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**EFFECT OF VIDEO BASED ROAD  
COMMENTARY TRAINING ON THE  
HAZARD PERCEPTION SKILLS OF  
TEENAGE NOVICE DRIVERS**

A thesis

submitted in fulfilment

of the requirements for the degree

of

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by

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## Abstract

Recent evidence in the road safety research literature indicates that skills in hazard perception, visual search and attention may be developing executive functions in young novice drivers before the age of 25 years, contributing to their unintentional risk taking behaviour and subsequent high crash rates. The present research aimed to investigate these skills, whether they are predictive of each other, and whether hazard perception can be improved through road commentary training. Twenty-two young novice drivers and eight experienced drivers were recruited as participants in this study. The experienced drivers performed significantly better than the novice drivers on the hazard detection task that was specifically designed for the study. Their visual search skills were also examined and compared using the Visual Search and Attention Test, with the experienced drivers performing significantly better than the novice drivers. Interestingly, a significant positive correlation was found between the scores of the participants on the hazard detection task and the Visual Search and Attention Test which may indicate that the hazard detection skills can be predicted. The novice driver group who received 12 trials of video based road commentary training significantly improved in their hazard detection skills, suggesting that video based road commentary could be an effective road safety intervention for young novice drivers and if developed into a more comprehensive programme, holds promise for future implementation into the New Zealand Graduated Driver Licensing System. The results also hold promise for future investigation into the use of the Visual Search and Attention Test as a predictor of hazard perception skills in novice drivers.

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## Ethics

Ethical approval for this research was obtained through the Psychology Departments ethics committee. Participants were given complete confidentiality, anonymity and the right to withdraw at any time. They were all briefed and given the opportunity to ask questions, a consent form was provided as well as a written summary of the results. Participants were recruited through a participant advertisement, the majority of who were first year psychology students who were given a 1% course credit. The others were given a \$10 MTA voucher.

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## Chapter 1: Introduction

Traffic related injury is one of the leading causes of death and serious injury among young adults aged 15-24 years in New Zealand. This age group continues to be over represented in official crash statistics (Begg & Langley, 2001). Sixteen year old drivers are involved in fatal crashes at a rate almost double that of 18 year olds and almost 8 times that of 45-64 year olds, who are the safest group of drivers. Crash rates are particularly high during the first month of licensure and decline rapidly for about 6 months and then much more slowly for at least 2 years, consistent with a typical learning curve (Fisher, Pollatsek, & Pradhan, 2006). A newly qualified driver is significantly more at risk in a road traffic accident than the same driver 10 years later (Underwood, 2007). The Ministry of Transport Web site provides recent statistics regarding young driver crashes. In 2005, young drivers (those aged 15-24) were involved in 142 fatal traffic crashes, 795 serious injury crashes and 3570 minor injury crashes. Of these crashes, the young drivers were at fault in 118 of the fatal accidents, 629 of the serious injury crashes and 2752 of the minor injury crashes, resulting in 149 deaths, 832 serious injuries and 4144 minor injuries. The total social cost of crashes in which young drivers were at fault was about \$1 billion, which is more than one third of the social cost associated with all injury crashes. Drivers aged 15-19 are seven times more likely to crash than drivers in the 45-49 year old age group. Drivers in the 20-24 year old age group are three times more likely to crash than 45-49 year old drivers. Young drivers make up just 7% of licensed car drivers, yet between 2003 and 2005, this group accounted for 14% of drivers involved in minor crashes, 15% of serious crashes and 14% of those involved in fatal crashes. Similarly, drivers aged between 20-24 account for only 9% of licensed car drivers, but between 2003 and 2005, they accounted for 14% of minor crashes, 13% of serious crashes and 12% of fatal crashes (<http://www.transport.govt.nz/young-index/>). Mayhew, Simpson, & Pak (2003) argue that “what is needed is a method to control this learning curve and ensure that it takes place in a more forgiving environment”(p.690).

An ongoing debate in the area of young driver research focuses on whether the primary causal crash factor, and therefore the primary target for intervention, is developing skills due to inexperience- 'the young driver problem', or intentional risk taking associated with adolescence- 'the problem young driver' (Senserrick, 2006). The complexity of the young novice driver crash problem is widely acknowledged. One reason for this is that the task of driving is itself extremely complex. Novice drivers learn the basic vehicle handling skills and traffic laws quickly, often after only 15 hours of driving. However they have limited experience to develop the complex, higher-order perceptual and cognitive skills required to safely interact with the driving environment (Deery, 1999).

Hazard perception is an executive function of the pre-frontal cortex that is still developing in young drivers, as well as a critical driving skill which therefore must be trained if a demand such as driving is to be placed on adolescents.

McKenna, Alexander, & Horswill (2006) report that anticipation in driving could be significantly improved by training in the laboratory using video simulation techniques, and that novice drivers could be improved to the level of experienced drivers within only 4 hours of training. The fact that the driving licensure age coincides with the developmental period of adolescence is problematic for a number of reasons. Lee (2007) describes five reasons for the high crash rate in young drivers: firstly, that imperfectly learned vehicle control skills lead to poor control and less spare attentional capacity to accommodate unexpected roadway demands, secondly that young drivers have a poor ability to anticipate and identify hazards, thirdly that young drivers have a willingness to take risks, such as shorter following distances and higher speeds, fourthly that there is a poor calibration of abilities relative to driving demands, and lastly that young drivers have a sensitivity to peer influences in adopting inappropriate norms. These five reasons incorporate aspects that relate to 'the young driver problem' and 'the problem young driver'.

My view is that 'the young driver problem' magnifies the effects of 'the problem young driver' and by training the skills that are still developing in young drivers, could minimise the effects of 'the problem young driver' that exist as an inevitable part of the developmental period of adolescence. Teenage 'risky driving' due to showing off, thrill seeking etc...does not account for so many young driver crashes; it may be a risk factor in many, but as a theory, it does not explain the young driver crashes involving 'model teens' that did not involve thrill

seeking or speed- the crashes that were due to poor skill. In my opinion, it is the reasons for these crashes that must be addressed.

## 1.1 Aims

This research has three aims. Firstly, the hazard perception skills of novice and experienced drivers will be assessed and compared. Secondly, the visual search and attention and working memory skills of novice and experienced drivers will be assessed and compared and the Visual Search and Attention Test and Digits Backwards task will be investigated as predictors of hazard perception skills. Thirdly, the effectiveness of a hazard perception training in the form of video based driving simulation and road commentary will be evaluated in both groups of drivers. This type of training may prove useful in the future to improve the safety and skills of novice drivers. The scope of this research will be contained to the New Zealand context in terms of future directions and recommendations. The research will examine this problem from the perspective that young drivers have developing higher-order skills which require formal training in order to safely interact with the driving environment. By doing so, will decrease unintentional/ignorance based risk taking and minimise the effects of adolescent driving behaviour.

This thesis will begin with a background literature review. This will firstly discuss the developmental period of adolescence in terms of brain physiology, subsequent behaviours and the potential for change. I will then discuss the important distinction between unintentional and intentional risk taking and how this distinction can be used to look at adolescent driving. I will then go on to discuss how unintentional risk taking relates to the adolescent brain in terms of developing executive functions such as hazard perception, visual scanning, attention, cognitive load and risk perception that are critical to driving safety, and how these executive functions can be trained to improve the skills of young drivers. Finally, I will provide an overview of the current driver training situation in New Zealand. Following chapters will include the method, results, discussion and conclusions.

## Chapter 2: Literature Review

### 2.1 The adolescent brain: a work in progress

Adolescence is a developmental period of rapid brain growth and change- an important factor to be considered when discussing the behaviour of teenagers. The anatomy, physiology and biochemistry of the brain changes measurably from early adolescence to late adolescence- another important factor to consider (Weinberger, Elvevag, & Giedd, 2005). Advances in neurological imaging has enabled researchers to further explore and understand how the adolescent brain begins to change structurally and functionally and continues to do so well into the third decade of life. As a consequence, our understanding of adolescent behaviour has become more robust and also more complex (Keating, 2007). Understanding the cortex's frontal lobes, particularly the pre-frontal cortex (PFC) and its links to other brain areas is critical in understanding teenage behaviour. The PFC or the 'CEO' of the brain is one of the last parts of the brain to fully develop- not until well into the third decade of life. The significance of this development for adolescent behaviour becomes clear upon examination of the PFC functions. It is responsible for skills such as setting priorities, organising plans and ideas, forming strategies, controlling impulses and emotion, allocating attention, inhibiting inappropriate behaviour and initiating appropriate behaviour, eye movement, insight, empathy and sensitivity to feedback through reward and punishment (Weinberger et al., 2005).

Keating (2007) offers the following rationale:

Accumbens activity in adolescents looked like that of adults in both extent of activity and sensitivity to reward values, although the magnitude of activity was exaggerated. In contrast, the extent of orbital frontal cortex activity in adolescents looked more like that of children than adults, with less focal patterns of activity. These findings suggest that maturing sub-cortical systems

become disproportionately activated relative to later maturing top-down control systems, biasing the adolescent's action toward immediate over long term gains (p.148).

This describes the complexity of adolescent brain development and the transition between child and adult. Society awards young novice drivers an adult status but does not take into account the existing child like properties that an adolescent brain has. This adult status demands too much from young drivers and the 'young driver problem' is clear evidence of that. Given the number and the extent of changes that occur in adolescence, there is no guarantee of synchrony among these changes. The asynchrony of these changes is useful when thinking about subsequent behaviours that are often associated with adolescence. Reyna & Farley (2006) discuss the popular explanation for risk taking behaviour: that adolescents engage in such activity because they think themselves invulnerable and must therefore be under-estimating their risks. They then go on to argue that studies over the past 5 years show that teens actually tend to over-estimate rather than under-estimate the true risks of potential actions. This over-estimation then declines after early adolescence, and evidence suggests that experience may be responsible: engaging in risk taking behaviour without incurring immediate consequences may encourage complacency. This then poses the question: why do teens take risks? A number of studies indicate that the reason for this is that the perceived benefits of an action tend to outweigh and offset the perceived risks. This poses a danger in that by encouraging teens to stop over-estimating risks, may cause them to under-estimate risk and take more risks for that reason as well as continuing to out weigh risk (Reyna & Farley, 2006). Based on this logic, a possible solution would be to provide an intervention or training program to target short-term consequences that are perceived as alluring to teens but in reality pose the most danger. For example, by providing skill training early on to teach young drivers about the dangers and risks associated with their age and level of experience.

A cognitive development theory known as 'fuzzy trace theory' is used by Reyna and Farley (2006) to support their argument. It is based on the idea that people rely on two different ways of reasoning to reach conclusions about situations that they are confronted with. The first way is a deliberative, analytical approach that relies on details. This verbatim style of reasoning involves the kind

of computational processing assumed by risk intervention programs, when risks are traded off precisely against rewards. The second way is the ‘fuzzy’ style of reasoning that occurs unconsciously and involves intuition, allowing people to penetrate quickly to the gist, or bottom line of a situation. These are not mutually exclusive and can be used in conjunction with each other, but each predominates at different stages of life in normal human development. Developmental psychologist Jean Piaget argued that we start off as intuitive children and grow into analytical adults. ‘Fuzzy-trace theory’ reverses this, proposing that with maturity, gist thinking takes over as we make decisions that disregard distracting details and instead are filtered through our experience, emotions and world view. This gives us a simple answer, a black and white conclusion of good or bad, safe or dangerous. In terms of risk taking, ‘fuzzy trace theory’ predicts that mature decision makers will not deliberate about the degree of risk and the magnitude of benefits if a non-trivial chance of a health compromising outcome exists. In contrast, the verbatim, analytical approach would be expected to take longer. This is a theory that offers a valuable approach to dealing with adolescent risk taking in terms of how best to intervene and reduce risk taking. Again, this points to a much more elaborate driver training system that teaches young novice drivers about the danger of potential risks so that they don’t have to judge it for themselves with a verbatim analysis that is too costly in the context of driving.

The adolescent brain undergoes significant brain growth and change, which must be addressed when looking at adolescent behaviour, in this case, safe driving and the required skills. The next section will discuss the subsequent behavioural nature of this developmental period based on the brain physiology discussed in this section.

## 2.2 Subsequent behaviours

“Adolescents like intensity, excitement, and arousal” (Dahl, 2004, p.7).

Dahl (2004) describes a health paradox that is evident in adolescence. He argues that “in almost every measurable domain, this is a developmental period of strength and resilience” (p.3). Despite these maturational improvements, mortality rates increase 200% over the same time interval. This is the result of difficulty in controlling behaviour and emotion, and leads to subsequent behaviours such as

accidents, suicide, homicide, depression, alcohol and substance abuse, violence, risk taking, sensation seeking and eating disorders. Cognitive processes that underlie the ability to inhibit inappropriate behaviour, control impulses, plan and judge behaviour, and make decisions are evolving and are not fully mature in early adolescence (Weinberger et al., 2005). Dahl (2004) then describes a second health paradox that is highlighted by the above behaviours: adolescents have improved cognitive skills that underpin making logical and responsible choices. However, they behave erratically and recklessly, with periodic disregard for the risks and consequences of what they do. Reyna & Farley (2006) describe risk taking as something that is hardwired into the adolescent brain.

It seems that the developing pre-frontal cortex in adolescence predisposes young drivers to risk taking behaviour and unsafe driving practises and that the developmental period of adolescence intensifies the problems that an inexperienced driver (regardless of age) faces. To me, this is a serious gap in the literature- the link between the fact that adolescents are physiologically unequipped with the higher-order skills that are critical to driving safety, and using that knowledge to train those skills that do not fully develop until the mid-20's. Presently, new drivers (regardless of age) are expected to learn to drive in the same way, are assessed in the same way and are given the same rules and restrictions. There is no consideration given to the huge difference in pre-frontal cortex development- the brain area that is responsible for critical driving skills and safety. A good point is raised by Fisher et al. (2006) who stated that "it is disturbing that there is no relation between the number of hours that a novice driver spends in supervised driving with his or her parents and the crash rate of the newly licensed driver once he or she is out on the road unsupervised" (p.25).

The nature of adolescent brain development is vital to understanding many adolescent behaviours. The developing PFC helps to explain much behaviour including that of driving skills. This knowledge can be used to improve these driving skills, instead of letting them develop with time in such an unforgiving environment.



## 2.3 Potential for change

This section will extend the discussion of sections 2.1 and 2.2 to describe the huge potential for change that is evident in the adolescent brain. In terms of changing the future young driver situation, this is a significant point to consider.

Reyna & Farley (2006) argue that many behaviours that affect adult health begin during adolescence. Risky activities which begin as voluntary experimentation can become perpetrated by addiction. They state that “preventing risky behaviour while it is still a matter of deliberate choice is crucially important – not just for protecting troubled teens but also for society” (p.60). Early intervention is an obvious strategy, as well as postponing risky behaviours. The logic behind this is that it will allow the forebrain and other neurological structures to mature and develop. Reyna & Farley (2006) argue that “avoiding unhealthy risks or buying time during adolescence before exposure to risks can therefore set a different lifetime pattern” (p.8). This logic makes sense in that delaying the driving licensure age would allow the PFC to mature. Or, to introduce more thorough skill training for young drivers while they are learning to drive.

Related to this is the concept of plasticity, which in my opinion is a concept that holds importance in thinking about providing skill training for adolescent drivers. Teaching or training a skill during this developmental interval before neurological structures mature may be an important concept to consider. The ‘use it or lose it’ pruning of over-produced brain cells just before puberty shapes, refines and speeds up the connections in the brain. These connections then determine how we become independent and successful adults in an ever-changing environment (Weinberger et al., 2005). The chemical messenger dopamine is critical for focusing attention on environmental stimuli when it is necessary to choose between conflicting options, especially when the goal may not be obvious and choices are based on memory, not impulse. Dopamine inputs to the pre-frontal cortex grow dramatically during adolescence, representing a neuronal mechanism that increases the capacity for more mature judgement, impulse control and reward learning (Weinberger et al., 2005). Adolescence therefore represents a period of rapid brain development and maturity, as well as a window of opportunity for change and future behaviour.

## 2.4 Intentional versus unintentional risk taking

Researchers have drawn a number of distinctions in the area of young driver research that are useful in thinking about this topic. I will discuss each distinction and then explain how linking them together makes up the basis for my research. Firstly, Senserrick (2006) discusses the difference between intentional and unintentional risk taking. The difference being whether or not the risk was deliberate ‘thrill seeking’, or simply a failure in skill or failure to actually recognise the inherent risk. Related to this is the difference between knowledge-based risk taking versus ignorance-based risk taking. The difference here being weighted on the level of understanding and decision making about potentially risky outcomes. A third distinction is that driving performance is dependently made up of both ‘driving skill’ and ‘driving style’. This refers to our driving ability as being a combination of our level of skill and how we use that skill (McKenna, Alexander, & Horswill, 2006). A similar distinction is the difference between error and violation. Error being a skill based failure in information processing, versus violation, being risk taking behaviour that involves a deliberate infringement of a regulation (McKenna et al., 2006).

These differences can be applied to adolescent drivers and in my opinion, highlights the target for practical and realistic safety interventions. Adolescence ‘predisposes’ young drivers to engage in intentional, knowledge-based risk taking and is a reflection of the driving style that is in some way inevitable during this developmental, exploratory period. This leads to subsequent deliberate violations of the driving environment and accounts for a significant part of why young drivers are involved in so many accidents. A major gap in the literature is linking this to a second significant part of the problem- a part that I consider to be most important in terms of changing the situation. Driving is a skill, and like any skill it requires practise and improves with experience, regardless of age but more importantly for young drivers for the following reason. A novice driver engages in unintentional, ignorance-based risk taking behaviour and is a reflection of their inexperienced driving skill. This leads to subsequent driving errors. This is of particular importance for adolescent novice drivers because the most critical driving skills are controlled by the pre-frontal cortex that is still developing in those under the age of 25.

I will now go on to discuss the issue of unintentional risk taking in terms of the developing skills of the pre-frontal cortex and how they affect the driving behaviour of adolescent drivers.

#### 2.4.1 Unintentional risks: what, why and the effectiveness of training

Underwood (2007) states that “to be safe on the roads, one needs to be predictable to other road users” (p.1237). Novice drivers are anything but predictable on the roads for a number of reasons, which will be discussed in this section.

“When newly qualified drivers encounter difficult driving conditions, their search of the road becomes stereotypical and inflexible. When their cognitive load is increased by the appearance of multiple hazards, novice drivers tend to look inflexibly at the road directly ahead of them” (Underwood, Chapman, Bowden, & Crundall, 2002). Pradhan, Hammel, DeRamus, Pollatsek, Noyce, & Fisher (2005) report the results of a review of almost 1000 crashes in which novice drivers were involved and identified the most common reasons for the crashes. The most common were failures to search ahead, to the side, and to the rear, which together were implicated in 42.7% of the crashes; failure to pay attention (23%) and failure to adjust the vehicles speed correctly (20.8%). Given the fact that ‘multiple hazards’ and ‘difficult driving conditions’ exist as a common and unavoidable part of the driving environment, it is disturbing how unequipped novice drivers are in terms of safety for themselves and for other road users.

Lee (2007) reports that most crashes result from errors of attention, visual search, speed selection, hazard recognition, and control during emergency manoeuvres. He also reports that others have found that young drivers are over-represented in crashes due to excessive speeds, curves, alcohol, fatigue, distraction and passengers. From this he argues that the predominant risk factor is lack of skill and poor judgment. I agree with this argument; that there is a multitude of contributing factors, but lack of higher-order skill is predominant and an important and realistic target for change.

Lee (2007) describes the interaction of risk factors as producing ‘cascade effects’ that have potentially powerful consequences for driving safety. “Cascade effects occur when the outcome at one level of control affects control at another” (p.205). For example, the decision to drive at night places greater demands on a driver’s ability to detect hazards, such as sharp curves at the tactical level. Failures

at the tactical level to detect those curves places a high demand on the driver's vehicle control skills at the operational level and may ultimately lead to loss of control of the car. In my opinion, improving higher-order skills such as hazard perception would help to reduce this cascade effect because the skill is such a fundamental component to driver safety.

To me, this is at the core of the problem; the current system is failing to provide fundamental skill training. This weakness at such a basic level may be failing to protect young novices from the other contributing factors.

Senserrick (2007) states that:

Understanding that only fractions of seconds make all the difference between a near crash, minor crash, or severe crash may demonstrate to young drivers why behaviours such as dialling a cell phone, reaching for a CD case on the floor, or turning around to face a rear seat passenger while driving are risky activities. It is possible that such activities are just as common among older, more experienced drivers yet do not similarly impact their crash rate due to better hazard perception skills, including more time with 'eyes on the road' (p.59).

Knowledge and awareness of the potential dangers of learning to drive are not part of the current driver training system. This is another missing link and again, comes down to providing something like hazard perception training. Getting a drivers license seems too easy. I will now go on to describe these unintentional risk taking behaviours that are the result of developing PFC functions: scanning behaviour, attention, cognitive load, hazard perception and risk perception.

#### 2.4.2 Scanning behaviour

Underwood et al. (2002) describe a result for the case of novice drivers on a dual carriage-way that varied between two and three lanes, with slip roads and merging traffic, with novices searching along the horizontal meridian no differently on this road than on a quiet rural road. They then proposed three alternative explanations for this: (1) novices need to look at road markers in order to steer the vehicle, therefore are unable to look around them for hazards, (2) novices are unable to allocate sufficient cognitive resources to visually search the road, and (3) novices have an inadequate mental model of the dangers present on

these roads. Underwood (2007) then goes on to suggest that it may be that novices have an impoverished set of scripts or mental models compared to experienced drivers, having been accumulated mainly as a passenger in a vehicle, not the driver. This is an important finding that is a direct illustration of inadequate skill training. Underwood (2007) reports that one of the remarkable changes that occur as drivers develop their skills is the increase in visual scanning. Novices are relatively insensitive to changes in the driving environment, whereas an experienced driver will anticipate change and drive in a predictable style that suits the driving conditions.

Deery (1999) described the visual search strategies of novice drivers. Compared to experienced drivers, novice drivers display a smaller range of horizontal scanning of the road, look closer to the front of the vehicle, check their mirrors less frequently, glance at objects less frequently, use peripheral vision less efficiently, and fixate on fewer objects. Underwood (2007) argues that scanning of the horizontal plane is developed and learned with experience. This finding is also reported by Pradhan et al. (2005); that novice drivers do not scan as widely as experienced drivers, perhaps missing the peripheral risk relevant elements in a scenario. Novice drivers also fixate more on stationary objects, whereas experienced drivers fixate more on moving objects. Research suggests that experienced drivers (and experts in other domains such as chess and radiology) perceive holistically, whereas novices perceive a scene as being made up of pieces and independent of context (Deery, 1999).

Underwood, Chapman, Berger, & Crundall (2003) report that when novice drivers were shown video recordings at night, their horizontal scanning was further restricted, whereas experienced drivers were unaffected by time of day. The Ministry of Transport Website states that in New Zealand, young drivers are disproportionately represented in fatal crashes at night. Between 2003 and 2005, 58% of fatal crashes that occurred on a Friday night and 47% of those that occurred on Saturday night involved a young driver. This compares to the 29% of Monday to Friday daytime crashes which involved a young driver. This suggests that novices are currently receiving inadequate night time driving experience. This is true; it is unlikely that on the learner license the supervisor would be willing to take part at night as opposed to during the day. The novice therefore gets the restricted license with limited experience in night time driving. On the restricted license, novices can not drive after 10pm, and before 10pm novices can not drive

with passengers unsupervised, again, getting very little night time driving experience. It is not surprising that when the full license is gained and novices are able to drive unrestricted and unsupervised, that their crash rates peak during the first few months and is worse at night. Essentially, the GDLS is 'protecting' novices from high risk situations but does not provide adequate training or exposure for those high risk situations.

#### 2.4.3 Attention

Attention is necessary for conscious perception (Recarte, & Nunes, 2003). When driving, some events are more likely than others to capture attention. Drivers are sensitive to hazardous situations and react to them by rapidly re-fixating in the appropriate direction. Fixation durations increase as hazardous objects appear in the field of view, even when drivers are watching video clips recorded from a driver's perspective, rather than driving themselves. The increase in fixation durations may reflect the increased workload as the driver decides upon a course of action (Underwood, Chapman, Berger, & Crundall, 2003). Underwood et al. (2003) go on to argue that in hazardous situations, saccadic activity is reduced, with a consequently reduced horizontal and vertical variance which effectively narrows the perceptual field. This suggests that during hazardous situations we should expect increased focusing upon central objects, and reduced recall of information about incidental objects. Novice drivers have longer eye fixations on hazardous objects. They also tend to detect fewer peripheral events. They argue that the detection of objects is influenced by acquired knowledge of the probabilistic structure of the environment, suggesting that experience of the environment will determine the allocation of attention. The increased workload on novices during hazardous situations, indicated by their fixation durations, and their impaired detection of peripheral events, suggests that the focusing effects upon attention and upon recall should be greater for novices than experienced drivers.

Related to the concept of attention is that of distraction/ inattention (lack of attention or attending to something irrelevant), which holds equal significance when it comes to driving safety. Inattention is one of the most cited causes of young driver road accidents (Underwood, 2007). The result of distraction is an impaired capacity to process relevant information because of perceptual inefficiency and/ or inadequate response selection (Recarte & Nunes, 2003).

Attentional distraction accounts for a large proportion of crashes, particularly with teenage drivers due to both developmental processes and their relative inexperience in driving (Keating, 2007). This is compounded by the presence of technological distractions such as cell phones, i-pods and other music devices, DVDs etc...that are now used so commonly in cars. These distractions, along with underage passengers being driven by young novices absorb attention and place an added demand onto central processing demands which will be discussed further in the following section.

Underwood (2007) reports the findings of the '100-car naturalistic driving study' that showed a dramatic result in terms of the high incidence of inattention in road accidents. The study involved 100 cars that were fitted with sensors and video cameras. A total of 241 drivers used the 100 cars and over 1 year, a total of more than 2 million miles were driven and recorded. During this time there were 82 crashes and 761 near crashes, showing that 78% of the crashes and 65% of the near crashes involved inattention of some form. This study also confirmed the high involvement of young drivers in distraction related accidents, with 5 times the involvement relative to older drivers. This was a significant finding in that it clearly showed an elevated estimation of accidents that occur which involve inattention.

Recarte & Nunes (2003) describe the phenomena of the 'psychological refractory period'. They describe this as being the difficulty in performing two tasks simultaneously when both require a central processing of evaluation and response generation; the attentional interference occurs at the central processing level. Recarte & Nunes (2003) point out that distraction can be exogenous-produced by external objects or events, or endogenous-produced by the drivers own thoughts or cognitive activity. In terms of driving, the implications of these differ in that in addition to attentional capture, exogenous distraction often also captures the gaze, which means withdrawing it from the road ahead. They explain this by saying "it is easy to understand how one cannot see because of not looking, but it is less obvious to explain how one looks but does not see" (p.119). 'Looking but not seeing' would be applicable to a great deal of young novice accidents I would imagine.

#### 2.4.4 Cognitive load

As we become more skilled in handling the vehicle, with the automation of subtasks, cognitive resources are released and can be allocated to other tasks such as general surveillance. When we no longer have to concentrate on the position of the gear lever and co-ordination of gear changing, we can think about the traffic around us while performing this operation without really thinking about it. Increased skill is associated with an increase in the capacity for acquiring information about the events around us. At the same time as we are developing our vehicle handling skills through practice, we gain experience of traffic events that include accidents, near accidents and traffic hazards that develop our situation awareness. When we next encounter similar situations we have an increased awareness of the potential danger and will scan more extensively than previously (Underwood et al., 2002).

Related to this is the concept of working memory which is a further function of the pre-frontal cortex. It refers to the structures and processes used for temporarily (in the order of seconds) storing and manipulating information. For example, driving a car while dialling a phone number that has been memorised. If this is a developing pre-frontal cortex function in young drivers, it offers some explanation for why cognitive overload occurs as an unintentional risk taking behaviour. Keating (2007) raises an important developmental finding: that on tasks that adolescents perform as successfully as adults, the adolescents may be using more central processing capacity, whereas adults divert the performance to peripheral and more automated neural circuitry. In the driving domain, where there are multiple tasks to attend to, the cumulative load on the central processor may be excessive. Keating (2007) then argues that this finding highlights the necessity of constructing pathways to expertise that make safe driving habits more automatic as quickly as possibly. In terms of working memory, this makes sense in that freeing up short term memory will reduce cognitive over load.

Gregersen, Berg, Engstrom, Nolen, Nyberg, & Rimmo (2000) describe the perceptual system of novice drivers as new and that it imposes special requirements on visual search skills, and interpretation of what is happening in the surrounding environment. With increased experience, the driving task becomes automated and the mental work load will reduce. They go on to describe the skill acquisition process that involves three levels. The first level is called the knowledge based level. Extensive mental effort is allocated to attention, decision



making and acting, including those needed to perform the actual driving task. Through experience, the task becomes familiar and mental rules are developed. These rules allow the driver to gain control over sequences of behaviour so that they are more combined and automated. For example, attention is then needed to decide when to change gear as opposed to how to change gear. This is known as the rule based level. This development to the skill based level, makes it possible to shift more of the attention and decision making from the primary driving task to the driving environment and makes it possible to predict the behaviour of other road users and evaluate hazards.

This skill acquisition process was used in the decision to lower the age limit for driving practise in Sweden from 17.5 years to 16 years in 1993. By keeping the licensure age at 18, this made it possible to gain 2 years of experience under mandatory supervision before driving alone. The implementation of this new system had a general risk reducing effect on young novice drivers of 15% during a follow up period of two years (Gregersen et al., 2000). This is an example of a positive injury prevention strategy that holds promise for the initiation of more elaborate driver training. It also shows a relationship between crash rate and the 'quality' of supervised driving experience- in combination with skill training. In section 2.2, I agreed with Fisher et al. (2006) when they said that it is disturbing how there is no relation between the number of hours a novice spends in supervised driving and the crash rate when unsupervised. The recent finding in Sweden, exemplifies my argument of the significance of placing more importance on the learner license period; including a more elaborate supervision system combined with skill training.

Underwood (2007) reported the results of a study that was designed to test whether novices fail to scan the horizontal plane because of inadequate cognitive resources or because they have a developing mental model of the driving environment. The study was conducted in a laboratory which eliminated the need to control the vehicle and the task was essentially observation and prediction as measured by eye movements. Participants watched a series of film clips recorded from a car as it travelled along five different roads. If novices have restricted search patterns because of inadequate cognitive resources allocated to vehicle control, then eliminating this component should result in visual search patterns that are similar to experienced drivers. However, if their search patterns result from a developing mental model, then they should continue to restrict their

searches while watching recordings in this non-interactive task. The results showed that the two groups of drivers were thinking about the scene differently. On a simple road, there was minimal horizontal scanning in both groups; however as traffic conditions became more complex, it was the experienced drivers who increased their scanning. This suggests that it is not the need to control the vehicle that induces the reduced scanning of the novices, so much as the difference in their situational awareness. This result however may have simply been due to the inexperienced drivers performing poorly on both types of road because of a lack of cognitive resources. The result does however clearly show the lack of skill in novice drivers.

#### 2.4.5 Hazard perception

The hazard perception of novice drivers is described by Deery (1999). He argues that novice drivers assess traffic hazards on the basis of a single characteristic, so that all situations that share a certain characteristic, such as wet roads, are perceived equally dangerous. In contrast, experienced drivers perceive situations on the basis of multiple characteristics, which they use to differentiate their degree of potential risk. This indicates that with experience, people are better able to integrate information quickly and consider hazardousness as a more holistic attribute of the driving environment. This is thought to stem from the re-organisation of knowledge that develops with experience. Chapman, Underwood, & Roberts (2002) describe this in that experience allows current information to be rapidly processed within existing schemata, and irrelevant information to be quickly dismissed. The concept of hazard perception latency is associated with a higher crash rate. Research shows that drivers who display long hazard perception latency may not necessarily show slow reactions in other contexts. Young drivers are more likely to miss detecting hazards altogether and take longer to detect the hazards that they do see. Many researchers have stressed the importance of anticipation, particularly in the context of hazard perception ability. Anticipation is critical to successful scanning in that anticipation of the road ahead and the behaviour of other traffic is necessary in selecting appropriate areas of the visual field to fixate next (Chapman, Underwood, & Roberts, 2002). Only a small fraction of hazards represent any real danger for a driver in any given situation, but a more experienced driver will be better able to quantify the degree of a given danger and respond appropriately (Ferguson, 2003). This is something that should

not be left to simply develop with experience; training in the area would greatly improve this.

Keating (2007) discusses the concept of expertise, its acquisition and its application to young driver safety. Firstly, he points out that although inexperience and lack of expertise are co-extensive concepts, they are not necessarily the same thing. Expertise and its development are specific to particular knowledge and skill domains and the focus is on the acquisition of expertise through experience and practice, rather than on age or developmental differences. The early demonstrations that young experts could outperform older novices were central to the argument of expertise. The acquisition of expertise involves several important constructs: the role of time, the role of an overarching framework to support a goal of competent, safe driving, and the role of deliberate, effortful, guided practice that focuses on error re-mediation and the automation of sub-routines to free up attentional and cognitive capacity.

An important idea to consider that is related to this is described by Keating (2007); that “the difference between having and avoiding a crash is measured in milliseconds, as is the difference between severe and more moderate crashes. This is an interesting paradox: skill acquisition in the driving domain takes a substantial investment of time in order to preserve a few milliseconds in an emergent situation, but it is those few milliseconds gained through more effective hazard detection etc... that are critical” (p.153). This paradox is central to the young driver problem; novices are oblivious to the potential dangers that are an inevitable part of learning to drive. They also point out that unsafe habits can be automated just as readily as safe ones. This is an important concept to consider in that there are significant risks associated with unstructured acquisition of expertise. This points to the fact that under the current Graduated Driver Licensing System (GDLS), because there is no compulsory formal driver training, unsafe driving habits are almost expected to form due to the lack of structured skill acquisition.

McKenna et al. (2006) showed a significant reduction in risk taking behaviour after hazard perception training. No evidence of increased overconfidence was found- a result that has been raised in past research as being a negative outcome of skill training. They also showed that the decrease in risk taking was not a result of general sensitisation to risk- illustrated by the fact that choice of speed reduction was particular to only hazardous situations- not in non-hazardous situations. The

results of this study show that skill training in the form of hazard perception/ anticipation training is beneficial to young drivers. Whether this effect on risk taking concerns intentional or unintentional risk is hard to specify, however by improving one, will improve the other in my opinion.

#### 2.4.6 Risk perception

Drivers differ in their attitudes about driving, including their perceptions about the likelihood of being in a crash (risk perception). They may also differ in their beliefs about what constitutes safe driving, including beliefs about their own driving ability. There are studies that document the risk perception of young drivers, as well as studies that point to their riskier driving and their rating hazardous situations as less risky than older drivers (Ferguson, 2003). Ferguson goes on to report that despite inexperience, young drivers perceive their own risk of being in a crash as significantly lower than that of their peers. Also pointing out the well established fact that few drivers believe they are bad drivers. Thus, drivers of all ages tend to rate their own driving skills as better than average. For young drivers with poor driving skills, this has serious consequences for driving safety.

It could be argued that poor risk perception is a direct result of poor hazard perception, which even further highlights the ‘young driver problem’; if you can’t perceive hazards very well or you misperceive them, it makes sense that you misperceive the risk. It would seem that by training hazard perception, it would have a follow on effect to improving risk perception in that it improves the skill and awareness of important driver safety issues. Hazard perception and risk perception are two distinct constructs, however in terms of young driver safety they should be considered hand in hand. The ‘risky’ driving that is seen so often with young drivers is, in my opinion significantly due to their risk misperception, a direct result of poor skill and awareness.

## 2.5 NZ driver training: The Graduated Driver Licensing System: The good, the bad and what it misses out

The Graduated Driver Licensing System (GDLS) was introduced into New Zealand on 1st August 1987 in an endeavour to reduce the high crash rate among young drivers (Langley, Wagenaar, & Begg, 1996). The GDLS was designed to give young drivers experience in driving while being excluded from what has been identified as high risk driving situations such as night time driving, driving after drinking alcohol, and driving with other young passengers. Before the GDLS was implemented, a full car license could be obtained at the age of 15 after passing a written, oral and practical driving test. Under the GDLS, gaining a drivers license has become a three step process: learner license, restricted license and full license. The learner license can be applied for at age 15 and involves passing a written, oral and eyesight test. Under this 6 month period, the young driver has to be accompanied at all times by a supervisor (someone who is at least 20 years old and has held a full license for at least 2 years). This 6 month period can be reduced to 3 months by gaining a certificate of competency from a driving instructor. The restricted license is then gained after sitting a practical driving test. This license involves three conditions: no driving between 10pm and 5am unless accompanied by a supervisor, no carrying passengers unless accompanied by a supervisor and an alcohol restriction. This is held for 18 months but can be reduced to 9 months by completing a Defensive Driving Course. A full license can then be applied for. A driver can be fully licensed after 2 years, but with formal driver training this can be reduced to one year (Langley et al., 1996).

Langley et al. (1996) evaluated the GDLS in New Zealand and showed that it has resulted in a substantial reduction in car crash injuries, particularly for those in the 15-19 year old age group. They did however state that caution should be exercised in attributing causation for a number of reasons including the fact that compliance with the key provisions of the GDLS is low. They suggest that one of the principal effects of the GDLS on crashes may have been indirect through a reduction in overall exposure. Overall, the GDLS has reduced the number of young driver crashes, but these rates remain unacceptably high. Addressing the problem will involve a co-ordinated approach involving education and awareness,

re-thinking the licensing process, more elaborate training, law enforcement, communication and the selective use of technology in combination with other road safety measures.

It seems that the GDLS is insufficient as the sole proponent of the driver training process. The concept of breaking down the learning process into provisional stages and providing restrictions on high risk driving situations makes sense. The fact that crash rates and learning to drive is consistent with a typical learning curve is justification enough for this (Fisher, Pollatsek, & Pradhan, 2006). However, something that the GDLS does not directly address is actually training people how to drive safely, especially in the high risk situations that drivers are protected from on the restricted licence. The learner license stage is presumably the period when you learn 'how to drive'. We know that young people are good at this, vehicle handling skills and traffic rules can be learned very quickly. This is evident by the fact that under this license, you are 'accompanied' and 'supervised' but not actually given any set training. Supervised learning seems inadequate and the fact that young driver crash rates peak once drivers become unsupervised is a sad illustration of this. These crash rates peak at night, and when there are passengers in the car- high risk situations that are not trained. Essentially the learner license is a six month period for you to teach yourself how to drive via trial and error with someone sitting next to you just in case. You are then legally permitted to drive unsupervised with no training in higher-order skills such as hazard perception that are most critical to driving safety. Leaving these higher-order skills to just 'develop with experience' is a ticking time bomb for serious accidents. A further component of the GDLS that misses the point is the fact that the learner and restricted licenses can be reduced if you gain a 'certificate of competency'. This is essentially a certificate to say that the driver has adequate vehicle handling skills and can therefore proceed to the next stage with even less experience and still no higher-order skill training. The GDLS also seems to inadequately distinguish between young novice drivers and older novice drivers. The age of learning to drive should be accounted for. A problem with the GDLS may be that the emphasis is on risk management, not driver training. It seems to presume that learning to drive is as simple as having adequate vehicle handling skills and knowledge of the traffic laws and then all other skills are gained through experience and time. To me, this is a big part of the problem and is a critical target for intervention.

A number of countries have recognised the need for a more comprehensive licensing system. Sweden, Norway, France and Belgium have all extended the learning period in an attempt to increase the total amount of supervised driving experience. One of the main assumptions of doing this is that it will better enable the learner driver to utilise mental resources, acquire knowledge and experience and increased automation of action and reaction. Sweden also placed greater importance on the level of skill and experience of the supervisor. This person must be at least 24 years old (as opposed to 20 years old in New Zealand), and must have held their license for at least 5 years (as opposed to 2 years in New Zealand). This person also requires a supervision permit (Gregersen et al., 2000). Several countries have also focused on improving training in order to increase experience in handling various traffic situations and therefore learning to safely interact with other road users. Sweden's 'Vision Zero' strategy for zero killed or severely injured is an injury prevention goal that is indicative of the importance their government places on young driver safety (Gregersen et al., 2000). The European Conference of Ministers of Transport established a target of a 50% reduction in traffic related deaths in the period 2000-2012. Reducing young driver risk is the key to that goal (Stacey, 2006). France has also made cutting road deaths a priority. Its fatality rate has since dropped from around sixth highest in the Organisation for Economic Co-operation and Development (OECD) in 2000 to 12th in 2004 after a call for more effective enforcement (Stacey, 2006).

One option that is under consideration is a two phased driver training program that involves a pre-license and a post-license phase. Four European Union (EU) states (Finland, Luxembourg, Austria and Estonia) already have obligatory post-license second phase training for all novice drivers. The aim being to provide an extended form of driver training that stretches into the initial, high risk period of independent driving in the months following the acquisition of a license (Molina, Sanmartin, Keskinen, & Sanders, 2007). The EU ADVANCED project was commissioned in 2000 by the EU to analyse the current state of voluntary post-license training. The RACC (Real Automobil Club de Cataluna) is a training intervention that was implemented in Spain and based on the guidelines set out by the ADVANCED project. They came up with a number of conclusions. Firstly, that training should be spread out over time during the initial period of independent driving, but should allow the drivers to have accumulated some driving experience beforehand. Secondly that training should be participant

centred and based on discussion and self evaluation. Thirdly, that the content should focus on higher level driving behaviours such as goals for life and skills for living, risk awareness and the context and motives behind individual car journeys. The training consisted of a combination of driving simulated track experiences, on-road feedback drives and group discussion about peer pressure, alcohol and drugs, speeding and risk taking. They found a significant positive change after a 9 month follow up period. This is a clear example of the need for more effort to be devoted to improving the 'on-road' part of driver training through post-license training (Molina, Sanmartin, Keskinen, & Sanders, 2007).

Australia has implemented several intervention strategies, with several jurisdictions having recently announced revisions to their licensing systems (Senserrick, 2007). From July 1st 2007, Queensland introduced the following initiatives which will apply to all applicants under 25 years: lower the minimum age to 16, extend the learner period to 12 months, a minimum of 100 hours of supervised practice (including two provisional stages with a hazard perception test to pass provisional stage 1 to provisional stage 2), restrict provisional stage 1 drivers to one passenger aged at least 21 years old from 11pm to 5am (excluding immediate family), restrict provisional 1 and 2 drivers from high powered vehicles, restrict all cell phone use (including hands free) and introduce late night driving restrictions for disqualified and suspended drivers. New South Wales has similar initiatives, as does Victoria which also includes a minimum 10 hours of supervised night driving. ACT (Australian Capital Territory) has a mandatory class room based program called 'Road Ready,' targeting teens under the age of 15 years 9 months (the minimum learner age) and their parents. The aim being to raise awareness of the road environment and the complexity of driving among young people via a range of problem solving and decision making sessions, group tasks and research assignments. It also prepares teens for the learner permit test. This is run through Year 10 classes in secondary schools. Other states have several similar pre-license initiatives, including a specific education program for Aboriginal communities (Senserrick, 2007). These are pre-license strategies that are making positive changes throughout Australia.

What about New Zealand? Given the fact that it has one of the highest young driver fatality crash rates (per capita) in the world, it is a problem that that must be urgently addressed.



This background review chapter has provided an overview of the relevant research surrounding the issue of adolescent unintentional risk taking in terms of the hazard perception skills of young novice drivers. Sections 2.1, 2.2 and 2.3 provided an overview of how the adolescent brain works, subsequent behaviours, and the significance of its potential for change. Section 2.4 discussed the important distinction between intentional and unintentional risk taking in adolescents. I have argued for the importance of focusing on unintentional risk as a way of explaining the young driver accidents involving ‘model teens’ where intentional risk was not a factor. It is the reasons for these accidents that must be addressed. The relevant concepts of visual scanning, attention, cognitive load, and hazard and risk perception were discussed as driving skills that are developing in adolescent drivers. It is these fundamental skills that are the predominant risk factors in young driver accidents and therefore must be trained if a demand such as driving is to be placed of young people. The next section described the current situation in New Zealand and how the GDLS is an insufficient sole component to gaining a drivers licence. The emphasis of the GDLS is risk management, not driver training. I am arguing for a more elaborate driver training component in the form of hazard perception skill training for all novice drivers, but especially for adolescents. This is the focus of my thesis and the next chapter will state the hypotheses of my research.

## 2.6 Research hypotheses

This research will test the following three hypotheses. The first two will explore the baseline skills of novice and experienced drivers and the third will investigate the effect of the road commentary training on each group.

1. It is predicted that the experienced drivers will show better baseline hazard perception skills when compared to novice drivers.
2. Also, that the experienced drivers will show better visual search and attention and working memory skills when compared to novice drivers and that the Visual Search and Attention Test and the Digits Backwards task are predictive of hazard perception skills.
3. Lastly, hazard perception skill training in the form of video based driving simulation and road commentary will significantly improve the hazard perception skills of young novice drivers as measured by the mean percentage of correctly identified hazards.

## Chapter 3: Method

### 3.1 Participants

Thirty New Zealand drivers (18, 19 or at least 25 years old) who held a valid license volunteered for this study. Twenty-two of the recruited participants (17 females and 5 males) were 18 or 19 years old. They were considered novice drivers, holding a license for an average of 1.5 years. Thirteen of these participants held a full NZ drivers license, 6 held a restricted NZ license and 3 held a learner NZ license. The ethnic background was predominantly Caucasian (20) with only 2 NZ Maori participants.

Eight participants (all females) were 25 years and older (mean age of 35.5 years). They held a full NZ driver license for an average of 15.5 years and were considered to be experienced drivers. They all considered themselves to be Caucasian.

All novice driver participants were first year students at the University of Waikato. Nineteen of those were enrolled in Psychology. Of the 8 experienced driver participants, 4 were first year psychology students, 3 were graduate psychology students and one was a University administrator. First year psychology students gained a 1% course credit and the others were given a \$10 MTA voucher.

### 3.2 Materials and Measures

#### 3.2.1 Overall experimental setup

The experiment was conducted in a research laboratory at the Psychology Department at the University of Waikato, containing two small rooms separated by a door. In one room there was a computer controlled by the experimenter and in the other room was the participant sitting in a recliner chair in front of a monitor.

### 3.2.2 Consent form, course credit form and MTA vouchers

A standardised consent form was used that was taken from the psychology ethics application document (see Appendix C). The consent form was signed upon agreement of the terms: that they had received adequate information about the research, were provided with the opportunity to ask any questions and had the right to withdraw from the research at any time. The first year psychology students also signed a course credit form in order to gain a 1% credit. Non-first year psychology students were given a \$10 MTA voucher which are redeemable for use at any New Zealand MTA associated business.

### 3.2.3 Demographic questionnaire

A demographic questionnaire asked for information including driving experience and number of traffic related accidents/violations (see Appendix D).

### 3.2.4 Visual Search and Attention Test

The Visual Search and Attention Test (VSAT) is one of the widely used visual cancellation tasks to measure sustained attention, visual scanning and the ability to activate and inhibit responses rapidly (see Lezak, 2004). The VSAT consists of a colour discrimination task to pre-screen for basic colour discrimination and four different visual cancellation tasks that require the participants to cross out as many letters or symbols that look like the target stimulus, within a time limit of 60 seconds. The measure of the VSAT is the total number of correctly crossed out letters or symbols on two of the four cancellation tasks.

The VSAT is a norm-referenced measure that was developed to address the need for a standardized test of this type. The fitted mean and standard deviation for the 18/19 year age group is  $M=163.93$ ,  $SD=23.16$ . The norms for participants of a similar age to the experienced drivers vary depending on their exact age. Scores at or between the 16<sup>th</sup> and 3<sup>rd</sup> percentile are suggestive of impairment and are considered to fall within the borderline performance range. Scores at or above the 17<sup>th</sup> percentile are considered normal.

### 3.2.5 Digits Backwards Task

The well known Digits Backwards Task (see Lezak, 2004) was used to test working memory functions. The task involves a series of number sequences that

are read aloud by the examiner and the participant must repeat in reversed order. The reversed digit span requirement of storing a few bits of data briefly while juggling them around mentally is an effortful activity that calls upon working memory (Lezak, 2004).

### 3.2.6 Video based traffic simulations

The video based traffic simulations were controlled by a computer (Dell Optiplex 745, 1G RAM) and displayed on a flat screen monitor (70cm x 40cm). The selected simulations (52cm x 18cm), lasting between 15 and 125 seconds long (mean duration 46.7 seconds) were taken from the DVD series 'a2om mind', a hazard perception and risk management training tool for novice drivers. This training product was created by the Psychology Department at Waikato University in 2007 specifically for the UK motoring company a2om (alpha to omega motoring Ltd: [www.a2om.com](http://www.a2om.com)). Figure 3.1 shows a screenshot of such a simulation including a fully functioning virtual dashboard and three rear mirrors. The videos in the three mirrors provided a near 360 degree vision around the virtual car.

### 3.2.7 Hazard perception dual task

The hazard perception dual task was specifically designed for this experiment and consisted of a hazard detection and identification task and a central tracking task. The hazard detection and identification task used video based traffic simulations as described above. The aim of that task was for the participants to detect and verbally identify immediate hazards. The participants were required to click a computer 'mouse' device each time they detected an immediate hazard before they had to verbally identify them. Each click was accompanied by a high pitched 'peep' sound and recorded as a hazard detected. The video based driving simulations involved an average of 5.4 immediate hazards. The voice of each participant was audio taped during the task when they verbally identified the hazards so that the detected hazards could be later matched up with what they verbally identified each one to be.

To make the hazard detection and identification task more similar to a real life driving situation, participants were also required to carry out a central tracking task whilst identifying the immediate hazards. As seen in Figure 3.1, a stationary rectangle (13cm x 8cm) was superimposed in the central, lower area of the driving

scene approximately in the location of the road ahead and the participants were required to keep a randomly moving dot (that moved at approximately 1 cm per second) within a square (3cm x 3cm) using a computer ‘mouse’. The randomly moving dot was contained in the stationary rectangle and bounced off the sides like a ball on a billiard table. Each time the participant miss-tracked and the dot moved out of the square, a sound alerted the participants to this and these occasions were recorded as ‘number of tracking errors’. The amount of time that the dot was out of the square was monitored and recorded as ‘time spent miss-tracking’ but not used as a dependent variable in the data analysis.

### 3.2.8 Television commercial video clips

For a control condition (see research design below) a number of television commercial video clips (including sound) were used. These clips were recorded randomly from TVNZ but were not used if they had any driving related content.



*Figure 3.1* Screen shot example of a video based traffic simulation for the hazard perception dual task including the central tracking task, the virtual computer generated dashboard and the three rear mirrors with the inserted video (see text for more information)

## 3.3 Experimental Design

This research used a mixed between and within subjects design to examine the baseline hazard perception skills of novice drivers and experienced drivers (between subjects) and to determine if these skills can be improved in the novice

drivers using video based road commentary training (within and between subjects). The novice drivers were compared to the experienced drivers in regards to their performance in the hazard perception dual task followed by a comparison in performance on both the Visual Search and Attention Test (VSAT) and the Digits Backwards Task (working memory). The road commentary training involved four groups, three of which were novice drivers who were randomly assigned to one of the three. A first experimental group of 8 novice driver participants (E1-novice) and a second experimental group of 8 experienced drivers (E2-experienced) were required to perform road commentary on 12 video based traffic simulations. A first control group of 7 novice driver participants (C1-novice) watched the same 12 video simulations without commenting. A second control group of 7 novice driver participants (C2-novice) watched television commercial video clips instead of the 12 video simulations. All participants were then re-tested on the hazard perception dual task.

### 3.4 Procedure

#### 3.4.1 Ethical approval, participant recruitment and consent procedure

After ethical approval was obtained through the Research and Ethics Committee of the Psychology Department, University of Waikato, the participants were recruited through an advertisement on a research notice board in the Psychology Department and given an information sheet (see Appendices A and B). The participants who signed up for the experiment were contacted by email and 45 minute individual appointments were arranged. After arrival at the research laboratory, information about the experiment was given, including their right to withdraw from the study, without penalty at any time. They were then required to sign the consent form and course credit form. Alternatively, an MTA voucher was given to non-first year psychology students.

#### 3.4.2 Demographics and pre-tests

The participants were then required to fill in the demographic questionnaire. The Visual Search and Attention Test (VSAT) was then administered in accordance with the instructions of the test manual, followed by the Digits Backwards Task.

### 3.4.3 Hazard perception dual task (baseline)

After the pre-tests, each participant was seated in a recliner chair 1 meter in front of the widescreen monitor. Instructions were then given for the hazard perception dual task as well as a written definition of an immediate hazard as it relates to driving. Immediate hazards were defined as hazards that would have needed some action from the participants (e.g., braking, or being prepared to stop, or change of direction) in order to avoid a dangerous encounter (e.g. pedestrian approaching a zebra crossing, car pulling out of a side street, or a bicycle) if they would have experienced them in a real world traffic situation. Participants then took part in a practice trial to ensure that the hazard perception dual task was clearly understood and performed correctly. The participants then completed four baseline trials of the dual task. All participants were shown the same four baseline clips in the same order.

### 3.4.4 Road commentary training and control conditions

The participants of the two experimental groups (E1-novice and E2-experienced) then took part in the road commentary training. Participants were given instructions to verbally identify immediate hazards (as defined above) in each of the 12 video based driving simulations. The novice driver participants in the first control group (C1) were given instructions to simply watch the 12 video based driving simulations without commenting. The second control group (C2) was told to simply watch the series of television commercial clips without commenting.

### 3.4.5 Hazard perception dual task (post-training)

After the road commentary training or control conditions, each participant then completed another four trials of the hazard perception dual task (post-training trials) using the same procedure as the four baseline trials, except that four new video based driving simulations were presented.

## Chapter 4: Results

All 30 recruited participants completed the full experimental procedure and a complete set of data was obtained for each participant.

The results of the demographic questionnaire provided background information about the driving habits of the participants. It firstly highlighted the fact that based on a self-estimation of the average number of kilometres driven per week; the experienced driver participants ( $N=8$ ) drove a lot more per week, with an average of 197km, (ranging between 6 and 300km,  $SD= 106.55$ ) than the novice driver participants ( $N=22$ ), with an average of 63km, (ranging between 0 and 300km,  $SD= 70.47$ ). Secondly, participants were asked to provide an estimation of the number of crashes and near misses in which they were involved in the past 12 months (irrespective of who was at fault). When comparing these estimations between the experienced and novice driver groups, there was not much difference. The experienced driver participants were involved in an average of .38 crashes (ranging between 0 and 1,  $SD=.52$ ), and the novice driver participants were involved in an average of .32 crashes (ranging between 0 and 2,  $SD=.57$ ). The experienced driver participants were involved in an average of 1.88 near misses (ranging between 0 and 5,  $SD=1.89$ ) and the novice driver participants were involved in an average of 2.1 crashes (ranging between 0 and 8,  $SD= 2.02$ ). Lastly, participants were asked whether they had received any form of formal driver training. Of those who had, this had been in the form of professional defensive driver training lessons while on the learner or restricted license. Of the experienced drivers, 38% had received some formal training and of the novice drivers, 64% had.

The following will report the main results in three sections based on the three research hypotheses. Section 4.1 will relate to hypothesis 1; that experienced drivers show better hazard detection skills than novice drivers. Section 4.2 will relate to hypothesis 2; that experienced drivers will show better visual search and attention and working memory scores than novice drivers and the investigation of



the Visual Search and Attention Test as a predictor of hazard detection scores. Section 4.3 will relate to hypothesis 3; that video based road commentary will improve the hazard detection skills of the novice drivers.

## 4.1 Hypothesis 1

This section will examine the performance of the participants in the baseline trials of the hazard perception dual task. It will firstly examine any differences in the mean percentage of correctly detected and identified immediate hazards between the novice ( $N=22$ ) and experienced ( $N=8$ ) drivers. It will then investigate the mean number of tracking errors made in the central tracking task.

### 4.1.1 Performance in the hazard detection and identification task

As seen in Figure 4.1 below, the experienced drivers detected and identified more immediate hazards with an average percentage (across the four baseline trials) of 89.3%, (ranging between 81.3 and 100%,  $SD=7.5$ ) than the novice drivers who detected and identified less hazards with an average percentage of 75.3% (ranging between 61.3 and 94.5%,  $SD=7.5$ ).

A one-way between groups analysis of variance (ANOVA) confirmed that the experienced drivers detected and identified a statistically significantly larger percentage of immediate hazards than the novice drivers,  $F(1, 28) = 20.88, p < .01$ . The magnitude of the differences in the mean percentages (effect size) was small to medium (eta squared = .43).

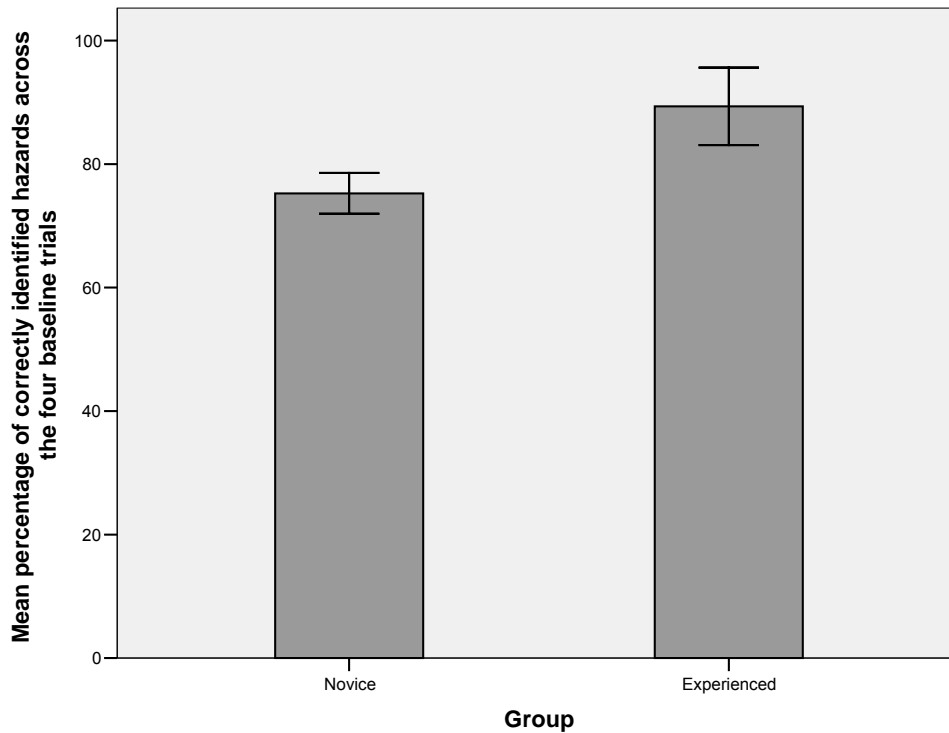


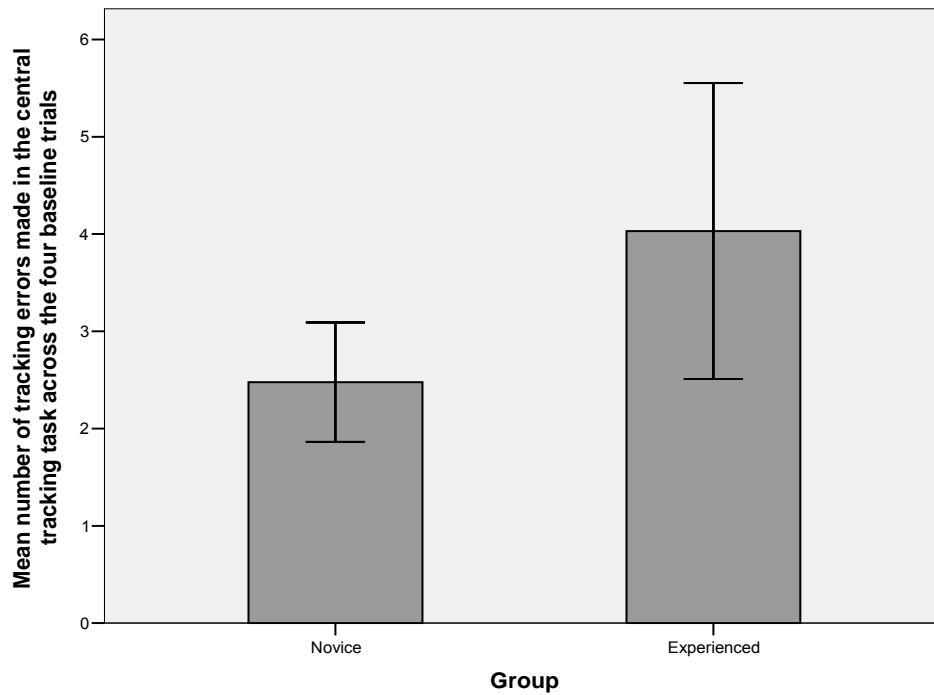
Figure 4.1 Mean percentage of correctly detected and identified hazards across the four baseline trials for the novice and experienced drivers (error bars denote 95% confidence limits)

#### 4.1.2 Performance in the central tracking task

This analysis will examine the performance on the central tracking task, looking at the mean number of tracking errors over the four baseline trials of the participants.

As seen in Figure 4.2 below, the experienced drivers made more tracking errors with an average of 4.03 (ranging between 1.3 and 6.5,  $SD=1.82$ ) than the novice drivers with an average of 2.48 (ranging between .75 and 6,  $SD=1.38$ ).

A one-way ANOVA confirmed that the experienced drivers had a statistically significantly larger mean number of tracking errors in the central tracking task than the novice drivers,  $F(1, 28) = 6.25, p < .05$ . The magnitude of the differences (effect size) in the means was very small (eta squared = .18).

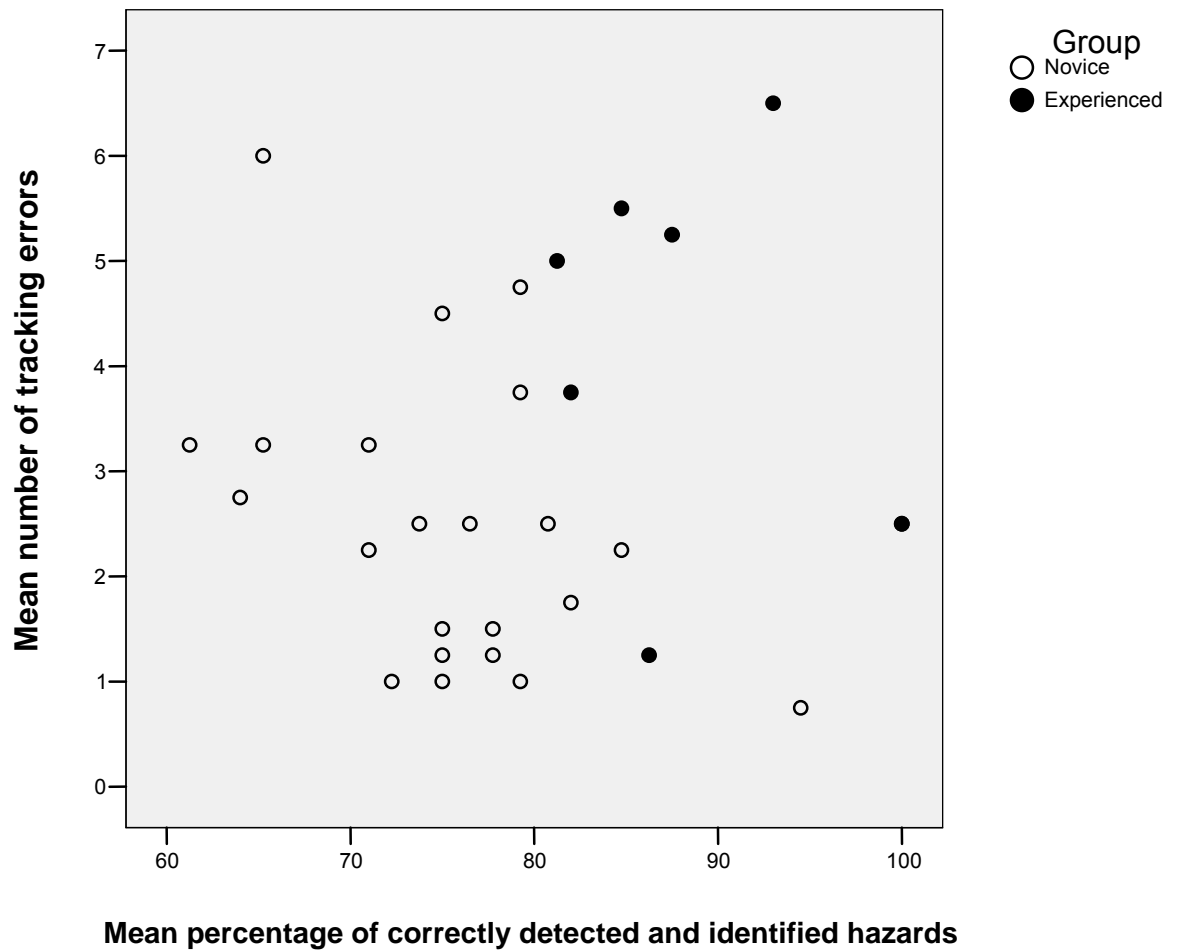


*Figure 4.2* Mean number of tracking errors made by the novice and experienced drivers in the central tracking task across the four baseline video simulations (error bars denote 95% confidence limits)

#### 4.1.3 Examining the relationship between the performance of the participants in the hazard detection and identification task and the central tracking task

The relationship between the mean percentage of hazards detected and identified and the mean number of tracking errors made in the central tracking task over the four baseline trials was then investigated for all participants, as seen in the scatter plot in Figure 4.3 below. Visual inspection of the scatter plot reveals that all symbols identifying the experienced drivers can be found on the right half of the scatter plot and most of them in the upper part except for two symbols. This indicates that most of the experienced drivers identified a large number of hazards but also made a large number of tracking errors. Most of the symbols identifying the novice drivers can be found on the left lower part of the scatter plot. There seemed to be two ‘outliers’ in this group symbolising one novice driver who performed poorly with a very small percentage of hazards detected and identified and a very large number of tracking errors and another novice driver who performed extremely well with more than 90% of the hazards detected and an average of only one tracking error.

The Pearson product-moment correlation coefficient revealed no statistically significant relationship between the two performance variables in the hazard perception dual task,  $r=.015$ ,  $n=30$ ,  $p>.05$ .



*Figure 4.3* Relationship between the mean percentage of correctly detected and identified hazards and the mean number of tracking errors made in the central tracking task of the experienced and novice drivers across the four baseline trials

Taken the results together so far, the experienced drivers performed statistically significantly better than the novice drivers in the hazard detection and identification component of the hazard perception dual task. However, the experienced drivers made significantly more tracking errors in the central tracking task than the novice drivers. However, there was no statistically significant relationship found between the mean percentage of hazards detected and identified and the mean number of tracking errors made across the four baseline trials.

## 4.2 Hypothesis 2

The second section will report the data analyses which tested hypothesis 2; that experienced drivers will show better performance in visual search and attention and also in working memory than the novice drivers, and that the scores of the participants in those assessments will predict the hazard detection and identification scores.

### 4.2.1 Performance on the Visual Search and Attention Test

As seen in Table 4.1 below, the experienced drivers performed better on the Visual Search and Attention Test (VSAT) with a mean total score of 164.9,  $SD=19.4$ , compared to the novice drivers who had a mean total score of 129.2,  $SD=16.9$ . The mean percentile score for the novice group was 11.82 which falls into the borderline impairment range. The mean percentile score for the experienced group was 60.5 which is considered normal (see 3.2.4 for details of percentile ranges).

A one-way between groups ANOVA confirmed that the experienced drivers performed statistically significantly better than the novice drivers,  $F(1, 28) = 24.31, p \leq 0.001$ . The magnitude of the differences in the means (effect size) was small to medium ( $\eta^2 = .47$ ).

### 4.2.2 Performance on the Digits Backwards task

There was no substantial differences in the total scores of the Digits Backwards task when comparing the experienced drivers (who had a mean score of 8.9,  $SD=2.4$ ) with the novice drivers (who had a mean score of 7.6,  $SD=2.1$ ) as seen in Table 4.1 below.

A one-way ANOVA confirmed that there was no significant difference between the novice and experienced drivers on this task,  $F(1, 28) = 2.08, p > .05$ . The magnitude of the differences in the means (effect size) was very small ( $\eta^2 = .07$ ). This indicates that the working memory scores are very unlikely to predict the scores of the participants in the hazard detection and identification task and no further analysis was attempted in this regard.

Table 4.1

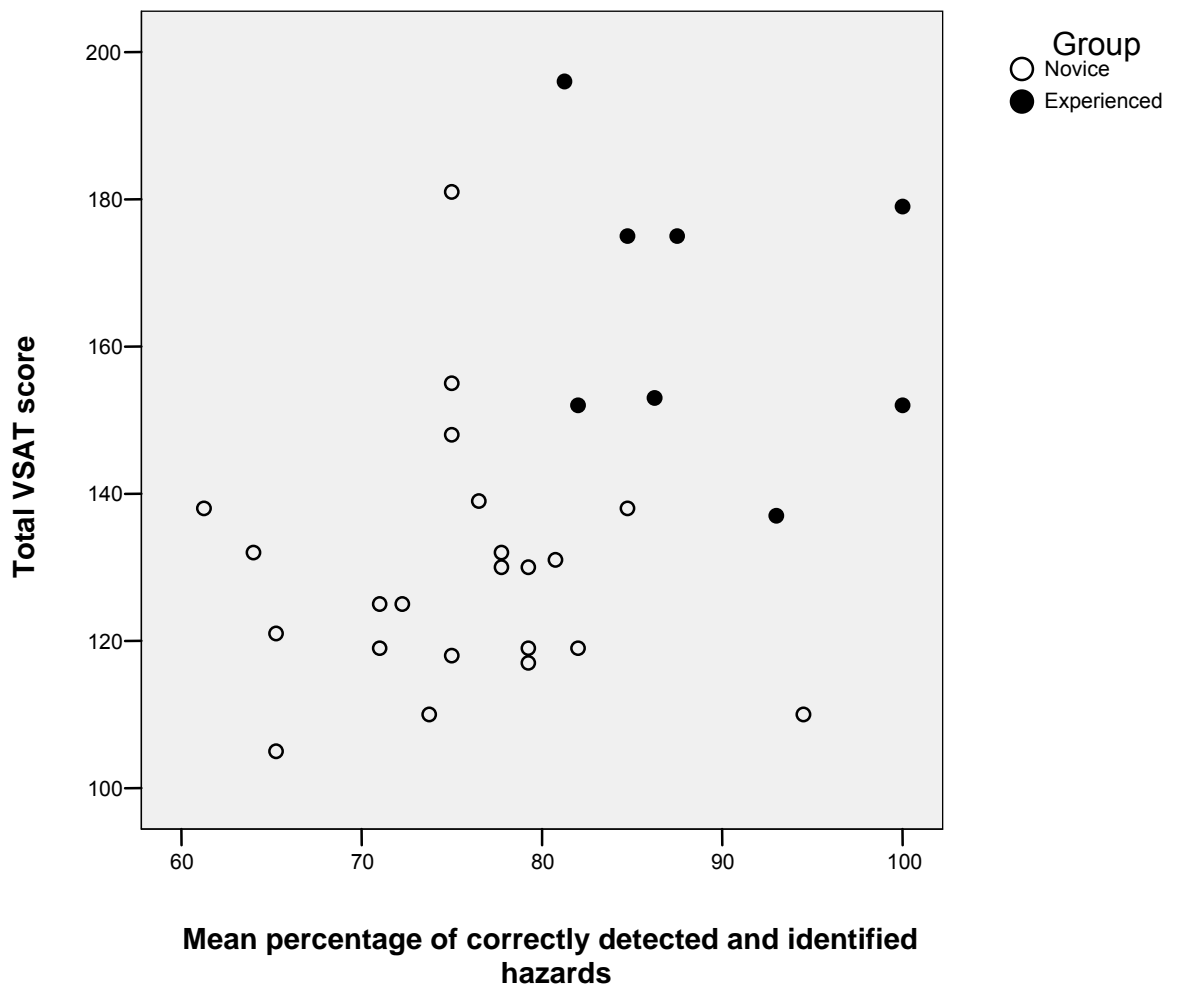
*Visual Search and Attention Test (VSAT) and Digits Backwards Task Scores for the Novice and Experienced Drivers*

Maximum Test		Mean $\pm$ SD	Mean percentile	Minimum value	Maximum value
VSAT	Novice	129.2 $\pm$ 16.9	11.8	1	74
	Experienced	164.9 $\pm$ 19.4	60.5	30	91
Digits Backwards	Novice	7.6 $\pm$ 2.1		5	13
	Experienced	8.9 $\pm$ 2.4		6	12

#### 4.2.3 Examining the relationship between the performance of the participants in the Visual Search and Attention Test and the hazard detection and identification task

The relationship between the performance of the participants on the Visual Search and Attention Test (VSAT) and the hazard detection and identification task was investigated using a scatter plot as seen in Figure 4.4 below. Visual inspection of the figure reveals that the symbols identifying the eight experienced drivers are loosely clustered together in the top right hand corner, showing their excellent performance on both the VSAT and the hazard detection and identification task across the four baseline trials. In comparison, most of the symbols identifying the novice drivers are loosely clustered in the opposite corner, showing their poor performance on both the VSAT and the hazard detection and identification task. There seems to be two ‘outliers’ indicating one novice driver with a very poor performance in the VSAT but excellent performance in the hazard detection and identification task (approximately 95% of all the hazards detected). The other concerned a participant who performed well on the VSAT (with a total score of approximately 180) but performed poorly on the hazard detection and identification task.

A Pearson product-moment correlation coefficient was calculated and interestingly, this confirmed a statistically significant positive correlation between the two variables,  $r=.380$ ,  $n=30$ ,  $p<.05$ .



*Figure 4.4* Relationship between the Visual Search and Attention Test scores and the mean percentages of correctly detected and identified hazards across the four baseline trials for the experienced and novice drivers

Taken together, the experienced drivers performed statistically significantly better than the novice drivers on the Visual Search and Attention Test. There was no statistically significant difference between the two groups on the Digits Backwards task. A statistically significant medium positive correlation was found between the visual search and attention scores and the hazard detection and identification scores, suggesting that the Visual Search and Attention Test might be a useful assessment tool for predicting the hazard perception skills of novice drivers.

### 4.3 Hypothesis 3

The final section will report the data analyses which tested hypothesis 3; that video based road commentary training will significantly improve the hazard perception skills of the novice drivers. This will involve two sub-sections; the first will report the effects of the road commentary training on the performance of the two test groups; novice (E1-novice,  $N=8$ ) and experienced drivers (E2-experienced,  $N=8$ ) in the hazard perception dual task. The second sub-section will compare the effect of the road commentary training on the performance of the novice driver test group (E1-novice) with the performance of the two novice driver control groups; C1-novice ( $N=7$ ) and C2-novice ( $N=7$ ), (see method).

#### 4.3.1 The effect of video based road commentary training on the performance of novice and experienced drivers in the hazard perception dual task

Figure 4.5 shows that after the road commentary training the mean percentage of hazards detected and identified by the novice drivers increased from 71.78 ( $SD=7.5$ ) and to 81.06 ( $SD=10.2$ ) while interestingly, the experienced drivers showed a decrease in their mean percentage of hazards detected and identified from 89.34 ( $SD=7.5$ ) to 72.66 ( $SD=11$ ). This could indicate that the experienced drivers showed 'ceiling performance' before and after the road commentary training with the post trials being more difficult than the baseline trials. It is unlikely that the road commentary training could have had a negative effect on the performance of the experienced drivers. In a previous analysis it was shown that the novice drivers detected significantly less hazards than the experienced drivers in the baseline trails. An equivalent analysis (one-way ANOVA) was attempted for the post-training trials and it revealed that this difference between the mean percentages of hazards detected and identified between the novice drivers and experienced drivers disappeared,  $F(1, 14) = 2.5, p > .05$  following training. In fact an inspection of Figure 4.5 reveals that the novice drivers detected and identified a slightly larger mean percentage of hazards ( $M= 81.06, SD= 10.15$ ) than the experienced drivers ( $M=72.66, SD=11.04$ ).



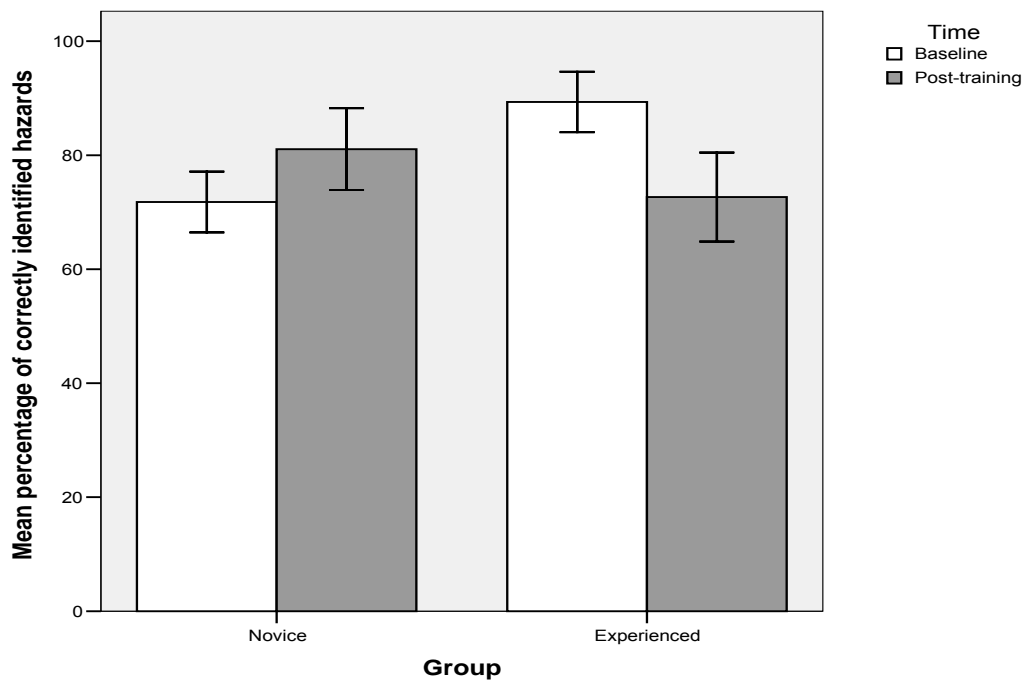


Figure 4.5 Mean percentage of correctly identified hazards for the novice and experienced drivers across the four baseline and post-training trials (error bars denote 95% confidence limits)

The experienced drivers made significantly more tracking errors than the novice drivers during the baseline trials (see 4.1.2). A similar result was found after the road commentary training, with the experienced drivers making an average of 3.81 ( $SD=1.73$ ) tracking errors across the four post-training trials and the novice drivers making an average of 1.75 ( $SD=1.09$ ) errors.

A further one-way ANOVA confirmed that after the road commentary training, the experienced drivers again made statistically significantly more tracking errors than the novice drivers  $F(1,14)=8.15, p<.05$ .

Taken together, the road commentary training significantly improved the mean percentage of hazards detected and identified in the young novice drivers while there was no similar positive training effect on the experienced drivers. It seems that the experienced drivers showed ceiling performance in the baseline and post-training

trials and that the novice drivers were able to improve their hazard perception skills to the level of the experienced drivers. After the road commentary training there was no significant difference between the performances of the novice and experienced drivers in the hazard detection and identification task. Similarly to the baseline trials, the experienced drivers made significantly more tracking errors in the central tracking task than the novice drivers in the post-training trials.

4.3.2 The effect of the road commentary training on the performance of the novice driver test group in the hazard perception dual task compared with the performance of the two novice driver control groups

Before the road commentary training, the full sample of novice drivers were randomly assigned to either the experimental group (E1-novice,  $N=8$ ) that received road commentary training (see method and previous section) or to a first control group (C1-novice,  $N=7$ , who only watched the same video simulations without giving road commentary) or to a second control group (C2-novice,  $N=7$ , who watched television commercials instead of the road commentary training).

A one-way between groups ANOVA first confirmed that there was no statistically significant difference between performances of these three groups in the hazard perception dual task during the four baseline trials,  $F(2, 19) = 1.510$ ,  $p > .05$ .

As shown in Figure 4.6 (and already established previously), the novice driver experimental group (E1-novice) increased in the mean percentage of correctly identified hazards after the training. The first control group (C1-novice) showed a decrease in the mean percentage of correctly detected and identified hazards from the baseline trials (with a mean of 76.43,  $SD=6.5$ ) to the post-training trials (with a mean of 63.04,  $SD=8.8$ ). Similarly, the second control group (C2-novice) also showed a decrease from the baseline trials (with a mean of 78.04,  $SD=7.7$ ) to the post-training trials (with a mean of 67.71,  $SD=10.0$ ).

A mixed between subjects (factor 'group' E1-novice versus C1-novice and C2-novice) and within subjects (factor 'training' baseline trials vs. post-training trials) ANOVA was conducted on the mean percentages of correctly detected and identified hazards and it showed that there was no statistically significant main effect for group,  $F(2, 19) = 1.71$ ,  $p > .05$ . The magnitude of the differences in the means (effect size) was very small (eta squared = .15). There was however a

statistically significant main effect for training,  $F(2, 19) = 5.21, p < .05$ . The magnitude of the differences between the means (effect size) was small ( $\eta^2 = .22$ ). There was a statistically significant interaction between group and training,  $F(2, 19) = 11.85, p < .01$ . The magnitude of the differences in the means (effect size) was medium ( $\eta^2 = .56$ ).

Post-hoc comparisons using the Fisher LSD test confirmed that the E1-novice group statistically significantly increased in the mean percentage of correctly identified hazards after the road commentary training,  $p < .01$ , while the two control groups both decreased in this performance measure ( $p < 0.1$  for C1 novice and  $p < 0.5$  for C2-novice).

This decrease in the performance of the control groups clearly indicates that the immediate hazards for the post-training trials were more difficult to detect and identify than the hazards in the baseline trials which emphasises the performance improvement of the E1-novice group.

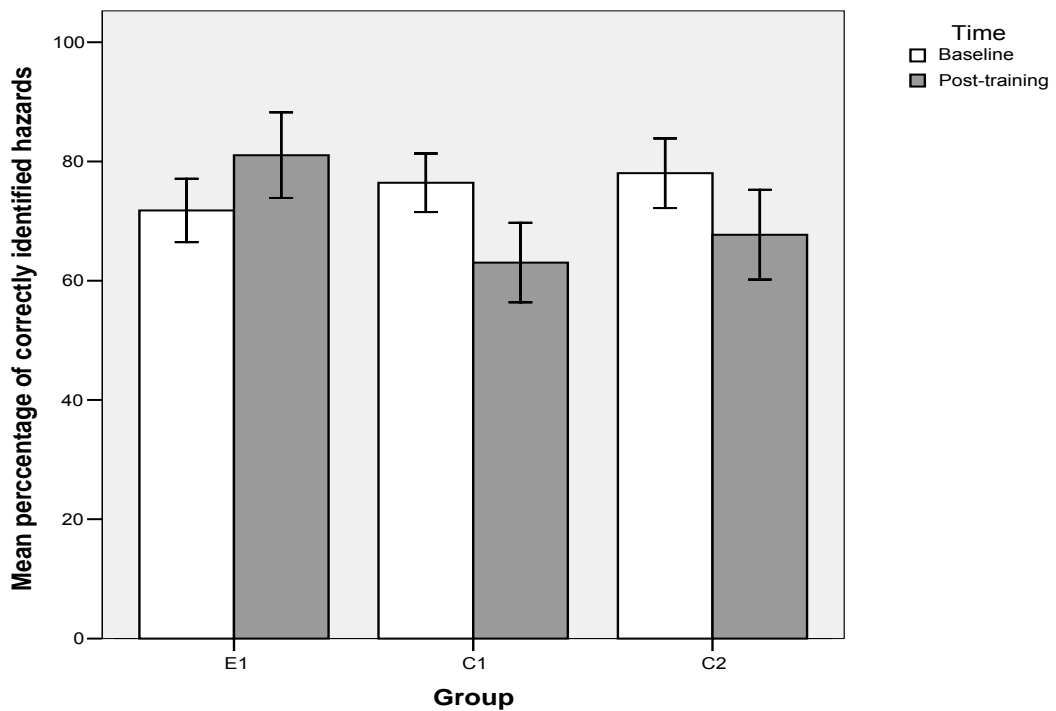


Figure 4.6 Mean percentage of correctly detected and identified hazards for the three groups of novice drivers (E1-novice, C1-novice and C2-novice) across the four baseline and four post-training trials (error bars denote 95% confidence limits)

Another mixed ANOVA was conducted the same way as the one above but this time on the dependent variable number of tracking errors in the central tracking task. There was neither a significant effect for the factor group,  $F > .05$ , nor for factor training,  $F > .05$ , indicating that the three groups of novice drivers showed no differences in the number of tracking errors before (baseline trials) or after the training (post-training trials). The magnitude of the differences between the means (effect size) was very small (eta squared = .03).

Taken together, the verbal road commentary training significantly improved the hazard detection identification performance of the novice driver experimental group, while no such improvement was seen in the two control groups. In fact, the two control groups decreased statistically significantly in their percentages of detected and identified hazards indicating that the hazards in the post-training trials were significantly more difficult to detect than the hazards in the baseline trials.

## Chapter 5: Discussion

This research has met the aims of the research and has supported my hypotheses; that experienced drivers have significantly better hazard perception and visual search skills than novice drivers, and that the Visual Search and Attention Test may be predictive in measuring hazard perception skills. Thirdly, that training in the form of video based road commentary significantly improves the hazard perception skills of young novice drivers.

The experienced drivers performed significantly better than the novice drivers in their detection and identification of hazards in the hazard perception dual task used in this study. The experienced drivers also performed significantly better than the novice drivers on the Visual Search and Attention Test (VSAT). A significant positive correlation was found between scores on the hazard detection and identification task and scores on the VSAT, suggesting that these skills may be predictive of each other. The video based road commentary significantly improved the hazard perception scores of the novice drivers suggesting that this may be an effective training technique.

The following will discuss the main results of the study with reference to the literature reviewed in Chapter 1. It will firstly discuss the poor hazard perception skills found in young novice drivers with reference to related skills including risk perception, visual search and attention and cognitive load. It will then discuss the performance of the participants on the Visual Search and Attention Test and the potential usefulness of the test as a predictive measure of hazard perception skills. The effects of the video based road commentary training will then be addressed as well as the potential implications for future modification of the Graduated Driver Licensing System (GDLS) in New Zealand.

This study involved a hazard perception dual task that required the participants to detect and verbally identify hazards while performing a central tracking task. The results of this study indicated that the experienced drivers have significantly better hazard perception skills than the novice drivers. This result has been well founded in

past research. For example, Underwood (2007) points out that several studies have demonstrated that experienced drivers respond faster to hazards. Further more, Deery (1999) argues that novice drivers assess hazards on the basis of a single characteristic; whereas experienced drivers perceive situations on the basis of multiple characteristics which they then use to differentiate the degree of risk. Similarly, Ferguson (2003) argues that an experienced driver is better able to quantify the degree of any given danger and respond appropriately. There are several theories that attempt to explain the poor hazard perception skills of young novice drivers which will now be discussed in relation to the main results of the study.

The experienced drivers were better able to detect and identify hazards while performing the central tracking task; whereas the novice drivers seem to have been more focused on the central tracking task and were less able to identify hazards simultaneously. On the road, this would correspond to the inability to identify hazards while engaged in the task of actually controlling the vehicle. In terms of novice driver crashes, this may be a significant factor in many of them, as opposed to intentional risk factors such as speeding. Deery (1999) argues that with experience, people are better able to integrate information quickly and consider hazardousness as a more holistic attribute of the driving environment, stemming from re-organisation of knowledge through experience. Also, that experienced drivers (and experts in other domains such as chess and radiology) perceive holistically, whereas novices perceive a scene as being made up of independent parts that each demand attention (Deery, 1999).

When young novices start to drive, the task of driving itself is not yet automated (Underwood et al., 2002). Hazard perception may be in competition with the task of vehicle handling in terms of cognitive load and attention. This could lead to young novice drivers being more likely to miss immediate hazards (Chapman et al., 2002), which this research has confirmed. As automation takes over with the task of driving, it frees up mental resources and there is then more attentional capacity to pick up hazards (Underwood et al., 2002). In terms of cognitive load and attention, it would be expected that the experienced drivers would be better at the hazard perception dual task while the novice drivers would find it more difficult and focus on only one aspect of the task. The experienced drivers made significantly more tracking errors than the novice drivers both at baseline and after the training. Although the

experienced drivers made more tracking errors they also identified more hazards. This suggests that the experienced drivers had a more holistic view of the driving environment. Tracking errors may even be more accurately representative of visual 'searches' than 'errors', so the experienced drivers made a higher number of visual searches and consequently identified more hazards. The novice drivers made less tracking errors but also identified fewer hazards, suggesting that the novice group had more focus on the central task directly ahead of them at the expense of identifying surrounding hazards. If looked at in terms of visual searches, the novice drivers made less searches than the experienced drivers and consequently identified less hazards.

Related to hazard perception is the concept of risk perception, as discussed in the literature review. Because learner drivers may be focusing too much on the vehicle handling task of driving at the expense of higher-order skills such as hazard perception, the prioritisation that they then give to detecting hazards could also possibly be distorted. With experience and automation of basic vehicle handling skills, the prioritisation of detecting hazards and searching the visual field may become more important. Having poor hazard perception skills could possibly lead to poor risk management which further limits the safety of young novice drivers.

Another skill that seems to be related to hazard perception which has also been investigated in this research is that of visual search. Deery (1999) described the lack of visual search strategies of novice drivers in that they display a smaller range of horizontal scanning, look closer to the front of the vehicle, check mirrors less frequently, glance at objects less frequently, use peripheral vision less efficiently and fixate on fewer objects. In more general terms, Underwood (2007) argues that scanning of the horizontal plane is developed and learned through experience. He then argues that one of the remarkable changes that occur as drivers develop their skills is the increase in visual scanning. This fact, coupled with the finding that young novice drivers are showing poor visual search skills, gives weight to the need for driver training in areas that are still developing in young novice drivers. Underwood (2007) also suggested that it may be that novice drivers have an impoverished mental model of the driving environment due to it having been accumulated mainly as a passenger of a vehicle, not a driver. Also that novice drivers are insensitive to changes in the driving environment whereas an experienced driver will anticipate change and drive in a predictable style that suits the driving conditions. This is not

surprising- young novice drivers do not seem to have the visual search skills to anticipate change, or to detect hazards effectively. Poor visual scanning is not only a developing skill in young novice drivers but could also be a consequential learned behaviour that then takes time and experience to rectify and develop. Chapman et al. (2002) report that studies in their laboratory have consistently found that visual search strategies, especially in hazardous situations are differentiated between novice and experienced drivers.

Visual search and attention skills were assessed and compared in the experienced and novice drivers. The experienced drivers performed significantly better than the novice drivers on the Visual Search and Attention Test. This is also consistent with frontal lobe brain development and physiology in that there is substantial evidence (as seen above) that visual search and attention may be pre-frontal cortex (PFC) functions that do not fully develop until the age of 25. This is a significant finding in that visual search seems to be such a critical driving skill.

The significant relationship between hazard perception and visual search and attention performance may suggest that these skills are inter-related and that the Visual Search and Attention Test may be used as a useful predictive measure of hazard perception skills. This test could potentially be used in the future to assess the visual search skills of young novice drivers in the learner period of the Graduated Driver Licensing System (GDLS). It makes sense that poor visual search skills may correspond to poor hazard perception skills. Hazards exist as part of the driving environment and must be visually attended to for perception to take place. It would seem that training one may improve and compliment performance in the other and if this is done alongside a 'speed up' of vehicle handling automation, may reduce the young novice driver crash rate.

The results of this study are consistent with the idea that hazard perception may be a developing brain function in young novice drivers, as discussed by Weinberger et al. (2005) who argue that pre-frontal cortex functions (including hazard perception and visual search) do not fully develop until the third decade of life. In support of this idea, Keating (2007) describes the existing 'child like' properties that are evident in the adolescent brain in that "the extent of orbital frontal cortex activity in adolescents looked more like that of children than adults" (p.148). An interesting theory to consider is discussed by Reyna and Farley (2006) - the cognitive development 'fuzzy



trace theory', which relates well to the results found here. It proposes that with maturity, gist thinking may take over as we make decisions that disregard distracting details and instead are filtered through our experience. So with experience, we have an automated ability to drive in terms of vehicle handling skills and as a result, are not distracted by the details of it. We therefore use unconscious gist thinking and intuition to make decisions about higher-order skills such as hazard perception, risk perception and visual search. Novice drivers on the other hand may use the deliberative, analytical approach that relies on detail and computational processing. This would take more time and demands full attention which would leave little or no room for higher-order skills and in the context of driving, this is too costly.

Taken together, the experienced drivers showed well developed hazard perception and visual search skills, which could also imply well developed risk perception and prioritisation of higher-order skills. The tracking errors made in the central tracking task may be a reflection of their holistic visual search pattern that develops with experience through the automation of other driving tasks, an established mental script as a driver and not a passenger and the ability to integrate driving skills. In contrast, the novice drivers showed poor hazard perception and visual search skills. Their lower tracking error rate in the central tracking task may be a reflection of their limited visual search pattern in that much of their focus was on the central tracking task, which in real life driving would correspond to the task of driving itself and the subsequent area of the visual field that is focused upon. It seems that the skills of hazard and risk perception, visual search and cognitive load and attention are inter-related and should be investigated in light of each other to fully understand each of them and for progress to be made. It seems as if they almost develop together and depend on each others development in order to become a safe road user; poor performance in one may equate to poor performance in the others. With automation of basic vehicle handling skills through experience, this becomes possible as mental resources become free enough for the critical higher-order skills and gist thinking can take over.

The verbal road commentary training improved the hazard perception scores of the novice drivers and eliminated the initial difference found between the two groups. The experienced drivers decreased in their hazard perception scores, suggesting that the four post-training video clips were more difficult than the four baseline video clips, which further highlights the improvement found in the novice drivers. It could also be that a training intervention of this type is only effective when given to individuals who have such a poor baseline level of skill. The experienced drivers however had a much higher baseline skill level and therefore had less room for improvement which may have produced a ceiling effect.

The results of this study are consistent with the findings of McKenna, Alexander and Horswill (2006). They found that hazard perception training could significantly decrease risk taking behaviour and that anticipation in driving could be significantly improved by training in the laboratory using video simulation techniques, and that novices could be improved to the level of experienced drivers within only 4 hours of training. Similarly, Underwood (2007) describes the results of a study that investigated hazard perception training using film based clips. The training encouraged scanning and the anticipation of hazards and it was found that the trained group scanned the driving scene to a greater extent than the untrained group of novice drivers. This simple laboratory training was also seen to transfer to on-road driving behaviour, even when tested a few months later, suggesting a general improvement in their situational awareness. Fisher et al. (2006) also found a significant improvement in the hazard perception skills of young novice drivers using a computer based training technique. They then replicated this finding several days later and again, the trained novice drivers performed better than the untrained novice drivers. When replicated in an on-road test, this difference was almost identical to what was observed on the driving simulator. Chapman et al. (2002) investigated the effectiveness of a verbal road commentary visual search training and also found positive improvements in young novice drivers both in the laboratory and on the road. They stated that “drivers are able to transfer skills learned during a brief video-based intervention into their actual on-road behaviour” (p.166).

In order to determine whether the improvement found in the novice drivers was the result of the verbal road commentary, two young driver control conditions were used.

The first control group who only watched the video clips showed a significant decrease in their hazard perception score, suggesting that the technique is only effective with the verbal component. The second control group who watched television commercial video clips also showed a significant decrease, suggesting that the improvement was not simply due to time passed. There was no difference in the hazard perception scores between control groups 1 and 2 after the training which suggests that the 'passive version' of the training is no better than just time. It also suggests that the four post-training clips were more difficult, which again, further highlights the effectiveness of the verbal road commentary training. After the training, the novice group who received the road commentary training identified significantly more hazards than both control groups.

This study has shown that video based verbal road commentary may potentially be an effective training technique for young novice drivers who have very poor baseline hazard perception skills. By simply re-focusing attention on the detection of hazards, this seems to have improved the situational awareness of young novice drivers. The improvement seen in the novice driver group is evident of the fact that even basic training holds promise. The decrease in hazard detection scores found in the experienced drivers and both control groups suggests that the four post-training video clips were more difficult than the four baseline clips which further emphasises the improvement seen in the novice group who received training.

In terms of the Graduated Driver Licensing System (GDLS) in New Zealand, the results of this study hold promise for further investigation: that a hazard perception training component should have to be passed in order to move onto the next provisional stage in the GDLS. This would constitute one aspect of training the higher-order skills that are still developing in young novice drivers. This study has shown that even the simple technique of verbal road commentary is effective; and if developed into a more comprehensive programme, may be beneficial to young novice driver training and road safety. In terms of inclusion into the GDLS, I would suggest the following: firstly as part of the learner stage, a compulsory hazard detection 'work shop session' in which the skill of hazard detection is discussed and trained in the form of verbal road commentary. Secondly, in order to pass the restricted and full license tests, there could be a second hazard detection component, tested by a driver instructor, or even a second training session. This component could also be in the

form of verbal road commentary, while driving with an instructor (sitting in the passenger seat) assessing the ability of the young driver to identify both immediate and potential hazards. This would be similar to the post-licence second phase training that Molina et al. (2007) discussed in reference to what four European Union states have implemented, in the hope of extending training into the initial high risk period of independent driving in the months following the acquisition of an unsupervised licence. This would aid in shifting the current emphasis of the GDLS from risk management to driver training. Training in other areas of driver safety such as experience in night time driving should also be addressed in order to further aid this shift of emphasis. Risk management is important but ineffective without driver training in those areas where the risk is managed. Also, by extending the learner stage as Sweden, Norway, France and Belgium have done (Gregerson et al., 2000) would further enable the young novice drivers to utilise mental resources, gain experience and a mental script as a driver instead of a passenger, and would also increase automation of the task of driving, freeing up their cognitive load for higher-order skills such as hazard detection. I would also suggest implementing Sweden's idea of placing greater importance on the level of skill and experience of the supervisor (Gregerson et al., 2000) so that the supervisor must be a certain age and with a certain level of experience, as opposed to the current rule that the supervisor has to have only 2 years experience and can be as young as 20 years old. In Sweden this person also requires a supervision permit which I think is a good idea, so that if you intend to supervise and subsequently teach a young learner to drive, you need to be given certain guidelines and advice in terms of how to best train a young driver. Queensland's recently implemented system also contains requirements that New Zealand could take note of for learner driver applicants under the age of 25. This has involved extending the learner period to 12 months, with 100 hours of supervised practise including two provisional stages with hazard perception tests.

The GDLS in New Zealand was implemented over 20 years ago and has aided in the reduction of young driver crash rates. These crash statistics however remain unacceptably high. Road safety and young driver research over the past two decades have revealed significant and beneficial findings towards the understanding of young driver behaviour and the improvement of licensing systems.

## Chapter 6: Conclusions

This final chapter will report the conclusions and limitations of the study.

This research was based upon an ongoing debate in the area of young driver research that focuses on whether the primary causal crash factor and therefore the primary target for intervention is poor skill due to inexperience ‘the young driver problem’ or intentional risk taking associated with adolescence ‘the problem young driver’. My research supports the argument that both play a part however a primary crash factor seems to be poor higher-level cognitive skill due to inexperience and developing brain functions. Lack of skill due to developing frontal lobe functions can be trained and improved and could potentially minimise the effects of the ‘problem young driver’ that exist as an inevitable part of adolescence. Hazard perception is one of these skills and this study has shown that it can be easily improved in young novice drivers to a safer level.

Adolescence is a developmental period of rapid brain growth and change (Weinberger et al., 2005). Unintentional, ignorance-based risk taking behaviour is something that the results of this study have shown can be changed. Training higher-order driving skills during adolescence before neurological structures mature is critical to setting a life long pattern when it comes to safe driving skills and style. Integrating certain higher-order skill training such as hazard perception into the GDLS and speeding up the process of automation would effectively coincide with this developmental period for young novice drivers.

This study has fulfilled the original aims and the results have provided support for the hypotheses. The skills of hazard perception and visual search and attention seem to be related and may still be developing in young novice drivers. Basic verbal road commentary training has been shown to significantly improve the hazard perception skills of novice drivers and if developed into a more comprehensive program, may be a beneficial component to the Graduated Driver Licensing System in New Zealand and would aid in shifting the current emphasis of risk management to driver training. The future of young driver road safety will rely on further investigation of these higher-order skills and the implementation of appropriate training techniques.

## 6.1 Limitations

This study involves several limitations, each of which will be addressed in this final section.

### 1. External validity

Generalising the results of an experimental design to the external environment is a consistent limitation in experimental research. The mean percentage of correctly identified hazards in the hazard perception dual task was used as the measure of hazard perception skills for the purpose of measurement and maintaining experimental control. However, in real life driving, the identification of hazards is much more complex and involves for example the mental pre-occupation with the task of driving itself, external factors such as interaction with traffic and multiple hazards, familiarity with certain areas, and passengers in the car, as well as internal factors such as attention and stress levels. Evidence however such as the research conducted by McKenna et al. (2006) suggests that hazard perception skill training in the laboratory can be replicated in a more ecological context.

### 2. Confounding variables

A second limitation concerns the confounding variables of age and experience. They are common confounding variables in the area of young driver research in that it is difficult to assess whether driver behaviour is the result of age or level of experience due to the coincidental timing of the two. Although experience is important to consider, Mayhew et al. (2003) showed that young novice drivers have a much higher crash rate than older novice drivers, highlighting the significance of age.

### 3. Measurement

Lastly, the measure of hazard perception that was used was a mean percentage, and not total numbers. The number of correctly identified hazards was calculated as a percentage of the hazards that I (as the researcher) identified. This percentage is therefore consistent in that all participants were measured in the same way and against the same total number of hazards; however individual variance in hazard

identification was not able to be fully accounted for. This was a matter of maintaining experimental control and consistency across individual participation.

Taken together, this research has been a successful study in terms of satisfying the aims that I set out to investigate in an ethical and consistent manner. The above limitations were acknowledged and taken into consideration but were inevitable issues to face in the conduct of experimental research.

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# Driving project: hazard detection.

## Participants needed



**Are you 18 or 19 years old and on your restricted or full driver's license?**

Good opportunity to be part of a graduate research project in psychology.

Participation will involve you completing several computerized tasks and will take around 30-45 minutes.

**\$10 MTA Vouchers for participation.**

If interested please email me and I will send you further information.

Thanks,

Amy Williamson, Email: [arw12@waikato.ac.nz](mailto:arw12@waikato.ac.nz)

Supervisors: Dr. Robert Isler and Dr. Nicola Starkey.

## Appendix B

### Information sheet

#### **Project: Hazard Perception in Adolescent Drivers.**

Thank you for your interest in participating in my Masters Research project.

All participation is anonymous and confidential and you have the right to withdraw at any stage for what ever reason.

A written consent form will be provided.

The experiment will take place during B Semester.

It will involve a short pen and paper task followed by watching a series of video simulated driving scenarios while performing a basic mouse task and/ or a simple road commentary task in a research room at the University. It will take no longer than 45 minutes. Full instructions will be given.

Upon completion of the research, a full summary will be made available to all participants outlining the results and background information.

1 % course credit will be given to Psyc 102-07B students.  
A \$10 MTA voucher will be given to all other participants.

If you are interested please email me to confirm a day and time that suits you and any further questions.

If you have any concerns about the project that you do not wish to discuss with me, please contact a member of the psych research and ethics committee. (Linda Nikora- [psyc2046@waikato.ac.nz](mailto:psyc2046@waikato.ac.nz)).

Regards,  
Researcher Amy Williamson.  
Email [arw12@waikato.ac.nz](mailto:arw12@waikato.ac.nz)

## Appendix C

University of Waikato  
Psychology Department  
**CONSENT FORM**

PARTICIPANT'S COPY

Research Project:

Name of Researcher:

Name of Supervisor (if applicable):

I have received an information sheet about this research project or the researcher has explained the study to me. I have had the chance to ask any questions and discuss my participation with other people. Any questions have been answered to my satisfaction.

I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Research and Ethics Committee (Dr Robert Isler, phone: 838 4466 ext. 8401, e-mail [r.isler@waikato.ac.nz](mailto:r.isler@waikato.ac.nz))

Participant's

Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

## Appendix D

### Driving Project: Demographics

Number. \_\_\_\_\_

#### Instructions

Please provide the following information by entering your response in the appropriate place

1. What is your date of birth? \_\_\_\_\_  
Day    Month    Year

2. Please indicate which best describes your ethnic background:

New Zealand European

New Zealand Māori

Asian

Pacific Islander

None of the above, please specify \_\_\_\_\_

3. What type of drivers licence do you hold?

Restricted for car

Full for car

4. What date did you obtain your restricted / full **car** driving licence? \_\_\_\_\_

\_\_\_\_\_

Month

Year

5. How many kilometres do you drive in a usual week? \_\_\_\_\_ km

6. Have you received any formal driving training? If so, please describe.

\_\_\_\_\_

**Instructions**

Almost every driver becomes involved in an adverse traffic event (accident or near-hits) of some sort during their driving years. We would like to know how often people experience such events. Please tell us how many ACCIDENTS or NEAR HITS that you have been involved in during **the last twelve months**

7. In the last twelve months, how many accidents have you been involved in? An accident is any collision that occurred on the public roads (but not private property), while you were the driver of the vehicle and irrespective of who was at fault.

\_\_\_\_\_ Accidents

8. In the last twelve months, how many near misses have you experienced? A near hit is when you narrowly avoided being in an accident on public roads, while you were the driver of the vehicle and irrespective of who was at fault.

\_\_\_\_\_ Near misses

**Instructions**

Nearly all drivers commit traffic offences and we would like you to estimate how often these have happened. Please let us know whether you have committed any traffic offences **in the last twelve months**. For each of the offences below indicate approximately **how many times** these happened.

**Please write the number of times in the space provided. If you have no traffic convictions or warnings please put zero.**

A **conviction** is when your offence has legal consequences resulting in a fine and / or demerit points.

A **warning** is when you are stopped by the police regarding your driving but no further action is taken

Offence type	Convictions	Warnings
Speeding - e.g., over the legal limit		
Racing - e.g., competing with other drivers		
Reckless driving - e.g., cutting off other drivers		
Drinking or drug related e.g. driving under the influence		
Dangerous overtaking - e.g., overtaking with limited visibility		
Following too close - e.g., not obeying the two second		

rule		
Roundabout offences - e.g., using the wrong lane or use of inappropriate signals		
Failing to obey road signs - e.g., a stop sign		
Traffic signal offence - e.g., running a red light		
Parking offence - e.g., parking in disabled parking, on footpath		
Failing to stop - e.g., for police, after an accident		
Vehicle defects - e.g., broken headlamp, noisy vehicle		
Uncertified vehicle modification - e.g., lowered suspension		
Seatbelt offence - e.g., driving without a seatbelt		
Taking a vehicle without consent - e.g., theft		
Driver Licence offense - e.g., driving whilst disqualified, driving outside of license restrictions		
Driving without legal certification - e.g., driving without a warrant of fitness or without registration		
Traffic signal offence - e.g., running a red light		

**Other, please provide details**