, 75-106.

[2] Osaka, N. (1976). *Visual reaction time as a function of target size and retinal eccentricity in the peripheral visual field*. Japanese Psychological Research, 18, 183-190.

[3] Eye fovea: In the eye, a tiny pit located in the macula of the retina that provides the clearest vision of all. Only in the fovea are the layers of the retina spread aside to let light fall directly on the cones, the cells that give the sharpest vision. Also called fovea or fovea centralis.

[4] Saccades are rapid, ballistic movements of the eye**s** that abruptly change the point of fixation. ... Saccadic eye movements are said to be ballistic because the saccade-generating system cannot respond to subsequent changes in the position of the target during the course of the eye movement.

[5] Chapman, P., & Underwood, G. (1998). *Visual search of driving situations: Danger and experience, Perception,* 27, 951-964.

[6] Miura, T. (1992). *Visual search in intersections: An underlying mechanism.* IATSS RESEARCH, 16, 42–49.

[7] (For reviews see Chapman and Underwood, 1998; Crundall, 2005; Underwood *et al*., 2007). One of 112

[8] (Kramer *et al.* 1990)

[9] Easterbrook, J. A. (1959). *The effect of emotion on cue utilization and the organization of behavior.* Psychological *Review*, 66, 183–201.

[10] Loftus *et al.* (1987)

In a similar study, they observed more frequent and extended fixations on central information in stressful conditions.

<u>Novices – Visual Attention Close to the Vehicle</u>

Novice drivers are statistically over-represented in reported road crashes, with recent evidence suggesting that some of this increased crash involvement may be a result of limitations in their cognitive processing. Such processing has typically been measured by recording drivers' patterns of eye movements; however, the exact ways in which eye movements are reported and interpreted varies substantially between different studies in various literatures. Therefore, it's important to investigate whether novice drivers and experienced drivers differ in clear and reproducible ways in their visual search. Safe driving depends on your ability to notice many things simultaneously. Our eyes provide two types of visions: central vision and peripheral or side vision. Central vision allows us to make very important judgments like estimating speed, distance and understanding details in the road ahead, whereas peripheral vision helps us detect events to the side that are important to us, even when we're not looking directly at them. Most driving mistakes are caused by bad habits in the way drivers use their eyes. Novices tend to allocate their visual attention to information close to the vehicle, which may be caused by their limited steering control skills compared to experienced drivers. ***(Mourant & Rockwell, 1972).*** [11] ***Summala, Nieminen, and Punto (1996)*** [12] showed that inexperienced drivers rely less on peripheral vision for lateral vehicle control, and fixate more on lane markers and areas close to the vehicle. [13] 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.

<u>Scanning, Detecting & Responding to Hazards</u>

An important concept in defensive driving is the acronym (IPDE): *Identify Predict, Decide,* and *Execute* which is the step-by-step process behind the principles of defensive driving and complexities of visual perception in traffic. IPDE is an organized thinking and acting process that you will constantly use while driving.

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[11] Mourant, Ronald R. & Rockwell, Thomas, H. (1972) Strategies of Visual Search by Novice & Experienced Drivers. Human Factors: The Journal of Human Factors & Ergonomics Society Journals. sagepub.com

[12] Summala, H. *et al* (1996) *Maintaining Lane Position With peripheral Vision During In-Vehicle Tasks. Human Factors, 38 (3), 442-451*. https://doi.org

[13] P.M. van Leeuven et *al*, 92013) *Task for simulator-based driver training*. Proceedings of the Seventh International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design. Delft University of Technology, The Netherlands.

In order to avoid last minute reactions and spot possible traffic hazards early, keep your head up and always look well ahead of your vehicle into the distance. *(Remember the Smith System - Aim High etc. Ed.)* Start braking early if you see any hazards or traffic ahead of you slowing down. Also check the space between your car and any vehicles in the in the lane next to you. It is very important to check behind you before you change lanes, slow down quickly, back up, or drive down a long or steep hill. You should also check your instrument panel frequently to ensure there are no problems with the vehicle and to verify your speed. Young drivers are overrepresented in road traffic crashes. Crash rates are highest in the first months of independent driving and decline as drivers gain experience. Many studies have shown differences in visual search behaviour between experienced and novice drivers. One factor that has been associated with the high crash rates among novice drivers is their poor ability to identify and anticipate hazards. 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.

<u>Novice Drivers - Elevated Mental Workload</u>

Driving statistics for many years have found that driver age and experience both make independent contributions to high crash rates. Young car drivers in the UK between the ages of 17 and 25 are statistically over-represented in reported road accidents compared to older drivers aged 25 and above. In the UK, young car drivers have been found to make up 18% of all reported road crashes, which is considerably higher than the 5% of miles they account for. In the US, young drivers which include drivers between the ages of 15–20 years made up 9% of all fatal crashes in 2016, despite accounting for only 5.4% of all licensed drivers. Globally, it has been found that road injuries sustained from driving are the leading cause of death for people between the ages of 15–29 years. Previous studies have indicated that inexperienced drivers tend to utilize only a small proportion of the visual field when driving, and this limited visual search strategy 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. ***McKnight and McKnight (2003)*** [14] reviewed 2,000 police accident reports, and showed that failure to search ahead, to the side, or the rear was a factor in 43% of young drivers' crashes. Several studies have shown that novice drivers have an elevated mental workload, a phenomenon which has been associated with spatial gaze concentration. ***Crundall and Underwood (1998)*** [15] found that inexperienced drivers are less inclined than experienced drivers to adjust their visual search to the complexity of the environment and to changing task demands.

Improve Visual Search Performance

One of the most difficult problems in driver training is the challenge of exposing learner drivers to hazardous situations in a realistic but safe manner. While the introduction of hazard perception testing in the British driving test has substantially increased awareness of hazards among both learners and trainers, there are still limited opportunities for learner drivers to experience real hazards while actually driving. And there are questions about the value of learning to respond to hazards in a purely video-based task. A three-year project at the Accident Research Unit, University Nottingham, explored the possibility of using hazard-perception training in simulators owned by the British School of Motoring (BSM). One of the main aims of the training intervention was to improve the visual search performance of novice drivers. The purpose of the project was to compare the typical visual search behaviour of drivers in the simulated hazardous scenarios with the behaviour of drivers in actual dangerous situations, and while watching videos of driving hazards. The results show that typical patterns of attention-focusing in hazardous situations occur in most simulated hazards and that they are particularly noticeable during the precursors to these hazards. Differences in visual behaviour among three types of hazard were explored and the time course of changes in visual behaviour was analyzed.

[14] McKnight & McKnight (2003). *Changes of Driver Performance & Gaze Behaviour of Novice Drivers During a 30 -Minute Simulator Based Training.* Sciencedirect.com

[15] Crundall & Underwood (1998) *Effects of Experience & Processing Demands in Visual Information Acquisition in Drivers. Ergonomics, 41, 448-458*

Cognitive Psychologists & "Weapon Focus"

Numerous studies have explored the visual behaviour of car drivers (for reviews see ***Chapman and Underwood, 1998;*** [16] ***Crundall, 2005;*** [17] ***Underwood et al., 2007).*** [18] One of the most important considerations in such studies is the way in which visual behaviours are modified in dangerous or stressful driving situations.

The idea that attention is altered in stressful situations has a long history in psychology. ***Easterbrook (1959)*** [19] proposed the general idea that arousal causes a narrowing in the range of cues attended to by an organism. Applied cognitive psychologists have extended this idea to 'weapon focus' ***(Kramer et al., 1990)*** [20] in which a witness to a crime may look at the weapon, but fail to remember the face of an assailant. ***Loftus et al. (1987***) [21] had participants watch situations where a shop customer holds either a gun or a cheque. They found that viewers fixated more on the gun than they did on the cheque. In a similar study, ***Christianson et al. (1991)*** [22] observed more frequent and extended fixations on central information in stressful conditions. If such attention-focusing occurs in driving situations, we might expect that in hazardous situations, participants would focus on the information directly ahead of them and fail to attend to more peripheral sources of information. ***Chapman and Underwood (1998, 1999)*** [23] tested this hypothesis by having drivers watch hazard-perception videos while their eye movements were recorded. They found that there were a few minor differences in the general locations fixated in hazardous situations, but there was no clear overall tendency for a focus on central locations at the expense of peripheral ones. ***Chapman and Groeger (2004)*** [24] argue that memory tests in such situations are consistent with the idea that what drivers focus on in dangerous situations is not information that is spatially central, but information that is central to the driving task.

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[16] Chapman, P. and Underwood, G. (1998) *Visual search of driving situations: danger and experience*. *Perception*, 27, 951–964.

[17] Crundall, D. (2005). *The integration of top-down and bottom-up factors in visual search during driving*. In G. Underwood (ed.), *Cognitive Processes in Eye Guidance* .Oxford: Oxford University Press. pp. 283–302.

[18] Underwood, G., Crundall, D. and Chapman, P. (2007) Driving. In F. T. Durso (ed.), *Handbook of Applied Cognition*, 2nd ed. Chichester: Wiley. pp. 391–414.

[19] Easterbrook, J. A. (1959). *The effect of emotion on cue utilization and the organization of behavior*. *Psychological Review*, 66, 183–201.

[20] *Behavioural Research in Road Safety*. (2007). DfT 17th Seminar. Accident Research Unit, School of Psychology, University of Nottingham. Nottingham NG7 2RD

[21] Loftus, E. F., Loftus, G. R. & Messo, J. (1987). *Some facts about 'Weapon Focus'. Law and Human Behaviour*, 11, 55–62.

[22] Christianson, S., Loftus, E. F., Hoffman, H. and Loftus, G. R. (1991*) Eye fixations and memory for emotional events. Journal of Experimental Psychology: Learning, Memory, and Cognition*, 17, 693–701.

[23] Chapman, P. and Underwood, G. (1999). *Looking for danger: drivers' eye movements in hazardous situations*. In. A. G. Gale, I. D. Brown., C. M. Haslegraveand S. P. Taylor (eds), *Vision in Vehicles VII* . Elsevier, Amsterdam. pp. 225–232.

[24] Chapman, P. and Groeger, J. (2004) *Risk and the recognition of driving situation*. *Applied Cognitive Psychology*, 18, 1231–1249.

Consistent with this idea, although there is little evidence for spatial attention-focusing from records of eye movements, there is plenty of evidence that drivers' visual search is systematically different if hazards are present. ***Chapman and Underwood (1998)*** [25] made systematic comparisons of a wide range of eye movements, variable for safe and dangerous situations, while participants watched hazard-perception videos. They found that, during hazards, fixation durations increased, the mean saccade amplitude decreased, and the overall spread of search (as measured by both vertical and horizontal variance in fixation locations) decreased. Although drivers did focus on hazards, the location of hazards was not always spatially central to the driving. To observe attention-focusing in hazardous situations, it is necessary to define eye-movement measures relative to individual hazard locations. ***Underwood et al. (2005)*** [26] did just this, defining each fixation relative to the appearance of an individual hazard. They found a dramatic increase in fixation duration the time an individual driver detects a hazard. Although this increase in fixation duration can be detected by comparisons across broadly safe and dangerous situations ***(e.g. Chapman and Underwood, 1998),*** [27] the data from ***Underwood et al. (2005)*** [28] strongly suggest that the actual duration of attention focusing is likely to be limited to the single fixation at the time a hazard is detected.

Training Drivers' Visual Search

Relatively few researchers have attempted to directly influence novice drivers' patterns of visual search. A danger in any such training is that eye movements are likely to be a consequence of other aspects of visual processing – thus a driver may fixate on a region until information from that region is fully processed. At that point they may move onto a new region, searching for additional information. Differences in fixation durations between novice and experienced drivers in unfamiliar situations (e.g. ***Chapman and Underwood, 1998)*** [29] will thus reflect the additional time a novice driver requires to process risk-related information.

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[25] Chapman, P. and Underwood, G. (1999). *Looking for danger: drivers' eye movements in hazardous situations*. In. A. G. Gale, I. D. Brown., C. M. Haslegraveand S. P. Taylor (eds), *Vision in Vehicles VII* . Elsevier, Amsterdam. pp. 225–232.

[26] Underwood, G., Phelps, N., Wright, C., van Loon, E. and Galpin, A. (2005) *Eye fixation scan paths of younger and older drivers in a hazard perception task. Ophthalmic and Physiological Optics* , 25, 346–35

[27] Chapman, P. and Underwood, G. (1999). *Looking for danger: drivers' eye movements in hazardous situations*. In. A. G. Gale, I. D. Brown., C. M. Haslegrave and S. P. Taylor (eds), *Vision in Vehicles VII* . Elsevier, Amsterdam. pp. 225–232.

[28] Underwood, G., Phelps, N., Wright, C., van Loon, E. and Galpin, A. (2005) *Eye fixation scan paths of younger and older drivers in a hazard perception task. Ophthalmic and Physiological Optics* , 25, 346–356

[29] Chapman, P. and Underwood, G. (1999). *Looking for danger: drivers' eye movements in hazardous situations*. In. A. G. Gale, I. D. Brown., C. M. Haslegrave and S. P. Taylor (eds), *Vision in Vehicles VII* . Elsevier, Amsterdam. pp. 225–232.

A visual search-training intervention that encourages novice drivers to copy the search strategies of experienced drivers may simply cause them to leave a region of fixation before the relevant information in fully processed. Such training could be potentially dangerous. If an intervention is aimed at reducing fixation durations, it makes better conceptual sense to teach novice drivers about hazardous situations with the intention that this will allow them to process relevant visual information faster and, consequently, reduce fixation durations and allow an increased spread of search. Thus, training that improves hazard perception is itself likely to improve visual search. Studies on hazard perception training (e.g. ***Deery, 1999; et al, 1998;*** [30] ***McKenna and Crick, 1994;*** [31] ***Horswill and McKenna, 2004;*** [32] ***McKenna et al., 2006)*** [33] provide useful basis for training broader visual search strategies, but relatively few studies have actually measured the influence of such training on drivers' eye movements.

"What Happens Next"

The first large-scale study attempting to train and measure drivers' visual search strategies was reported by ***Chapman et al. in 2002.*** [34] Their training intervention took the form of a one-hour video-based task designed to train three specific components: knowledge, anticipation, and scanning. Similar to previous hazard perception studies, it was assumed that watching videos of potentially dangerous situations while providing commentaries and listening to expert commentaries would improve novice drivers' knowledge of hazardous road situations and they would potentially process them faster. Anticipation training was provided using a *'What Happens Next?'* prediction test similar to that used by ***McKenna and Crick (1994).*** [35] The final component of this intervention was designed to more directly influence drivers visual scanning. Here drivers were shown videos of dangerous situations with multiple areas of potential hazard circled.

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30 Deery, H. A. (1999) Hazard and risk perception among young novice drivers. *Journal of Safety Research*, 30, 225–236.

31 McKenna, F. P. and Crick, J. L. (1994) *Hazard Perception in Drivers: A Methodology for Testing and Training.* TRL Report No. 313. Crowthorne: Transport Research Laboratory. McKenna,

32 Horswill, M. S. and McKenna, F. P. (2004) *Drivers' hazard perception ability: situation awareness on the road.* In S. Banbury and S. Tremblay (eds), *A Cognitive Approach to Situation Awareness*. Aldershot: Ashgate.

34 Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F*, 5, 157–167.

35 McKenna, F. P. and Crick, J. L. (1994) *Hazard Perception in Drivers: A Methodology for Testing and Training.* TRL Report No. 313. Crowthorne: Transport Research Laboratory. McKenna,

Such videos were played initially at half speed to give drivers time to fully process information in all areas and were subsequently played at full speed to encourage a scanning strategy that was both wide and rapid. ***Chapman et al*,** [36] monitored their novice drivers' eye movements while performing hazard-perception tests before training, immediately after training and in a long-term follow-up condition between three and six months after the training intervention. ***Chapman et al, (2002)*** [37] found that the training intervention reduced fixation durations and increased the novice drivers' spread in a laboratory hazard-perception test. ***Chapman et al. (2002)*** [38] concluded that eye-movement training can help novice drivers to develop visual search strategies in filmed hazardous situations that are more like those of experienced drivers. ***Pollatsek et al. (2006)*** [39] have found similar effects in a driving simulator. They showed novice driver's overhead views of road scenarios and asked them to mark on the pictures the location of hazards that were obscured from view. They then drove in a simulator while their eye movements were recorded. Trained drivers showed more successful visual search for potential hazards on those scenarios that were structurally the same as the overhead views on which they had been trained.

Training Can Improve Drivers' Visual Search Strategies

There was also evidence that visual search in new scenarios had been affected by the training, suggesting transference of skill between driving situations. A follow-up study found that such training effects were reasonably long-lasting. ***(Pradhan et al., 2007).*** [40] ***Chapman et al. (2002)*** [41] also reported evidence that eye-movement training can influence visual search during real on-road driving. They recorded the eye movements of their drivers, both before and after training, while driving on a real road. ***Chapman et al. (2002)*** [42] also reported evidence that eye-movement training can influence visual search during real on-road driving.

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[36] Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F,* 5, 157–167.
[37] Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F,* 5, 157–167.
[38] Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F,* 5, 157–167.
[39] Polletsek, A., Narayanaan, V., Pradhan, A. and Fisher, D. L. (2006) .*The use of eye movements to evaluate the effect of a PC-based Risk Awareness and Perception Training (RAPT) program on an advanced driving simulator. Human Factors*, 48,447–464.
[40] Pradhan, A. K., Fisher, D. L. and Pollatsek, A. (2007) *Risk perception training for novice drivers: evaluating duration of effects on a driving simulator.* Transportation Research Record. *Journal of the Transportation Research Board*, 1969, 58–64.
[41] Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F,* 5, 157–167.
[42] Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F,* 5, 157–167.

They recorded the eye movements of their drivers, both before and after training, while driving on a real road in an instrumented vehicle. Although there were no significant differences infixation durations, they did find significant differences in the spread of horizontal search immediately after the intervention, although these differences were no longer significant in a follow-up three to six months after the intervention. ***Pollatsek and colleagues*** have recently followed up a variant of their aerial view training technique using eye tracking on real roads ***(Pradhan et al, 2006).***[43] Here they explored eye movements in critical scenarios that either occurred naturally or were staged. They found significant training effects both for scenarios that were like those in the training phase, and those that were less similar. The training effects were, however, smaller for less similar scenarios, and they attribute this reduction to the modified training procedure used, in which photographed situations may have been very visually similar to those encountered during the actual drive ***(Pollatsek et al, 2006).*** [44] There is thus evidence that various types of training can improve drivers' visual search strategies, that these benefits can be observed in hazard-perception tests, simulated driving and actual driving, and that some of these benefits are reasonably long-lasting. Despite this promising conclusion, there are still a number of unanswered questions about the effectiveness of training.

A Good Driver Could Have Avoided Many Hazards

Although the training described by ***Pollatsek et al. (2006)*** [45] does appear to be successful in encouraging drivers to look to the location of potentially-obscured objects, it is arguable that this is only one component of expert visual search in driving. In contrast, a problem with eye-movement based training is that it may encourage a general scanning strategy that is not always appropriate; indeed, there was evidence from ***Chapman et al, (2002)*** [46] that changes in scanning strategy occurred in both dangerous and safe situations. Video-based hazard-perception training can also be criticized on the grounds that a good driver could have avoided many hazards by an appropriate approach speed and direction.

[43] Pradhan, A. K., Fisher, D. L., Pollatsek, A., Knodler, M. and Langone, M. (2006) *Field evaluation of a risk awareness and perception training program for younger drivers. Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting,* San Francisco, pp. 2388–2391.

[44] Polletsek, A., Narayanaan, V., Pradhan, A. and Fisher, D. L. (2006) .*The use of eye movements to evaluate the effect of a PC-based Risk Awareness and Perception Training (RAPT) program on an advanced driving simulator. Human Factors*, 48,447–464.

[45] Pradhan, A. K., Fisher, D. L., Pollatsek, A., Knodler, M. and Langone, M. (2006) *Field evaluation of a risk awareness and perception training program for younger drivers. Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting,* San Francisco, pp. 2388–2391.

[46] Polletsek, A., Narayanaan, V., Pradhan, A. and Fisher, D. L. (2006) .*The use of eye movements to evaluate the effect of a PC-based Risk Awareness and Perception Training (RAPT) program on an advanced driving simulator. Human Factors*, 48,447–464.

A clear improvement over training using videos would thus be the use of simulated driving, in which car control was required but hazardous situations could be created for the driver to deal with in a safe and controlled environment. The suggestion, therefore, is that further efforts at training drivers' visual search patterns might be best concentrated on strategies that are appropriate in both general driving and in specific hazardous situations. The advent of low-cost high-fidelity driving simulators suggests that these may be an ideal location for training in simulated hazardous situations. In addition to proposing the driving simulator as an ideal location for training, there have been specific proposals for the components of training that are most likely to be effective in producing optimal visual search strategies in novice drivers.

Predicting the Behaviour of Other Road Users

Many real accidents are preceded by the unexpected behaviour of other road users and could have been prevented if the driver had correctly predicted their behaviour in advance. Realizing that an oncoming vehicle might be planning to turn in front of your car, or that a pedestrian walking on the pavement might be about to step into the road, requires very deep processing of the visual scene. In such cases a driver needs to be aware of potential sources of danger, fixate them at length and return to them frequently. A driver can never be sure of the behaviour of other road users, but knowledge about how potential hazards might develop will help the novice driver choose appropriate areas of the visual scene on which to concentrate their search. This may be one of the main benefits of expert commentaries, and important knowledge may be gained by simply watching a wide variety of hazardous scenarios. Additional training based on getting the driver to predict 'what happens next' in a variety of scenarios may also be valuable.

Developing a Mental Model of the Situation

Some of the dangers to a driver cannot be seen until they become hazardous. For example, a child who steps out into the road from behind a parked ice-cream van becomes an immediate hazard. Experience allows a driver to identify and monitor these dangerous areas prior to the appearance of the hazard. This component is similar to the concept of 'anticipation' as used by ***McKenna and colleagues (e.g. McKenna et al., 2006)*** [47] and is clearly one of the main skills trained in ***Pollatsek et al, (2006)*** [48] training regime. *(Perhaps the "What If" may be a useful tool to anticipate hazards. Ed.)*

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[48] Polletsek, A., Narayanaan, V., Pradhan, A. and Fisher, D. L. (2006) .*The use of eye movements to evaluate the effect of a PC-based Risk Awareness and Perception Training (RAPT) program on an advanced driving simulator.* *Human Factors*, 48,447–464.

Dividing and Focusing Attention

The ability to monitor multiple potential sources of hazards is essential when navigating congested urban roads. The driver must prioritize locations in the visual scene according to their importance and must frequently monitor the most likely hazard spots, (areas) while inhibiting the impulse to fixate on non-hazard related information. Such ability is similar to the concept of 'scanning' training as proposed by ***Chapman et al. (2002).*** [49] However, one particular focus is the need to not just scan the road continually but particularly to disengage from hazards once they have been detected. ***Crundall et al. (1999, 2002)*** [50] have observed a reduction in the ability to detect peripheral targets in hazardous situations that may be particularly pronounced for inexperienced drivers. Thus, training should focus on ensuring that, once a hazard has been appropriately identified, attentional resources are redistributed and the remainder of the driving scene is also considered.

Hazard Management

One danger with emphasizing the role of eye-movement training in novice drivers is that it avoids the general issue that many hazards can be avoided by simply adopting a safe and defensive driving style. There is always a danger that any training intervention will encourage overconfidence in a driver. Although there is evidence that components of hazard-perception training can be safely trained without encouraging an increase in risk-taking behaviours ***(McKenna et al., 2006),*** great care needs to be taken during any skill-based driver training. It is thus important that any training of visual search is integrated into a more general model of safe and responsible driving. In order to assess and train these aspects of driving, it is important to develop simulated hazardous driving to measure these components of driving, and to demonstrate that visual search in such situations is representative of that found in real and videoed driving studies of the type described above. When driving through different types of hazard, the following are particularly important for three aspects of training:

- Predicting the behaviour of other road users;
- Developing a mental model of the situations; and
- Dividing and focusing attention.

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[49] Chapman, P., Underwood, G. and Roberts, K. (2002) *Visual search patterns in trained and untrained novice drivers. Transportation Research F,* 5, 157–167.

[50] Crundall, D., Underwood, G. and Chapman, P. (2002) Attending to the peripheral world while driving. *Applied Cognitive Psychology,* 16, 459–475.

Visual Search Results During Simulated Hazardous Driving

For the purposes of these analyses, pilot data from drivers in the simulated hazardous scenarios described in ***Crundall et al. (2006)*** [51] were analyzed. Eye-movement data were aggregated over three windows:

- A window in which the hazard was actually present;
- A window in which the driver is approaching the location of the hazard, but the hazard is not actually in progress; and
- A window immediately preceding where the road and traffic situation are similar but the hazard location is not present.

Conclusion

When a new driver becomes qualified, it is relatively easy to confirm that they possess adequate motor skills to control the vehicle (steering, braking, gear-changing etc., however; there is evidence to suggest that their higher order cognitions are not fully developed. Cognitive processing demands are reflected by several aspects of eye movement behaviour, therefore measuring this behaviour is a strong indication of cognitive difficulty on the road. Studies investigating drivers' visual search typically use eye tracking technology, allowing for moment-by-moment tracking of the driver's eye movements over the visual scene. It is typical for drivers' general visual search to be measured over the visual scene in terms of fixation durations (how long each fixation lasts before the next saccade), the number of fixations made in a given time period, and horizontal and vertical spread of search (in terms of the variance in fixation locations across the visual field). Novice drivers are overrepresented in road traffic crashes and accident rates are particularly high in the first few months after obtaining a driver's license and decline as drivers gain experience. It is important to understand how novice drivers differ from experienced drivers, and how novice drivers learn from experience, in order to develop effective crash countermeasures. Several studies have indicated that inexperienced drivers tend to utilize only a small proportion of their 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.

[51] Crundall, D., Chapman, P., Underwood, G., van Loon, E. and Chapman, P (2006) *Developing simulator-based visual search and hazard perception training.* In *Behavioural Research in Road Safety 2006, Sixteenth Seminar.* London: Department for Transport. pp. 213–224.

This deficiency in visual search is especially evidenced through crashes occurring at intersections, or other densely populated road environments. Some studies have also shown that novice drivers have an elevated mental workload, a phenomenon which has been associated with spatial gaze concentration. These studies also found that inexperienced drivers are less inclined than experienced drivers to adjust their visual search to the complexity of the environment and to changing task demands. Novices tend to allocate their visual attention to information close to the vehicle, which may be caused by their limited steering control skills compared to experienced drivers and those inexperienced drivers rely less on peripheral vision for lateral vehicle control, and fixate more on lane markers and areas close to the vehicle. 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. Collecting visual information about the roadway environment and scanning ahead must be an active process. This can be a challenge for new drivers, particularly those who are accustomed to using their eyes passively while staring at a TV, tablet or computer screen. Finally, do not wait for information to come to you while you're driving, instead, train yourself to seek out information and look for dangers everywhere within your path of travel. If you practice proper visual targeting every time you drive, actively scanning the roadway will soon become a habit, eventually, choosing a target area on the road well up ahead will become more or less automatic and you will not even realize you're doing it.