# Driving as You Feel: A Psychological Investigation of the Novice Driver Problem

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**Declaration**

I, Neale Andrew Duncan Kinnear, hereby certify that this thesis has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date - 11th May 2009

Signature of candidate -

Printed name - Neale Kinnear

**Dedication**

This thesis is dedicated to my Dad, the late Kenneth Duncan Kinnear who passed away on 10th August 2006. His constant encouragement and enthusiasm are sorely missed but were a great part of getting me to this stage in life.

I must also pay tribute here to my wonderful Gran and Aunt Marjory who passed away shortly before Dad.

## Acknowledgements

My wise Grandfather used to say that you are better born lucky than rich. At times I questioned this wisdom, however during my PhD I have been fortunate to have met and worked with some exceptional people. In this regard, I have been very lucky, although not rich.

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## Publications arising from this thesis

Publications

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Kelly, S., Kinnear, N., Thomson, J. and Stradling, S. (2009). A comparison of inexperienced and experienced drivers' cognitive and physiological response to hazards. In, L. Dorn (Ed.). *Driver Behaviour and Training: Volume IV.* Aldershot: Ashgate.

In Preparation

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Conference Presentations

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Posters

Kinnear, N., Stradling, S.G. and McVey, C.J. (2006). Driving as you feel: An investigation into the role of Somatic Markers in driving. Presented at Glasgow Caledonian University Graduate Conference, Glasgow, July 2006

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Newspaper Articles

Why teen drivers take 1,000 miles to know the true meaning of fear. Daily Mail, September 6, 2007; page 27

Boy racers must grow up fast if death toll to fall. The Scotsman, February 23, 2008; page 28-29

Young 'lack fear of road dangers'. Daily Mail, April 11, 2008; page 7

Parents in cop drive. Sunday Mail, June 15, 2008; page 8

A drive to safety. The Extra, June 19, 2008; page 14

## Abstract

The current thesis aimed to explore the novice driver problem from a psychological perspective. The ultimate aim was to enhance knowledge and understanding which may advise how to improve novice driver safety. The novice driver problem is a worldwide trend; which in the UK involves one in five newly licensed drivers being crash involved in their first year of driving (Maycock & Forsyth, 1997). Research suggests that both age and inexperience are the major factors of novice driver crash risk; although inexperience has been shown to be the more important (Maycock, 2002). Crash risk reduces dramatically as drivers gain experience of driving after licensure, although what drivers are psychologically learning through experience is not yet understood. Using the Task-Capability Interface model (Fuller, 2005) to conceptualise driving, the current thesis sought to extend the theory by exploring the psychological processes through which drivers appraise risk and how this shapes a decision and behavioural response. Study One reports that there are two distinct ways in which drivers appraise risk, which supports theory proposed by Slovic et al. (2004): risk as feelings and risk as analysis. Current neurological theory, in the form of the Somatic Marker Hypothesis (Damasio, 1994), supports the role of feelings and emotion as an evolved automated system of human risk appraisal that biases judgement and decision making. Studies Two and Three investigated emotional appraisal of hazards between novice and experienced drivers through physiological skin conductance. The results suggest that novice drivers fail to emotionally appraise developing hazards when compared to experienced drivers. Study Three demonstrated that novice drivers who had driven less than 1000 miles had physiological anticipatory scores similar to learner drivers whereas novices who had driven more than 1000 miles had scores approaching those of experienced drivers. This demonstrated a learning curve mediated by driving experience. As a result of the thesis, it is suggested that further research into the role of feelings and emotion in learning to drive is performed. The implication of the results for graduated licensing is also discussed.

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## Context and rationale

Based on reports of casualty reductions in other countries, the United Kingdom Department for Transport investigated the possibility of introducing a more structured approach to learning to drive in 2002. A consultation paper was produced seeking opinion from interested companies, associations, academics and charities within the UK. Amongst much else, the paper suggested the following:

> "the Department has estimated that the introduction of a 12-month minimum learning period would reduce casualties by some 6,000 - 7,000. Of these 800 - 1,000 would be deaths or serious injuries. As a minimum estimate, the prevention of 800 serious injuries alone would therefore be valued at £97.6 million."
> (DfT, 2002, p2)

Three-hundred and twenty responses were officially received and summarised. To further summarise, the majority of respondents supported: a minimum learning period of twelve months; compulsory log books for learners; pre-test requirements (i.e. a minimum number of hours of practice or mileage); compulsory theory training; a minimum number of hours supervised by a professional instructor; compulsory delay before retaking a failed test; introduction of a probationary period after passing the test of up to two years with possible restrictions; and compulsory use of P-plates. In essence, the majority of respondents supported major changes to the current UK licensing system that could be beneficial to the safety of novice drivers.

In riposte, a final decision was reached:

> "In the light of the comments received…the Department has decided that further statutory regulation on the way new drivers learn would be unlikely to make enough of a contribution to road safety to justify legislative action at present."
> (DfT, 2004, p2)

By their own definition, saving 1000 deaths or serious injuries and a minimum of £97.6 million per year is not enough of a contribution to road safety. Further, by 2007, based upon Department for Transport figures, a minimum of £500 million has *not* been saved and neither have 5000 deaths or serious injuries. When just one death is personalised, the real impact is realised. For example, on 18th May 2006, Dr

Margaret Davidson was killed on her way home from work when she was hit by a 19-year-old driver. Margaret's mother, Elizabeth Davidson, was asked to write a letter to the Judge at the trial to explain the impact that it had had on her life. Mrs Davidson kindly agreed that the letter could be included in this thesis:

**Dear Sir,**

How can I explain the impact the loss of my daughter Margaret has had on my life to some one who did not know her? I would ask you to therefore bear with me for a moment to allow me to introduce her to you.

Margaret was physically beautiful, fiercely intelligent and a caring thoughtful girl who loved fun, good food and wine and the especially the company of family and friends.

How much time can I spend telling you about the two summers she spent working in dreadful conditions in Bulgarian orphanages? Of the hours spent working for KEEN which is an organisation in Oxford helping disabled youngsters to have fun and reach their potential.

How do I feel knowing I will never see her smile again? How do I feel knowing I will never see her arrive off the train, toss down her bag wrap her arms around me and hear her say, "How's my wee Mum?" How do I feel when I know a text message or phone call will never again be from her? How do I feel knowing I will never hold her child in my arms?

My heart is broken and nothing in this life will ever mend it. I feel a physical pain when I see her photograph or when a memory comes to mind or when I see a little girl with bunches in her hair.

Can you imagine the pain of having to choose flowers, pick hymns for a church service and arrange for a meal for people attending your daughter's funeral instead of her wedding? Can you imagine the distress of having to choose the dress she will wear in her coffin instead of the one she will wear on her wedding day?

I can't begin to tell you the sorrow of telling my son by phone, because he lives in London, that his dear sister Margaret was dead?

All that talent, all that hard work all wiped out in an instant.

Another strange thing has happened. I am conscious of now not being Elizabeth Davidson but of being the woman whose daughter was killed. People have been very kind but you sense their discomfort because they don't know what to say.

We were able to see Margaret and strangely those are the only moments of real peace I have known since she died. I wish I had sat with her longer. But how long would have been enough? I tried to go to my church recently but all I could see was her coffin and I wanted to run out.

On the 16th of July 2005 we, as a family, had one of the happiest days of our lives. After years of studying and hard work on her part and financial struggles on ours Dr Margaret E. Davidson, BM, Bch, MA graduated from Oxford University. On her way up to receive her degree she turned to me and smiled a smile of sheer joy, love and gratitude.

Less than a year later I collected a very tasteful carrier bag containing a cardboard box labelled "The remains of the late Dr Margaret E. Davidson."

I know I was lucky to have a daughter like Margaret but then I knew that when she was alive. And while I am devastated that she was taken after only 26 years I would rather suffer this pain than never to have had the love we shared in those 26 years.

I don’t know if these words have conveyed to you my sense of loss. Maybe there are no such words. Perhaps I should just have saved your time and said I loved Margaret from her first breath and I will love, mourn and miss her until my last.

**Elizabeth R Davidson (Mother)**

In 2007, a House of Commons Transport Committee report stated the following:

> "The driver training regime needs to be modernised as a matter of urgency…too much time has already passed since its [the Department for Transport's] last consultation on the subject in 2002."
> (House of Commons Transport Committee, 2007a, p 49)

The political dragging of feet on this issue will come as no consolation to Elizabeth Davidson and many others. Such tragedy is impossible to comprehend.

The current thesis was inspired by the desire to establish a greater scientific understanding of why young novice drivers' involvement in crashes is sadly common. Research is flooded with reports into young/novice drivers, but such is the complex nature of the problem, many questions remain. Unfortunately, whilst questions remain, political action can be deferred.

One area which required investigation was an understanding of the psychological learning process through which a driver progresses. As will be detailed in Chapter One, contrary to logic, learning to drive involves crash risk being at its highest level at the moment of licensure. As already acknowledged by Government, the UK licensing regime is not currently in tune with drivers' natural learning.

**The ultimate aim of the current thesis is therefore to offer a greater understanding of the psychological process through which a person learns to drive safely. This in turn may advise of appropriate improvements in licensing that could help to prevent novice driver crashes.**

Further specific detail about what each chapter of the thesis aims to achieve and the route the thesis will take is given at the end of Chapter One. The intention of Chapter One is to offer a context of the research area and the problem described above. Due to the complexity of the issue, many topics must be covered that lay the foundations upon which the remainder of the thesis could be constructed.

# Chapter One

## Exploring the context and exposing the gaps

## Chapter One Outline

## 1.1: The problem

On the UK's roads in 2006 there were 258,404 casualties; 28,673 people seriously injured, 226,559 people slightly injured and 3,172 people killed (DfT, 2007a). The financial cost of UK road casualties in 2006 was estimated to have been almost £18 billion, based on lost output, human costs, medical costs, police costs, insurance costs and property damage (DfT, 2007b). Despite this, in international terms, the UK has a good road safety record being amongst the top three countries in Europe, along with Sweden and the Netherlands (Twisk, 2006). This established prominent international position may account for the historical resistance to change the UK driving test since Mr J Beene became the first licensed car driver in 1935. Why then, seventy-three years on, would a change in the way people learn to drive influence these statistics?

The main reason is substantial evidence suggesting that drivers who have recently passed their driving test are at greater risk of being crash involved than the general driving population. It has been estimated that between fifty and seventy percent of initial driver collisions are attributable to inexperience (Gregersen, 1996). Within the UK, it has been reported that eighteen percent of newly qualified drivers will be involved in at least one crash within their first year of solo driving; falling to thirteen percent in the second year and ten percent in the third year (Maycock & Forsyth, 1997). In fact, it is estimated that almost 38,800 people are killed or injured each year in collisions involving at least one driver with fewer than two years solo driving experience (DfT, 2002).

### *1.1.1: Definition of Novice and Young drivers*

The popular media and academia generally term this troubled group as 'Novice Drivers' or 'Young Drivers'. Novice drivers are often defined as drivers who have less than three years of solo driving experience (House of Commons Transport Committee, 2007a). This definition therefore includes all qualified drivers under twenty years old (in the UK) but also any older drivers who are within the first three years since passing the driving test. This is the definition used for the 2007 House of Commons Transport Committee report on Novice Drivers and it is the definition that will be utilised in the current thesis.

The definition of young drivers can depend on the jurisdiction of the country from which a report is published, although it is generally considered to be drivers under twenty-five years old. In the UK, the Department for Transport defines 'young drivers' as being between 17 and 25 years old (House of Commons Transport Committee, 2007a). Again, where the term 'young driver' is used within this thesis it will imply this definition, unless stated otherwise. Of course separating the two definitions of driver is impossible as youth and inexperience generally go hand in hand. Maycock (2002) reports that the Pearson correlation co-efficient between age and driving experience of registered UK drivers is 0.62, hence most, though not all, inexperienced drivers are also young drivers.

### *1.1.2: Novice and young driver statistics*

In the UK, thirteen percent of drivers are 'young drivers' yet they disproportionately represent twenty-nine percent of all drivers killed each year (Brake, 2007a). But the UK is not alone with this pattern. The ratio is repeated in Sweden where drivers aged 18-24 years old make up twelve percent of the driving population, yet account for twenty-five percent of those killed or seriously injured in road crashes (Thulin & Nilsson, 1994). In Iceland, young drivers (17-20 years old) make up twenty-five percent of the crash statistics and have a collision rate of nearly two hundred young drivers in every 10,000 (Briem, Ragnarsson & Thordarson, 2002). In fact, the frequency of serious traffic collision rates is highest among young drivers (17-24 years old) across all Nordic countries (Alexandersson, 1998), and beyond. This consistent trend is also reported in the Netherlands, Australia, USA (Vlakveld, 2004; Lam, 2003, Williams, 2003), and many other countries, as shown in Figure 1.1.

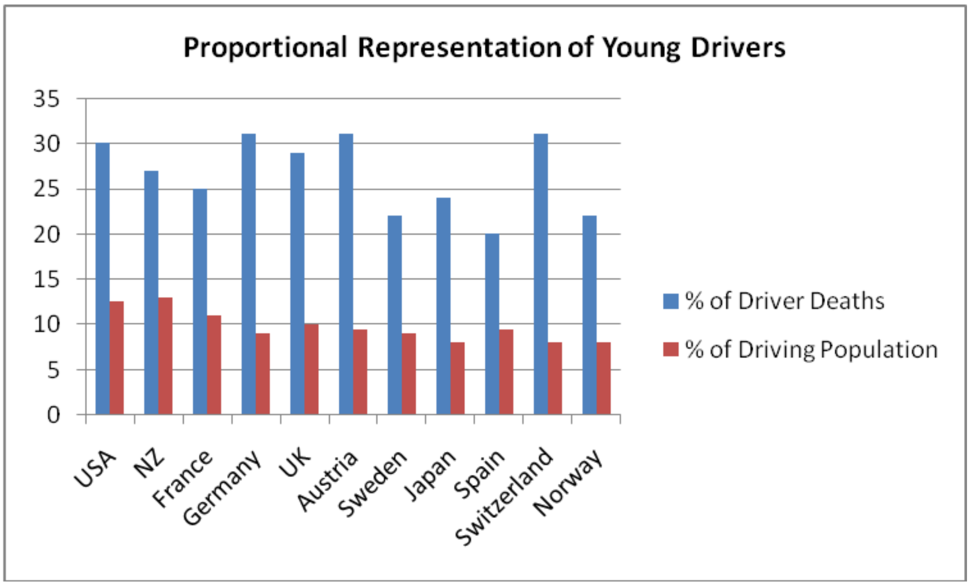



*Figure 1.1: Demonstration of young drivers' relative fatality risk across eleven countries (White, 2005)*

The magnitude of the problem becomes apparent when it is realised that road traffic crashes are the biggest killer of those between 15 and 29 years old in high income countries and the second biggest killer, after AIDs, in low and medium income countries (Peden, McGee and Krug, 2002). In Canada, road crashes are reported as the largest single cause of premature death amongst 16-24 year olds (New Driver Safety, 1993). Meanwhile in the UK, it is estimated that 76% of deaths for 16-19 year olds can be accounted for by road crashes (DfT, 1993). Figure 1.2 graphically demonstrates this trend across eleven worldwide developed nations. Figure 1.3 further graphically demonstrates this cross-cultural trend across thirty worldwide countries and compares traffic crashes to other causes of death.

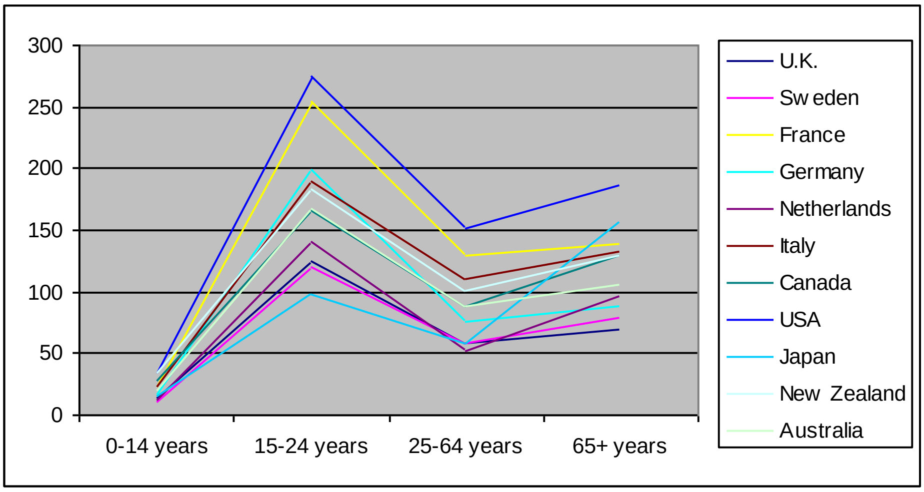



*Figure 1.2: International comparison of number of road user fatalities by age group (Scottish Executive, 2003)*

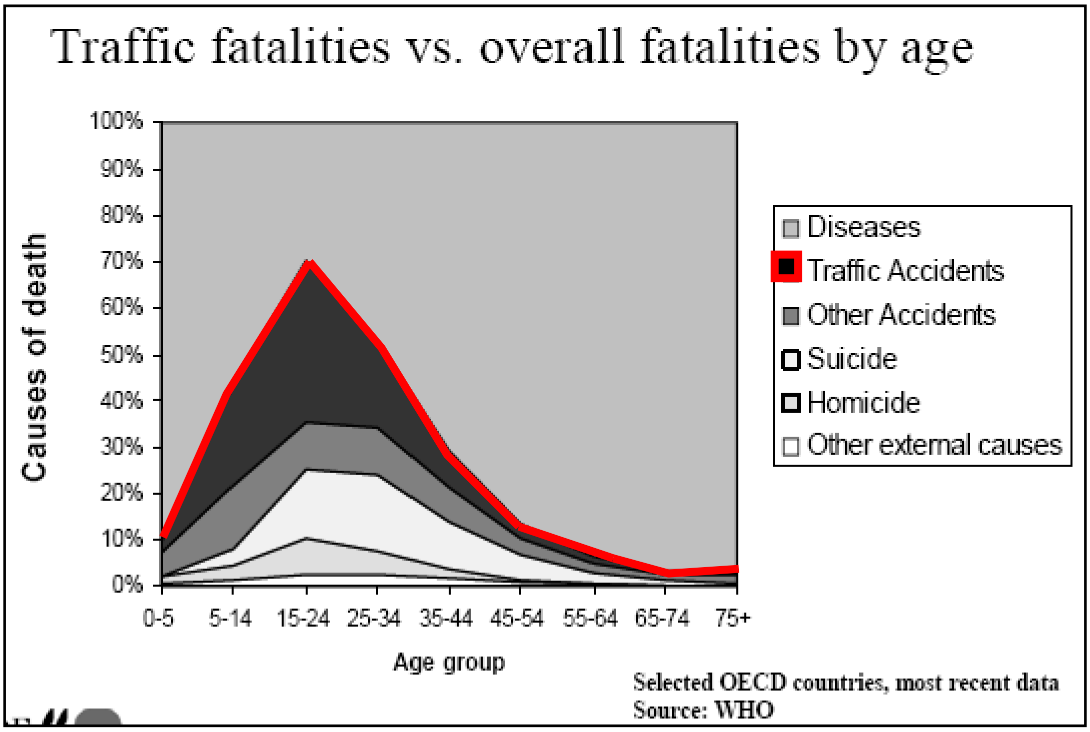



*Figure 1.3: Comparison of causes of death by age range (White, 2005)*

With the revelation that this is a worldwide trend, comes the realisation that this phenomenon eclipses both cultural differences and a multitude of licensing and training methods. This suggests that there may be a common denominator which is not yet being appreciated

**1.2: Age and experience**

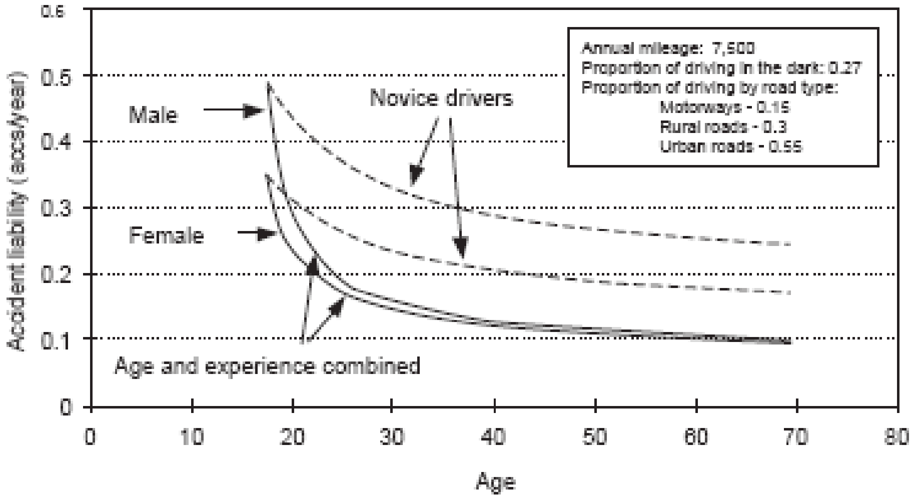
Given that most novice drivers are also young drivers would imply that it is likely the common denominator is either an age related factor or an inexperience related factor. Overall, the crash risk of seventeen year old novice drivers reduces by forty-three percent after their first year of licensed driving (Forsyth, Maycock & Sexton, 1995); by which time the driver is eighteen years old of course. This reduction in crash risk is attributable to both age and experience, but which is more important?

Forsyth et al. (1995) argue that the effect of age alone means that drivers who start driving at eighteen years old will have nine percent fewer collisions than drivers who start at seventeen years old. This argument is supported by Canadian research after a change in licensure age in Canada allowed a comparison of crash data before and after. Canada reduced its minimum driver licensing age from eighteen years to sixteen years. The comparisons of before and after data found that crash involvement among new drivers increased by twelve percent and fatalities by twenty-four percent (Gaudry, 1987, cited in Gregersen & Bjurulf, 1996).

Whilst age is obviously a contributor to young driver crashes, studies have found that all new drivers, regardless of age, have initial crash risk (Levy, 1990; Cooper, Penili & Chen, 1995). In Victoria, Australia, first year drivers have 3-5 times the crash involvement when compared to more experienced drivers (Senserrick & Haworth, 2004). Most of these new drivers though are also young (18-19 years), hence it was concluded that youthfulness and inexperience tend to run in parallel for most new drivers. This is a commonly reported in the international literature from Australia, USA, Canada and Sweden (Levy, 1990; Mayhew, 2007; Gregersen & Bjurulf, 1996)

In trying to separate the age effect from the experience effect, Maycock, Lockwood and Lester (1991) studied newly licensed drivers in the UK at different ages (17, 20, 25, 36 & 50 years), who all travelled around 12,000 kms per year. Using an initial sample of 13,500 UK drivers, they found that crash liability for young drivers can reduce by 35-40% in the first year of driving alone. Further, it was reported that crash risk during the first few years of solo driving decreased by about 31% due to age and about 59% due to experience. A similar finding is reported by Vlakveld (2004).

Extracted from a study using logistical regression analysis, Figure 1.4 demonstrates the independent effect of age compared to age and experience on novice drivers' crash risk (Maycock, 2002). It would appear from this data that whilst there is an obvious age effect, initial driver experience is absolutely crucial to a reduction in overall crash risk.




Source: Maycock (2002) – Novice driver accidents and the driving test

*Figure 1.4: The influence of age and experience on the accident liability of male and female drivers*

Recent research would also support the claim that inexperience is of greater importance as both miles driven and time of licence are seen as more important than age in reducing crash risk. McCartt, Shabanova and Leaf (2003) reported that crash rates were highest within the first few months and specifically the first 500 miles after licensure. Meanwhile Mayhew, Simpson and Pak (2003) also found the first month after licensure to be a critical period for crash risk and that risk drops off month by month after this.

The dramatic reduction in crash risk due to experience within the first few months of licensed driving suggests that drivers are continuing to learn rapidly even after passing their test. It also creates something of a licensing paradox. For example, the more inexperienced a driver, the higher the crash risk; reducing the crash risk requires gaining experience; yet gaining that experience means increased exposure which in itself causes increased crash risk (Simons-Morton, 2002). It is therefore important to appreciate how the current licensing system within the UK fits into this picture.

### *1.3: Learning to drive in the United Kingdom*

Drivers in the UK can begin learning at seventeen years old. They must firstly apply for a provisional licence before being allowed to drive on public roads with either an

Approved Driving Instructor (ADI) or an accompanying driver. Accompanying drivers must be over twenty-one years old and have held their licence for over three years. The Driving Standards Agency (DSA) is responsible for maintaining and checking the standards of ADIs.

In order to gain a full driving licence a learner driver must pass a theory test and a practical test. The theory test is made up of two parts: multiple choice and hazard perception. Once these two components of the theory test have been passed a learner driver can take their practical test. In the practical test, drivers are examined on their general driving and on two reversing exercises (reversing round a corner; turning in the road; or reverse parking). They are also tested for basic physical checks of the vehicle and may be asked to complete an emergency stop. Drivers can make up to fifteen minor driving faults and still pass, although making three faults of the same kind will result in failure. One serious or major fault will result in failure. The test takes around forty minutes.

Once a driver has passed both the theory and practical components of the test, they are free to drive unaccompanied with no restrictions. The only regulation that is unique to novice drivers is that they will be disqualified from driving if they receive six penalty points (typically equivalent to two speeding convictions) within the first two years. After two years the limit raises to the normal limit of twelve points.

For the average driver, the cost of learning to drive will be around £1000 (House of Commons Transport Committee, 2007a). A one-hour lesson with an ADI is generally around £20-£30 and the theory test fee is £21.50. The practical test costs £48.50 on weekdays and £58.50 on evenings and weekends.

### *1.4: Problems with learning to drive in the UK*

The recent House of Commons Transport Committee report on Novice Drivers (2007a) details evidence from a wide range of road safety professionals and notes that the vast majority consider the current system of learning to drive to be inadequate. In answering the question, ‘How effective are the existing practical and theory driving tests at identifying safe driving skills and behaviour?' the Norwich Union (part of the same company as RAC and BSM) responded:

> "Not very effective...The practical test currently produces drivers with little practical experience"
> (Ev26: Memorandum submitted by Norwich Union, House of Commons Transport Committee, 2007b)

The set-up of driver training in the UK is heavily orientated towards initial driver licensing, and that is all (McKnight, 1992). It is a system criticised for not giving drivers experience on all road types and in all weather conditions (House of Commons Transport Committee, 2007a). With no minimum learner period, a driver may start to drive in the summer months and pass their test without encountering driving in wintery conditions. Learner drivers are also not permitted to drive on motorways; this type of road can only be experienced once a driver reaches full licence status and is driving alone and unrestricted. Similarly, as many instructors are based near highly-populated areas, experience of driving at speed on rural roads may only occur after licensure.

A further problem is that the cost of learning to drive under the current system offers a financial incentive to pass the test with minimum tuition (House of Commons Transport Committee, 2007a). With no minimum learner period, a driver can go from a non-driving status to a full licence within the first week of turning seventeen years old. Some official DSA companies offer the ironically titled '1 week crash-course' to learn to drive, which is apparently popular with parents as a seventeenth birthday present (Brake, 2007b). The current test could therefore be argued to present an inconvenient hurdle to drivers rather than a necessary learning process for the understanding, appreciation and control of a complex piece of machinery on public highways. The fact that there was only a forty-three percent pass rate in 2004 could suggest a lack of preparedness by drivers eager to jump this hurdle as quickly as possible (DSA, 2004).

A further complaint about the current system regards the lack of care for shaping drivers' attitudes to driving (House of Commons Transport Committee, 2007a). There is no set pre-driver education that aids the learning to drive experience and no post-test follow up. The theory section of the driving test is further criticised. All possible multiple choice questions are openly published and some argue this leads to a test of rote learning rather than an appreciation of driving on the road (House of Commons Transport Committee, 2007a).

In acknowledgement of these issues, there is now significant pressure for a change to the current licensing system. The [then] Minister for Transport recently stated,

> "I entirely share the view that the way we teach people to drive and the way we test them […] needs to be fundamentally reformed."
> (House of Commons Transport Committee, 2007a, p11)

Meanwhile, the second review of the Government's Road Safety Strategy, Tomorrow's Roads: Safer for Everyone, states:

> "The time has come to reform fundamentally the way people learn to drive. We need to do more than tinker with the particular elements, we need to overhaul the current system for learning, including predriver education, testing and maintaining driving skills through life."
> (DfT, 2007c, p40)

The need for 'fundamental' change demonstrates that obtaining a full driving licence in the UK currently only takes a novice driver from non-driver status to having the basic skills on which all higher order driving skills must be built. The statistics and trends reported earlier regarding novice driver crash risk would suggest that this is not enough. To fill the gaps left by the current regime, many have historically relied on extra driver training and education.

### *1.5: Supplementary driver training and education*

Beyond the licensing regime, attempts to reduce the casualty rate on Britain's roads have often been addressed through additional training and education. This has led to organisations, private businesses, local authorities and charities all providing supplementary education initiatives. Most education schemes involve the use of 'high school' time to target an audience of young drivers as they reach the legal driving age of seventeen years old (Stradling, Kinnear & Mann, 2005). For most initiatives, this is the most efficient use of time and is the easiest access to the target audience. This, however, requires the cooperation of the schools or local authorities who have ever increasing demands on 'social education' time slots (Stradling et al., 2005).

*1.5.1: Pass Plus*

As well as in-school education programs, some organisations target drivers at the vulnerable post-test stage. Driver training to improve driver skills are available to newly qualified drivers with the most prominent being the Pass Plus system. The Pass Plus system is aimed at newly qualified drivers who wish to take further instruction with professional instructors. The financial incentive for taking this course is a discount on insurance premiums with affiliated insurers. The Pass Plus system introduces drivers to driving on motorways, bad weather driving, night time driving and out of town driving. However, Pass Plus is a voluntary scheme at added cost to the driver and has not had a full evaluation since its implementation twelve years ago, although one is due (House of Commons Transport Committee, 2007a)

*1.5.2: The effectiveness of driver training and education*

Unfortunately, it is commonly reported that road safety education programs aimed at influencing young driver attitudes and risk perception have failed to document any effect on the number of crashes (Ulleberg & Rundmo, 2003). Despite the well meaning nature of such programs, the failure to reduce collisions, injuries, deaths or even risk has led some to question if driver education programs are worthwhile. It has been argued that from a public health perspective, any public health programme needs to be effective in: reducing death or injury, be cost effective and do no further harm (Christie, 2001). Disappointingly, educational programs struggle to justify any of these criteria (MacIntyre & Petticrew, 2000; Christie, 2001; 2002; IIHS, 2001).

The state of Pennsylvania, USA spent US$43.5 million per year on a high school education programme (Christie, 2002). To break even, in cost-effective terms, the programme would have needed to yield a saving of around fifteen fatalities per year

(Bureau of Transport Economics, 2000). An evaluation of the programme included 1,200 drivers aged between sixteen and eighteen years old (McKenna, Yost, Muzenrider & Young, 2000). Details across sixteen variables were collected from the participants, including their driver education, conviction and crash records. Analysis revealed that those who had completed the school-based education showed no lower crash rate; no lower conviction rate; no difference in seat belt use; no lower rate of risk taking behaviour; and, no lower rate of crash severity or injuries. McKenna et al. (2000) concluded that their finding added to prior international literature that there was no evidence for driver education leading to reduced rates of crashes, injuries or fatalities among young drivers.

The international literature includes that of Sheehan (2000) in Australia. In 1988 a comprehensive school based education programme aimed specifically at drink driving was introduced throughout Queensland, Australia. In all, over 60,000 students took part in the education programme which was evaluated on three separate occasions (Sheehan, 2000). Although it was found that students' attitudes and intentions had changed at the time the programme was taught, the researchers admitted that the programme had no or little effect on subsequent drink driving related convictions (Sheehan, 2000).

Vernick, Li, Ogaitis, MacKenzie, Baker and Geilen (1999) reviewed literature in the USA relating to high school driver education courses. The aim was to establish if high school aged students who enrol on these courses have fewer motor vehicle crashes or violations or are more likely to obtain a driving licence. Vernick et al. (1999) also sought to ascertain if the availability of high school education courses in a community is related to lower community rates of motor vehicle crashes involving young drivers. Nine studies met the strict criterion to be included in the review. Based on these studies there was no evidence found that high school driver education reduced motor vehicle crash involvement for young drivers, either at an individual or community level. In fact, by providing an opportunity for early licensure, there is evidence that these courses are associated with higher crash involvement rates for young drivers. Vernick et al. (1999) conclude by suggesting that because of the lack of support for high school driver education, schools and communities should consider other ways to reduce motor vehicle-related deaths in this population, such as graduated licensing (graduated licensing in discussed later in this chapter, page 30).

Other countries have also produced evaluative research supporting the suggestion that driver education is not effective in reducing crash risk. Initiatives in New Zealand and Australia have both found safe driving knowledge gains but no reduction in crash and conviction records post-licensing at eighteen months and twenty-four months respectively (Wynne-Jones & Hurst, 1985; Woolley, 2000). In the Australian example, the results led to the near elimination of Government funding for the scheme (Woolley, 2000). It is likely that this was because from the public health perspective, this initiative was deemed both ineffective and not cost efficient. Despairingly, there is also evidence that educational programs can also fail the third public health evaluation criteria and actually do more harm.

Health promotion campaigns have reported that raising a topic with an intervention group can raise confidence in trying the behaviour instead of warning participants away from the behaviour. For example, on evaluating a sex education course Speller, Learmonth and Harrison (1997) reported that after only six lessons aimed at reducing pre-marital sex, most of the intervention group claimed to have initiated sexual intercourse. Similarly, a major evaluation of compulsory learner driver education in Quebec, Canada from 1983-1990 found that as well as no reduction in crash risk, the programme had actually encouraged earlier licensing, particularly among women (Potvin, 1991). An overall concurrent trend was noticed that saw an increase in fatal crashes involving young females and the programme was eventually removed on this evidence (Dussault, 1998). Despite the well meaning nature of the compulsory driver education, the side effect was that it led drivers to undertake the activity earlier than they might otherwise, and this had put them at increased risk.

Supporting this, Robertson (1980) followed up on nine schools in Connecticut that dropped driver education from their curriculum after state subsidies were stopped. All other schools kept it in the curriculum, leading to a comparison scenario. Robertson (1980) claimed that in the nine schools which dropped the curriculum, the number of 16-17 year old licensees dropped by fifty-seven percent and collisions by sixty-three percent. In the schools that kept the curriculum, licensing dropped by only nine percent and no change was found in the number of collisions. More recent reviews of Robertson's (1980) data do not find such overwhelming results but still show support for his claims (Lonero & Clinton, 1998).

Nevertheless, it is appropriate to note at this point that the role of driver education as part of a graduated licensing scheme has recently been gaining praise (Hedlund & Compton, 2005). Graduated licensing is discussed later in this chapter on page 30.

### *1.6: Why has education not worked?*

The primary aim of any road safety authority must be to save lives, reduce crashes and prevent injuries. In most cases, therefore, the aim of the educational approach in road safety is to substantiate this primary aim. However, many believe that it is unreasonable to expect driver education or training to deliver crash reductions (Woolley, 2000; Christie, 2001; 2002). Christie (2001) notes that expecting driver education to reduce crashes is like expecting the teaching of general economics in schools and universities to have a significant effect on the economy. Lonero & Clinton (1998, p1) state:

> "Even the simplest of behaviours is determined by a complex mix of biological, psychological, social and cultural factors"

Driving is essentially a self-paced activity therefore a driver's choice at any given moment of driving is compounded by their internal motivations and external influences. Whilst training and education may improve knowledge and skills, the driving trainer has little influence over post-course behaviour (Christie, 2001). Hence, drivers, specifically young drivers, can and do take risks that are nothing to do with knowledge or skill, and instead much more to do with situation-specific motivations and thrill seeking (McKnight & Resnick, 1993). An Australian study into crashes involving 18-25 year olds concluded that risk taking due to the influence of non-safety motivations associated with youthfulness was a major contributory factor (Catchpole, Cairney & Macdonald, 1994). Further, research into alcohol and driving concluded that reported reasons for drink-driving incorporated individual motivations influenced by organisational, economic, environmental and social factors (Ferguson, Sheehan, Davey & Watson, 1999). Driving behaviour appears to be more complex than simply knowing what is right and wrong.

### *1.7: Young drivers in a social context*

It is argued that there is a requirement to start understanding driving as a broader social activity including the wider social context in which the driver operates (Gregersen & Bjurulf, 1996). Further, it is also argued that advances in road safety will only be made when road safety is viewed as a social issue with a similar ideology to that of multi-faceted health promotional approaches today (Lonero & Clinton, 1998). 'A man drives as he lives' (Tillman & Hobbs, 1949) may be more insightful than it first appears.

Research in the UK has attempted to study the wider social context of young drivers by using descriptive data through structured interview techniques (Rolls, Hall, Ingham & McDonald, 1991). Rolls et al. (1991) measured external social influences on driving behaviour including: parental influences; peer influences; drinking behaviour; perceived risk & risk taking; and perceived ability. What emerged for the researchers was a separation between 'safe' and 'unsafe' drivers. Unsurprisingly, the 'unsafe' drivers were considered to be those most at risk of crash involvement and were involved in a 'car culture' (Rolls & Ingham, 1992).

The key aspect of the 'unsafe' drivers' 'car culture' appears to be that driving is seen as an expressive activity rather than a mode of transport. The 'unsafe' driver sees the car as an accessory to their personality, hence can be driven in an expressive manner. Not surprisingly, the wish to test their own and the car's abilities was also prevalent in this 'car culture'. 'Unsafe' drivers also reported that 'mood' whilst driving was important and that certain music could enhance the driving pleasure and influence driving style (Rolls & Ingham, 1992).

'Safe' drivers appear to mainly use their car as a mode of transportation. 'Safe' drivers were also more likely to have regular girlfriends or partners with whom they spent a lot of time with. A 'safe' driver was also happy to admit that they were safe drivers rather than expressing excessive confidence in their own driving abilities. Interestingly, 'safe' drivers also reported higher debts, therefore, spent less on their car and going out when compared to 'unsafe' drivers.

Stradling, Meadows and Beatty (2000, p1) note that:

> "Driving is a technical skill undertaken in a social context that affords expressive opportunities"

This is certainly supported by Rolls et al. (1991) who concluded that understanding the social context of young drivers is key to understanding their driving behaviours. Driving is a unique social experience in which drivers will engage with numerous others who are generally strangers, from all backgrounds, of all ages, and each and every one has their own particular driving context.

### *1.8: Influences on young drivers*

Appreciating the wider context in which young drivers interact requires understanding the influences on them and their crash risk. A European review suggested that young drivers' crash risk was a complex blend of exposure and experience; type and state of vehicle; the use of drugs and/or alcohol; the personality of the driver; the type of training; the level of driving skill and the driving style adopted (Lynam & Twisk, 1995).

#### *1.8.1: Parents*

With death through road crashes being one of the biggest killers of young people in the UK, it is not surprising that parents of 7-18 year olds view road safety as being one of the top three risks for their children (Graham, 2004). However, parents' confidence in their own child's road use is high, and instead, it is the behaviour of others on the road that worries them (Graham, 2004). Graham (2004) also reported that parents perceived themselves as having the main responsibility for the development of their child's road safety skills, however, it was also found that many parents lacked key road user knowledge. Similarly, in Australia, it was found that whilst parents acknowledged that they were in the best position to teach their children road safety, this was amalgamated with some disgruntlement that they should be primarily responsible (Elliot, 1999). Parents in both Australia and the UK have shown that they place great expectation on the school system to teach their child about road safety (Elliot, 1999; Graham, 2004).

A review in 2001 established that parents are very important road safety role models for their children (Ivett, 2001). A RoSPA (2002) poll supports this with ninety-four percent of young driver respondents stating that their parents helped them to learn to drive. Parents can provide a critical opportunity for a novice driver to gain experience in the relative safety of supervised driving. However, whether parents have a real understanding of the dangers facing young drivers once their licence is gained is questionable. Simons-Morton and Hartos (2003) found that although ninety-two percent of parents rated their teenager driving after consuming drugs or alcohol as risky, other circumstances were only seen as only moderately risky: sixty-one percent for driving without a seatbelt; forty-eight percent for driving in bad weather; thirty-two percent for driving at night in the rain; and, twenty-eight percent for driving with two or more teens in the car. These circumstances are those that represent higher risk situations for young drivers, yet the perceived risk by parents is underestimated (Simons-Morton & Hartos, 2003). For example, research has demonstrated a link between carrying teen passengers and crash risk (Chen, Barker, Braver & Li, 2000; Doherty, Andrey & MacGregor, 1998). Despite this, Hartos, Eitel, Haynie and Simons-Morton (2000) found that most newly licensed teens were allowed 'many' teen passengers, 'most of the time'.

Beck, Shattuck and Raleigh (2001) performed interviews with parents and their teenage driving offspring. Results demonstrated that parents were unaware of the extent to which their teen driver engaged in high-risk driving behaviours, such as being distracted by friends or speeding. It was also found that teens given unsupervised access to a car several times a week were three times as likely to have driven too fast compared with those who had more restricted access. It was concluded that it was essential that parents were empowered to enforce driving restrictions on recently licensed teens.

Unfortunately though, many parents are not involved in their teenage children's driving much beyond the date of licensure (Simons-Morton & Hartos, 2003). Modest initial parental restrictions are often not restrictive enough to even touch upon promoting safety (Hartos et al., 2000). Whilst many parents admit that road safety is a concern, many parents are influenced by other factors such as the reduced time they have to spend transporting their children. Further, most parents want to give their children what they want, and what teens often want is to drive (Simons-Morton & Hartos, 2003).

Parents are also important role models for their children. By the time children reach the legal driving age, they will have had up to fifteen years of conscious exposure to their parents and other drivers, with much of this behaviour being negative (Ivett, 2001). Ferguson and Williams (1996) demonstrated a link between parents and their children's driving behaviours. Children (aged 18-21 years) whose parents had three or more crashes on their driving record were twenty-two percent more likely to have had at least one crash compared to children of parents with no crash history. Similarly, children whose parents had three or more convictions were thirty-eight percent more likely to have had a conviction than children whose parents had no convictions (Ferguson & Williams, 1996).

### *1.8.2: Alcohol*

Although drink-drive casualties - deaths, serious injuries and minor injuries - decreased significantly during the 1980s, they have risen by nearly a third between 1993 and 2002 (from 14,980 to 20,140) (DfT, 2007a). Drink-drive related crashes account for one in six road deaths in the UK (DfT, 2007a). It is estimated that a further eighty road deaths per year are caused by drivers who are under the drink-drive limit but who have a significant amount of alcohol in their blood (Institute of Alcohol Studies, 2007).

The legal blood to alcohol limit for driving in the United Kingdom is 80mg of alcohol per 100ml of blood. In some European countries the legal limit is zero (e.g. Czech Republic, Estonia, Hungary, Romania and Slovakia), although many others allow 50mg per 100ml blood (e.g. Austria, Belgium, Denmark, Finland, Germany, France, Greece, Italy, Netherlands, Portugal, Spain and Turkey) (European Road Safety

Observatory, 2006). In fact the British Medical Association suggested a lower limit of 50mg in 1960 (Havard, 1986). This was again suggested in a 1984 report to the Home Secretary by Sir William Paton (Paton, 1985). Research suggests that drivers' crash risk is doubled at 50mg and multiplied by a factor of ten at 80mg (Gerondeau, 1990). There has been no legislative change to date.

As well as an overall reduction to the current legal drinking and driving limit, there are some who call for an even greater restriction on young drivers (Institute of Alcohol Studies, 2007). There is support for this greater restriction on young drivers with research demonstrating that alcohol is much more likely to be a factor in young drivers' crashes than in older drivers (McGwin & Brown, 1999; Hingson, Heeren & Winter, 1994). It is postulated that the effect of alcohol on young drivers is exaggerated by driving inexperience and immature driving skills, hence leading to greater crash risk.

Hingson et al. (1994) compared twelve states in the USA that had lowered the legal alcohol limit for drivers under twenty-one years old with twelve states that had not. It was found that fatal night time crashes involving alcohol and those under twenty-one reduced by sixteen percent on average in states that had reduced the legal alcohol limit. During the same post law period, the same form of crashes rose by one percent in the states that had not changed their laws.

*1.8.3: Other drugs*

> "The BMA is concerned at the influence of drugs (both illegal and prescribed) on driving skills and calls on the Government to:
>
> - undertake a campaign to educate the public that the side effects of illegal and certain prescribed drugs can affect their ability to drive,
> - and ensure speedier and more specific and co-ordinated research to establish appropriate drug testing devices"
>
> (British Medical Association, 2007, p1)

No drug has been studied as extensively as alcohol with respect to motor vehicle crashes. Available evidence concerning other drugs suggests that they have a small, yet measurable, association with impaired driving and the occurrence of impaired driving crashes (Terhune, Ippolito, Hendricks, Michalovic, Bogema, Santinga, et al., 1992; Mathijessen, Koornstra & Commandeur, 2002). Post-mortem evaluations of 1,882 fatally injured drivers sampled in seven states in the USA during 1991 and 1992 found alcohol in 51.5% of the drivers (Terhune et al., 1992). Of the forty-three other drugs for which tests were conducted, the most prevalent were cannabis (6.7%), cocaine (5.3%), benzodiazepine tranquilizers (2.9%), and amphetamines (1.9%). Analysis of the circumstances surrounding each of these fatal crashes suggested that they were caused by impairment effects associated with alcohol (alone), alcohol-drug combinations, and drug-drug combinations. Statistically significant crash causation was not found for drugs when used alone. This finding is supported in Europe where Mathijessen et al. (2002) conclude that drugs alone have a limited effect on driving, but that drug taking with only a slight amount of alcohol in the blood leads to increased crash risk.

Further research into drugs and driving carried out by Preusser, Ulmer and Preusser (1992) involved ten police forces, in which officers had been specifically trained to identify drivers impaired by drugs. Of 1,469 drivers arrested under suspicion of drug intoxication, 46.5% of suspects tested positive for cannabis. Other drugs found in suspects systems were stimulants including cocaine (29.6%), depressants (23.3 %), narcotic analgesics (15.5%), phencyclidine, prevalent in the USA and known as "PCP" (5.9%), inhalants (1.4%), and hallucinogens (0.8%). However, many of these drugs leave traces in the human body for an extended period of time after intoxication and initial ‘trip’, hence, detection of these drugs did not infer that users were currently driving whilst intoxicated by the drug. Instead it was estimated that between 1-4% of all persons arrested for impaired driving during this study were found to be under the influence of drugs. This finding is consistent with the conclusion that drugs are a small, yet measurable, part of the total impaired driving problem.

Although drugs and driving has not been extensively studied, research to date suggests that whilst drugs alone have some effect on drivers’ crash risk, it is the combination of alcohol and drugs that presents the most serious concern. Nevertheless, some argue that it is the lack of instruments available to the police to test for drivers drug use at the scene of an crash that is preventing the real problem from being uncovered (British Medical Association, 2007). There is concern that drug use and driving is on the increase (Tunbridge, Keigan & James, 2001) and especially as a high incidence of young driver fatalities have been found to have drug, drug-alcohol and drug-drug combinations in their bodies (Williams, Peat, Crouch, Wells & Finckle, 1985).

*1.8.4: Personality*

The role of personality traits being linked to road crashes can be traced back to Farmer & Chambers (1939) who proposed the theory of "accident proneness". The theory suggested that there were a small number of people who possess certain personality characteristics that make them more prone to accidents, hence, it is those people who will crash. The theory has since been disregarded but there is now evidence of a small but consistent link between certain personality characteristics and crash involvement on the roads (Ulleberg & Rundmo, 2003). Examples of such characteristics are sensation seeking, aggression and social deviance (Briem et al., 2002; Lawton, Parker, Stradling & Manstead, 1997; Meadows, Stradling & Lawson, 1998; Parker, Lajunen & Stradling , 1998).

Personality traits that influence behaviour have been defined as being either 'permanent' or 'transient' (Briem et al., 2002). Permanent traits are traits that predict a person's behaviour over many years. However, it is 'transient' traits that interest road safety research as these are traits that are evoked due to a certain situation and only last as long as the situation lasts. Many drivers can recall a time when they behaved 'out of character' whilst driving. Tapping into whether transient personality traits are linked to crash involvement may therefore be useful to the understanding of driving behaviour.

Svensson and Trygg (1994) investigated these transient personality traits in relation to crash involvement in people who drove as part of their work. It was found that crash involvement could be predicted with relatively high accuracy, based solely on the results of the personality measure used. Whilst the result was predominantly evident in older drivers, predictions were still found among younger drivers. As with any personality measure that demonstrates predictive capabilities, the potential for screening is considered. In road safety, the potential to screen young drivers for crash risk is possibly too idealistic although road safety charity BRAKE called for its consideration to the recent House of Commons Transport Committee report on Novice Drivers (House of Commons Transport Committee, 2007b).

### *1.8.5: Sensation seeking*

Sensation seeking is seen in psychology to be a personality trait that is concurrent with youth, yet decreases with age (Briem et al., 2002; Stradling et al., 2000). Being a personality trait, it is found more in some individuals than in others. For example, Ragnarsson, Briem and Thordarson (1998) found that a group of racing drivers displayed significantly greater sensation seeking tendencies compared to other occupations included in the study. Where driving on the road is concerned, studies have linked those with higher sensation seeking tendencies to crash proneness (Zuckerman, 1994; Stradling et al., 2000). In a large scale self-report study of English drivers, Stradling et al. (2000) found that drivers who had been crash involved in the past three years, scored significantly higher on the sensation seeking scale than drivers who were not crash involved in the past three years. Similarly, Rimmo and Aberg (1999) found a connection between sensation seeking and self-reported traffic offences.

Stradling et al. (2000) also provide data that suggests certain driver characteristics are linked to sensation seeking. These include inexperienced drivers, male drivers and those from households with earnings over £20,000 (at the time of research). More insight was provided by Jonah (1986) who found that a specific sub-scale of Zuckerman’s Sensation Seeking Scale (SSS) measuring ‘thrill and adventure seeking’ was most clearly connected to driving behaviour. Jonah also concluded that sensation seeking was involved in most cases of predicting drivers’ crash proneness.

Summala (1987) notes that young novice drivers lose their sensation seeking tendencies. It is suggested that young drivers gradually develop a more sophisticated and automatic driving style during the first few years of road experience. Another important change is that the perception of the car alters from one of potential sensation seeking and self-assertion to that of a transportation tool (Summala, 1987).

*1.8.6: Over-confidence*

A range of studies have reported that young drivers have an over-confidence in their driving abilities and that this is a major influence in crashes involving young drivers (Rolls & Ingham, 1992; DeJoy, 1992; McKenna, 1993; Gregersen, 1995). Rolls and Ingham (1992) reported that young drivers rated their own driving skill as being significantly better than their peers. It was further reported that the same young drivers considered their driving ability to also be better than that of an experienced driver (30 years or over), but only just. Rolls and Ingham (1992) therefore noted that whilst young drivers could appreciate older drivers have more ability than drivers of their age group in general they still had the confidence that they, themselves, were better drivers.

Over-confidence is not simply the belief that one is good at the task of driving. It also encompasses the belief that as one has superior skills than most other road users, therefore, one is a safer driver and less likely to be involved in a crash (DeJoy, 1992). It is exactly this concept of unrealistic optimism that is considered to contribute to high crash statistics for young drivers (DeJoy, 1992). Further consideration of this issue will be discussed in Chapter Two (page 53).

**1.9: Crash analysis**

Studying collision trends can help us to appreciate what factors in the driving context are influential to drivers' crash risk. For example, simply the gender of a driver is important to the types of collision that they may be involved in. Male drivers are prone to single vehicle crashes; crashes on bends; overtaking crashes and crashes during the hours of darkness (McKenna, Waylen & Burkes, 1998). Female drivers on the other hand are more prone to crashes at junctions whilst trying to turn right or left (McKenna et al., 1998). Therefore, gender or the type of road, be it driving in town or driving on country roads, can have an influence on the crash risk of a driver.

In a large scale analysis of collision data in the UK, Maycock (2002) noted that one of the clearest differences between young and older drivers was that young drivers have more crashes in the evening and early morning, and that a high proportion of these are single-vehicle crashes. Forsyth (1992) also reported a common time frame for novice driver crashes between 10pm and 2am; it is important to note that other factors such as alcohol, fatigue, speed and peer pressure were also contributors to young driver crashes during these periods of the day (Maycock, 2002).

American analysis of crash involved young drivers reported that they were poorer than experienced drivers in their 'search' skills: maintenance of surveillance, keeping a proper lookout and anticipating the actions of others (Lestina & Miller, 1994). Meanwhile, Stutts, Reinfurt, Staplin & Rodgman's (2001) analysis of 30,000 crash reports concluded that younger drivers were much more likely to have been distracted just before the crash than older drivers. Operating devices such as CD players, radios, and mobile phones were noted as causing distraction, as was having passengers. It is postulated that the presence of peers whilst driving can be a cause of major distraction to young drivers' attention (Vlakveld, 2004).

Young drivers' driving style has also been reported to alter depending on the type of passenger they are carrying (Rolls et al., 1991). The presence of friends has an adverse effect, especially on young males. Yet when driving with parents, young drivers modified their driving style, as they wanted to give the impression that they drove safely (Rolls et al., 1991).

### *1.9.1: Passengers and crash risk*

The increased risk of death from driving with peer group passengers was measured in a North American study (Chen et al., 2000). The risk of death clearly increased per extra passenger for drivers of sixteen and seventeen years old, as can be seen in Figure 1.5. For both sixteen and seventeen year olds, the risk of death doubled when taking three passengers compared with taking one. Importantly, the fatality risk from taking passengers increased irrespective of the time of day or sex of the driver; males fatality risk was slightly higher than females.

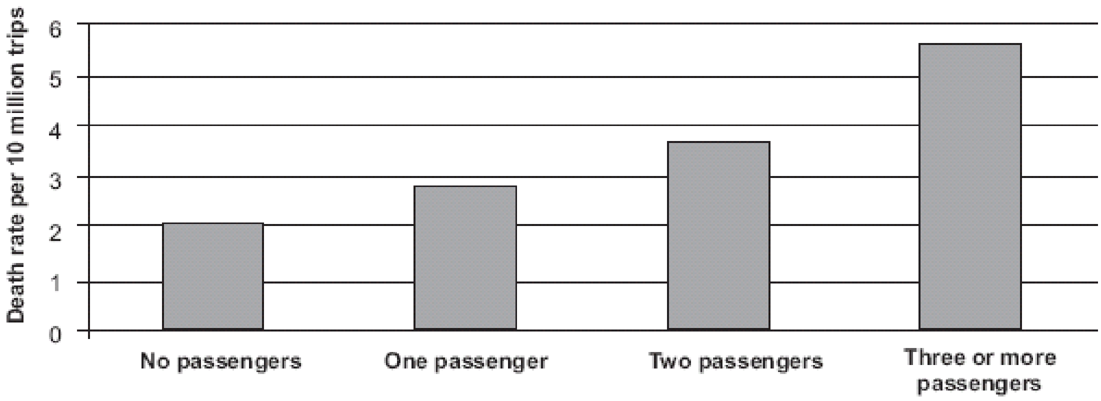



*Figure 1.5: Comparison of the death rate per 10 million trips for 16 and 17 year old drivers when driving with or without passengers (Chen et al.., 2000)*

Due to the evidence that passenger numbers and night time driving increase crash risk among young and novice drivers, this has been considered an important area for graduated licence schemes, as demonstrated by its recommendation for inclusion by the House of Commons Transport Committee (2007a) report.

### *1.10: Graduated licensing*

Graduated licensing aims to allow novice drivers to obtain necessary driving skills under conditions of low risk before moving onto more challenging driving tasks, whilst allowing drivers to mature both physically and psychosocially (Lam, 2003). Research has identified conditions in which novice drivers are more likely to be crash involved and graduated licensing aims to counteract the risk through restrictions, therefore giving drivers experience but under initial low risk conditions. This could be achieved, for example, by extending the period of supervised driving or restricting the number of passengers, alcohol allowance and night time driving (Senserrick & Haworth, 2004). There is no set plan to graduated licensing but it typically involves a series of restricted driving stages for up to three years with the aim of keeping crash risk to a minimum (Christie, 2001). Graduated licensing started in New Zealand and has gained popularity over the last fifteen to twenty years, specifically in North America, Canada and Australia (Mayhew & Simpson, 1996; Baldock, 2000; Begg & Stephenson, 2003). The flexibility of graduated licensing has made it very popular in applying it to suit different state laws in the Australia and USA, with all US states now incorporating at least one graduated licensing restriction (Williams, 2007). Simons-Morton (2002) has hailed the GLS as a modern classic social innovation due to its advantages, communicability, divisibility, compatibility and timing.

In Ontario, Canada, the system is fairly straightforward. After a written test, young drivers can drive a car as long as they are accompanied by an adult with at least five years driving experience. If they take a driver education course, they are eligible to take a road test after eight months. If they then pass a road test, for the next year they can drive alone as long as they have a blood-alcohol level of zero and have no more people in the car than there are seatbelts at all times. After a year of driving under these rules, young drivers can take a second road test for a full, unrestricted licence.

The Ministry of Transportation for Ontario has reported that collision rates for young drivers are down over thirty percent since 1994 (Mayhew & Simpson, 1996). Further, it is estimated that the cost savings to society after factoring in savings in property damage, emergency response and medical care, lost future earnings, and other factors was approximately US$60 million in just eighteen months (Smart Motorist, 2006). Similar results have been reported across North America with almost all evaluations showing crash reduction (Senserrick & Haworth, 2004). Crashes involving 15-19 year olds in Florida, Connecticut, Ohio, Pennsylvania and Michigan have all reduced, by up to twenty-five percent, since the introduction of Graduated Driver Licensing Systems (Shope & Molnar, 2003).

In the southern hemisphere, preliminary evaluations of South Australian GLS programs indicate that it has contributed to statistically significant reductions in fatality and serious injury rates among 16-19 year olds (O'Connor & Giles, 2000). Meanwhile in New Zealand, the introduction of a Graduated Driver Licensing Scheme has seen the rate of serious injuries and fatalities to 15-24 year-old vehicle occupants, nearly halve (Begg & Stephenson, 2003). The authors report that night-time driving and peer passenger restrictions have been the most influencing factors in these exceptional results (Begg & Stephenson, 2003).

Research is also claiming that public opinion of Graduated Licensing programs is good (Lin & Fearn, 2003; Waller, Olk & Shope, 2000). In Michigan, USA, around ninety-seven percent of respondents rated the GLS to be ‘good’ or ‘very good’. Meanwhile, in a literature review of GLS restrictions, Lin and Fearn (2003) state that contrary to expectations, research shows strong support for GLS programs from young drivers and parents. A more expected initial reaction was reported in Ontario when the GLS was first launched, with young drivers opposed to it as it toughened the licensing system (Smart Motorist, 2006).

The evidence that graduated licensing is a modern classic social innovation is therefore building. So why has it not been applied throughout Europe? Some countries are now realising the potential benefits, for example in Sweden and the Netherlands (Vagverket, 2000; Vlakveld, 2004). Sweden introduced an extended supervised driving period and found the average hours of pre-test training and practice increased from 47 hours to 118 hours. Once data was adjusted for socio-economic and other factors, collision rates for the first two years of solo driving were down forty percent compared to previous rates (Baughan & Simpson, 2002). However, results from a similar scheme in Norway are not so clear and the reasons for this are not fully understood (DfT, 2002). As noted in the context and rationale, it has been estimated that the introduction of a minimum supervised period of twelve months in the UK would reduce casualties by 6,000-7,000 (DfT, 2002).

Nevertheless, change is not always popular and European nations have possibly questioned the cross-cultural abilities of the graduated licensing. Overhauling the set up of a country’s licensing scheme is a substantial task involving change at all levels. But, as fatality rates of novice drivers fail to improve in the UK and other European countries, the requirement to implement a graduated style of licensing may become necessity. If graduated licensing continues to demonstrate reductions in collisions, injuries and fatalities, then policy makers will not be able to ignore the potential benefits of saving lives, many of which will be young lives.

Although evaluation results have been generally positive, some suggest caution must be heeded when viewing the reported casualty gains and that Graduated Licensing is simply delaying the crash risk (House of Commons Transport Committee, 2007b). This claim would appear to be substantiated as there has not been an evaluation to date that reports there has been a carryover effect after full licensure (Hedlund &

Compton, 2005). This means that drivers' crash risk is still heightened at whatever point they are given the freedom to drive unrestricted. Despite this, it is claimed that the reduction of casualties and the delay in full licensure achieved through Graduated Licence Schemes still makes them worthwhile (Hedlund, Shults & Compton, 2006).

## 1.11: Chapter One Summary

### *1.11.1: The problem*

After passing the driving test, almost one in five new drivers in the UK will be crash involved within their first year of driving. Young drivers are overrepresented in crash statistics and road crashes are the leading singular cause of death for people around the age of licensure, in the UK and worldwide. **The worldwide fatality trend of young drivers eclipses both culture and driver training methods, suggesting a human element in the learning to drive process that is currently not understood and more importantly, is being ignored.**

### *1.11.2: Age and experience*

Age and inexperience are factors that are almost impossible to separate as most novice drivers are also young drivers. This is not a problem as long as we appreciate a) the independent influence of both factors, and; b) the psyco-social context of being a 'young driver'.

**Research suggests that the effect of inexperience on drivers' initial crash risk is twice as important as age. Whilst age should always be considered as an important contributory factor, the larger role of inexperience suggests that our understanding of the psychological learning process is currently poor.**

### *1.11.3: Learning to drive in the UK*

The current licensing regime in the UK is widely acknowledged to be lacking, as demonstrated by the recent House of Commons Transport Committee (2007a) report. Drivers' crash risk is at its highest *after* they have passed their test, yet the current regime does not attempt to counter this in any way. **Change to the licensing structure in the UK is necessary and heavily supported, although what to change**

**to is of great debate. There is a need for scientific study that can help to guide the most appropriate course of action.**

***1.11.4: Supplementary driver training and education***

Driver education and training has often been seen as a tool with which to treat young/novice driver deficiencies in the hope of reducing casualty rates. Unfortunately, there is little or no evidence that education or training alone can fulfil this role, despite good intentions, however, this does not mean that it would not have a place as part of a more multi-faceted approach.

**It would appear that simply increasing novice/young drivers' skill and/or knowledge level is not related to reducing their crash risk. If it is not the skills of how to drive or the knowledge of how to drive safely that are deficient, the question therefore remains, what are novice/young drivers' lacking?**

***1.11.5: Young drivers in a social context***

It could be that the influence of young/novice drivers' wider context places them beyond the realm of intervention. It is important to recognise that parents and peers have a part to play in shaping drivers' attitudes and driving behaviours. It is also important to realise that the combination of youth and/or driving inexperience mixed with alcohol, drugs, sensation seeking, risk taking and over confidence is lethal, as supported by research.

**Research has identified important influences that all increase young/novice drivers' crash risk. These factors must be appreciated as the wider context of research into the current topic. Nonetheless, that increased crash risk is inherent in novices of all ages and not simply young novices suggests that there is still more that needs to be understood.**

***1.11.6: Crash analysis and Graduated licensing***

Analysis of the types of crashes that young/novice drivers are involved in allows an insight into potential ways of counteracting problem trends. Research suggests that novice drivers are most at risk during certain times of the night and when carrying passengers. As a result, Graduated Licensing Schemes often incorporate these areas into their design.  Graduated licensing evaluations have shown some encouraging results in Australia, New Zealand, Canada and USA (O'Connor & Giles, 2000; Begg & Stephenson, 2003; Mayhew & Simpson, 1996; Shope & Molnar, 2003).  European countries appear to be showing interest in the potential of these licensing methods (Vagverket, 2000; Vlakveld, 2004).

**Graduated licensing has shown early promise and yielded several impressive casualty savings.  Evaluations suggest that some of these savings are due to the restrictions on passenger and night time driving (Begg & Stephenson, 2003). However, there is recent suggestion that much of the gain is due to the delay of full licensing and that drivers still have a high crash risk when they graduate. This needs to be better understood and a greater understanding of the psychological process of how a person learns to drive may help.**

### 1.12: The current thesis

On the basis of the key points noted above, the current thesis aims to address the knowledge gaps identified.  To do this the following journey will be undertaken:

**Chapter Two** … looks to dissect driver behaviour and understand it through an appropriate driver behaviour model.  Understanding driving from this perspective allows for investigation of how driver behaviour is constructed. Discussion of literature which has led to the formulation of modern theories of driver behaviour demonstrates both clues regarding the psychological nature of driving and further gaps in our understanding.

**Chapter Three** … details a quantitative study aimed at providing support for the driver behaviour model selected and detailed in Chapter Two.  The results provide interesting scope for further discussion and research.

**Chapter Four** … discusses the theoretical impact of the findings from the study in Chapter Three and investigates a new angle from which to view driving behaviour.  Discussion of literature out-with the realm of driving provides intrigue when placed alongside some historical driver behaviour research.

**Chapter Five** … details a quantitative study aimed at investigating the theoretical concepts discussed in Chapter Four.

**Chapter Six** … details a quantitative study that sought to build on the results from Chapter Five. The results provide potential insight to the psychological nature of the novice driver problem.

**Chapter Seven** … summarises and concludes the theory and results in the overall context of the thesis topic and discusses the potential implications.

# Chapter Two

## Modelling driver behaviour: The search for a suitable model

## Chapter Two Outline

## 2.1: Introduction

The aim of Chapter One was to explore and contextualise the problem of young and novice driver crash rates. In doing so, many influences on a driver were noted and gaps in our understanding were highlighted. To investigate these gaps, Chapter Two further discusses the psychological nature of the problem, with the aim of exploring if a driver behaviour model can provide the framework from which to conduct further research. Certain criteria were considered essential for a model to provide such a framework. First, as driving behaviour continually evolves due to technological advances, it is important that a model is up to date and grounded in current literature. Second, the model should be adaptive enough to accept and integrate a multitude of influences on a driver, which as discussed in Chapter One, can be important crash risk determinants. Third, the model should provide the potential to explore new areas of driver behaviour that are not yet understood.

When exploring driver behaviour models, achieving the first of these criteria is immediately problematic. As can be seen in Table 2.1, the mainstream publication of driver behaviour models became fashionable in the 80's although it appeared to subsequently lose popularity. For a full list of the models included here see Appendix 2A.

*Table 2.1: Number of published theoretical models applied to driver behaviour by decade [adapted and updated from Vaa (2001a) and Summala (2005)]*

| Decade of publication | Number of models published |
|---|---|
| 1938 | 1 |
| 1960-1969 | 2 |
| 1970-1979 | 2 |
| 1980-1989 | 11 |
| 1990-1999 | 1 |
| 2000-2007 | 3 |

In order to satisfy the first criteria the three models published since 2000 will be evaluated in depth. However, the work published before this time is far from worthless and provides the context in which the more recent models developed.

As driving is a unique and complex behaviour, traditional psychological models, not specific to driving, struggle to fully explain the processes involved. Conventional psychological debates like nature versus nurture are not so pertinent in the realm of driving behaviour. Humans have not evolved to drive. It has been very difficult, therefore, to categorise driving behaviour and apply a relevant model from within traditional psychology, although there are some exceptions. Social psychological models, like the Theory of Planned Behaviour (Ajzen, 1985, 1988), continue to be applied to driving behaviour and have demonstrated some relevance (Parker, Manstead, Stradling & Reason, 1992; Parker, Stradling & Manstead, 1996; Elliott, Armitage & Baughan, 2003; 2005), however, the theory is criticised for lacking ecological validity as studies often measure reported behaviour rather than actual behaviour (Rothengatter, 2002). Nevertheless, no driver behaviour model to date has provided a satisfactory explanation either. Carsten (2002) states that a lot of energy has been wasted in creating complex descriptive models which often state little more than human behaviour is not straightforward and that a lot of factors influence it.

Carsten's (2002) perspective might be interpreted as a sigh of frustration at the lack of progress made in creating an all encompassing model, although reviews of driver behaviour modelling are more optimistic. Rothengatter (2002), Vaa (2004) and Summala (2005) all suggest that by learning lessons from the models of the past, modelling driver behaviour has a future. They all agree that researchers need to accept that a multi-faceted approach is required and that research into individual areas can provide critical input to advise other fields. This chapter therefore rejects structuring the discussion of driver behaviour models by traditional psychological approach headings (e.g. social, cognitive, etc.) and instead discusses the evolution of driver behaviour modelling, summarising the key influences to our current understanding. There are important aspects that can be extracted from some of the historical models and some that have been the cause of great debate.

## 2.2: Early driver behaviour modelling

### *2.2.1: Wilde's (1982) Risk Homeostasis Theory*

Possibly the most contentious model published is that of Wilde's Risk Homeostasis Theory (RHT) or Risk Compensation model (Wilde 1982, 1988), later re-branded the target risk theory (Wilde, 1994). Gerald Wilde was still prompting debate about this model twenty years on, despite some fierce criticism (Wilde, Robertson & Pless, 2002). Evans (1986) commented that the theory demanded as much respect as the flat earth hypothesis. O'Neill and Williams (1998) further quote Evans (1986, p81) summary of the theory:

> "…there is no convincing evidence supporting it and much evidence refuting it"

They additionally note that Haight (1986) called this summation 'generous'. Nevertheless, there are elements of the model that are worthy of discussion.

The basic proposal of RHT is that our driving behaviour is governed by a target level of risk that we strive to maintain. Our intuitive assessment of risk is based on overall population accident rates and thus sharpened through our experience, the experience of others and the mass media (Wilde at al, 2002). Through this learnt knowledge, our decisions will be given feedback regarding whether they are in line with the overall target level of risk. Therefore, if driving in general was seen to become safer, a homeostatic reaction would be that drivers' risky driving behaviours would increase, maintaining accident rates overall (see Figure 2.1). Wilde argues that studies which have evaluated the safety impact of new safety measures (i.e. airbags) and found a change in driver behaviour (i.e. more aggressive driving) demonstrate that the average driver is altering his/her behaviour to maintain a holistic level of risk homeostasis (Peterson, Hoffer & Miller, 1995; Wilde et al., 2002).

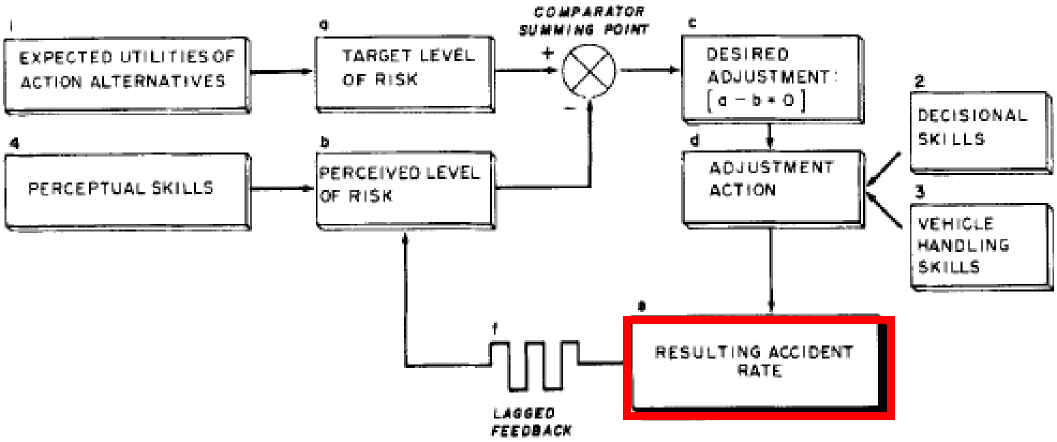



*Figure 2.1: Wilde's Homeostatic model relating accident rate to driver behaviour (Wilde, 1982)*

One criticism of Wilde's work is his selective use of evidence for the theory. For example, whilst one study found drivers with airbags drove more aggressively (Peterson et al. 1995), there are six others that did not find any risk compensating behaviours (see Sagberg, Fosser & Saetermo, 1997). Further, it is refuted that drivers can calculate their risk within the overall accident rate of a population (see highlight in Figure 2.1). It is questionable whether drivers possess the required knowledge and judgement to be able to feedback accurately to their perceived level of risk. For example, just as humans erroneously determine their odds in a casino (Wilde et al., 2002), drivers are useless at mentally calculating distances required to pass a vehicle safely in a laboratory study (Robertson, 1983) or when calculating the time savings of driving similar distances at different speeds in a questionnaire (Fuller, Gormley, Stradling, Broughton, Kinnear, O'Dolan & Hannigan, 2008b). Wilde's (1982) theory therefore fails to convincingly explain the psychological process of determining perceived risk and how it feeds back into drivers' decision making process.

Nevertheless, positive elements can be extracted from Wilde's (1982) model. First, there is the structure of the model involving a feedback loop that involves a perception of risk; an area for the decision making process (summing point comparator) and the behavioural response. This is a novel concept and although the structure is criticised by some for remaining unsupported (Michon, 1989), it has not been invalidated either. Second, the idea that behavioural adaptation is used to maintain some homeostatic process appears sensible, although Wilde's explanation of this process seems inadequate. In support of this, there is still debate about drivers' risk compensating behaviour to new safety equipment and this is an important area that needs to be understood (Risk Compensation is discussed further on page 47). Finally, an expanded model of RHT can be seen in Figure 2.2 and demonstrates that Wilde (1982) has appreciated the many external influences on drivers' behaviour from distant underlying variables to momentary influences. External motives for drivers have been shown to be important and do appear to affect accident involvement (Hatakka, Keskinen, Gregersen, Glad and Hernetkoski, 2002). It is unfortunate, therefore, that Wilde has not addressed and updated the areas of the model that have faced key criticisms.

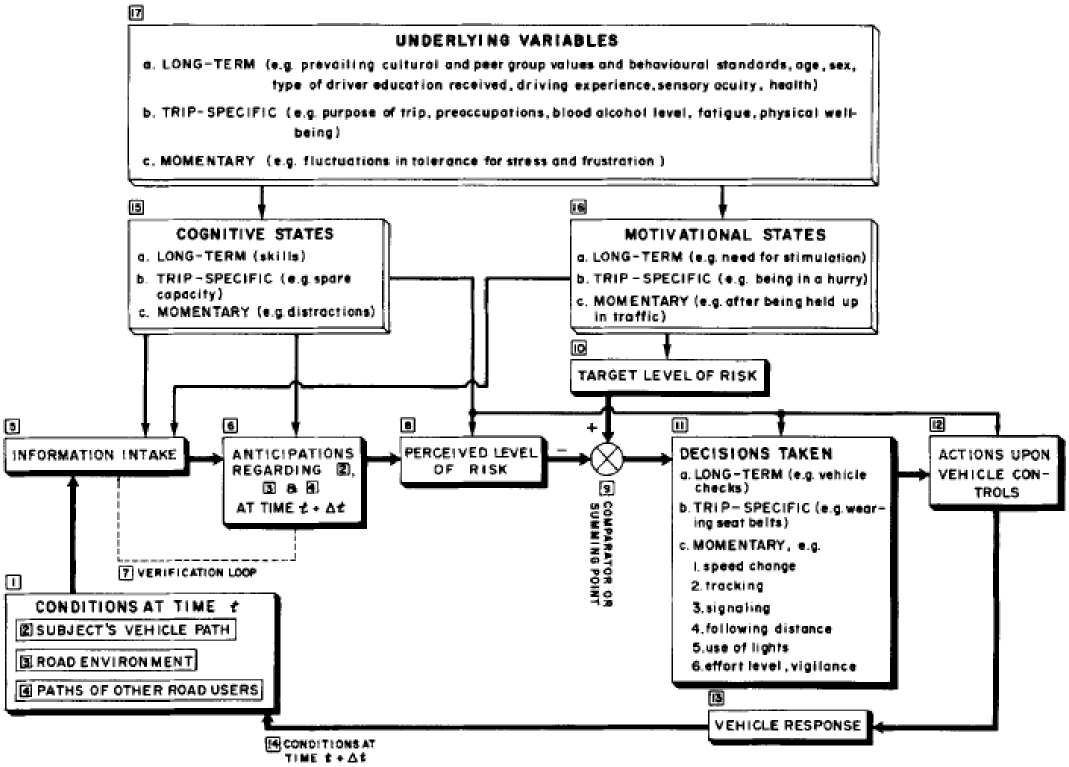



*Figure 2.2: A task analysis model of driver behaviour from Wilde (1982)*

### *2.2.2: Naatanen and Summala's (1974) Zero-Risk Theory*

Whilst Wilde argued a feedback mechanism that was homeostatically controlled by an overall target level of risk, Naatanen and Summala (1974) proposed that drivers drive for much of the time, with no feeling of risk. The 'zero-risk' theory is so called because it is postulated that under normal driving circumstances drivers do not feel risk until their safety margin is violated, when a 'subjective risk monitor' will inform their decision making processes to take action (see Figure 2.3) (Summala & Naatanen, 1988). It is purported in the model that 'with repeated confrontations, drivers adapt to situations which at first elicited a 'risk response' and drive most of the time with overlearnt [*sic*] habitual patterns based on safety margins, with no concern for risk: hence the label 'zero-risk theory'' (Summala, 1996, p104). The model therefore differs from Risk Homeostasis Theory in that whilst RHT suggests drivers constantly adjust their driving due to risk, according to the zero-risk model, drivers only begin to adapt their behaviour once perceived risk exceeds drivers' threshold. The rest of the time, a driver is driving to automated learnt procedures.

The creation of a 'subjective risk monitor' is central to the zero-risk theory, although it is essentially a theory of driver decision making with motivational influences (Ranney, 1994). In this regard, similar to Wilde's (1982) model, the authors have again seen the importance of including the many external influences on drivers' behaviour and of an information-processing feedback loop.

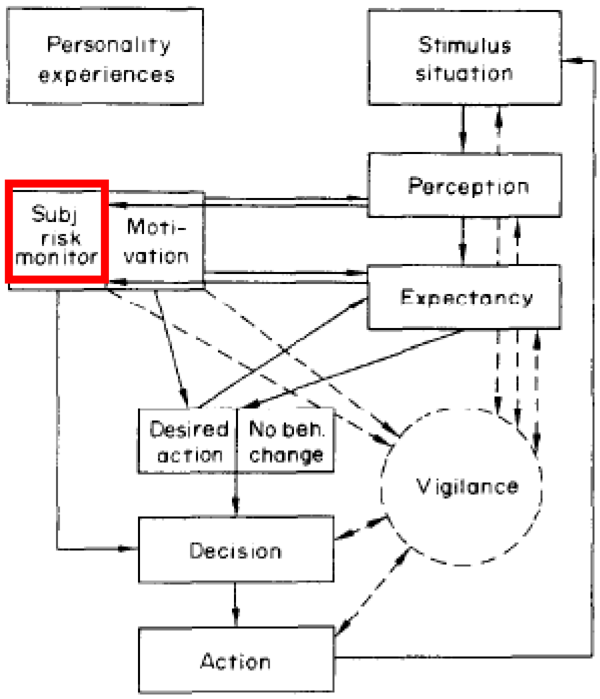



*Figure 2.3: Graphical representation of the zero-risk model (Summala & Naatanen, 1988)*

### *2.2.3: Influences on Risk Homeostasis Theory (Wilde, 1982) and Zero-Risk Theory (Naatanen and Summala, 1974)*

Another similarity between Risk Homeostasis Theory and the zero-risk model is that they were influenced by the same research context. Studies in the late 1950's and early 1960's had begun using skin conductance to measure autonomic physiological changes which can signify anxiety, arousal and emotional activity (a discussion of skin conductance can be found in Chapter Four, page 139). Hulbert (1957) and Michaels (1960) reported that drivers demonstrated distinct measurable skin conductance and resistance responses (SCRs and SRRs respectively) when driving and that they occurred relatively frequently. In Michaels' (1960) study, it was reported that a 'high proportion of them occurred in response to observable traffic events, greater responses being shown to potentially more serious interruptions to the drivers travel.' (Taylor, 1964, p440). These studies provided the first evidence that there were psychophysiological reactions to driving events and suggested that feelings of anxiety and arousal may have a role to play in mediating driver behaviour.

Expanding on these studies, Taylor (1964) measured the level of skin conductance over the duration of several journeys. Taylor (1964) reported supporting Michaels' (1960) results that observable traffic hazards were related to increases in SCRs, but he also reported that the distribution of skin conductance level per unit distance travelled was similar to the distribution of accidents per unit total distance of vehicle travel (i.e. the accident rate for the driven route). Taylor (1964, p449) therefore suggested that,

> "The idea that drivers adopt a level of anxiety that they wish to experience when driving, and then drive so as to maintain it, could perhaps be used to influence their behaviour."

From this, it is possible to appreciate the influence these findings had on Wilde's (1982) theory of Risk Homeostasis. However, the concurrent finding that SCR were also related to observable hazards on the road can also be seen to be the inspiration for Naatanen and Summala's (1974) zero-risk model.

### *2.2.4: Critique of Risk Homeostasis (Wilde, 1982) and Zero-Risk (Naatanen and Summala, 1974)*

Whilst debate has raged over Wilde's (1982) model and his view of risk perception, criticism of Naatanen and Summala's (1974) work was the lack of well-formulated mechanisms that could provide testable hypotheses (Hoyes & Glendon, 1993; Ranney, 1994). For example, how can a driver determine that a threshold has been exceeded if they are not constantly assessing risk (Vaa, 2001a; Rothengatter, 2002)? Therefore, whilst the structure of the model is logical, the explanation of how risk is processed and evaluated remains questionable and somewhat unsupported. In fact, much of the reason for the apparent stagnation of 'motivational' driver behaviour modelling in general was the lack of testable hypotheses and developed processes (Ranney, 1994).

Motivational models like RHT and zero-risk theory focus on what drivers actually do and what has influenced them to behave in such a way. This is in contrast to the original spotlight in driver behaviour which focussed solely on what caused accidents and how to stop them (Ranney, 1994). Motivational models, therefore, tackle driving as a whole and emphasise that at any one time there are many influences on a driver. Whilst these models would appear to offer the best overall explanation to understanding driver behaviour, such modelling has been hampered by a lack of clear research that can support it and an inability to test predictions. A further reason offered, however, is that debate surrounding Wilde's (1982) theory of risk homeostasis has dominated debate and stalled progress (Janssen & Tenkink, 1988).

### *2.2.5: Other approaches to modelling driver behaviour*

Other approaches to modelling driver behaviour include proxemics and hierarchical modelling. Along with the zero-risk model, Summala's (2005) further work on time margin and available time for action was influenced by the proxemics work of Gibson and Crooks (1938). Similar to Hall's (1966) concept of personal space, Gibson and Crooks (1938) proposed a safety zone idea when in motion that includes a 'field of safe travel' and a 'minimum stopping zone'. These zones are obviously determined by the driver and include the complex calculation of time-to-collision. In essence, the proxemics approach highlights the importance of appreciating that humans must calculate a safety margin around them at all times and much of that time, when in motion. As Vaa (2001a) points out however, it does not explain the process of how drivers may make these crucial calculations.

Hierarchical modelling generally attempts to distinguish functional levels of driving behaviour (Jansen, 1986; Van der Molen & Botticher, 1988; Michon; 1989; Summala, 1997). For example, Summala (1997) distinguishes three functional levels: (i) strategic planning of journey and route; (ii) tactical performance of manoeuvres; (iii) low-level operational vehicle control. The advantage of displaying driver behaviour on different levels is not clear, which has led to criticism (Rothengatter, 2002). It is argued that even though certain tasks can follow on from one another and that one can influence the other, this does not necessarily imply that one is above or below another in importance. Rothengatter (2002) states that by introducing a hierarchy, it is assumed that all lower level tasks must be completed before higher level tasks can be performed. As alluded to in Chapter One, driving is a complex behaviour and models that represent it are likely required to be more flexible than a hierarchical model would permit.

### 2.3: Risk compensation

As noted in the previous section, Wilde (1982) based his theory of risk homeostasis on the assumption that drivers alter their behaviour in order to compensate against a rise or fall in experienced risk. In support of his ideas and central to the great debate was the notion of 'risk compensation'. Risk compensation has been defined as 'behavioural adaptation to a perceived lower risk situation, especially when the lower risk is brought about by an accident countermeasure' (Assum, Bjornskau, Fosser & Sagberg, 1999, p545). In essence, it is argued that when vehicles or roadways are made safer, drivers will take advantage of the safer conditions and increase a direct or indirect risky driving behaviour, for example, by increasing their speed or reducing their attention (Hedlund, 2000). The change in behaviour would therefore compensate for the intended safety benefits of the accident countermeasure. It is, however, a far more complex arena of research than this simplistic definition would suggest.

Along with Wilde's (1982) theory, the origins can be traced to Peltzman's (1975) review of automobile safety regulations in the USA and Adams' (1982) review of seat belt legislation in the UK. Both reports surprisingly concluded that improvements in vehicle safety had not brought about a reduction in overall traffic fatalities. Adams (2007) continues to argue that there is no evidence of seat belt laws being effective and seeks for them to be repealed. The overall effectiveness of road safety legislation and the statistical methods utilised to measure effectiveness have been the main source of the debate (see OECD, 1990 and Hedlund, 2000 for reviews). For example, a met-analysis of literature published on drink-driving prevention from 1960 to 1991 identified 6500 pieces of work of which only 125 passed minimal standards of scientific quality (Wagenaar, 1999). This therefore confuses the literature and makes extracting overall trends difficult. The current thesis, however, is not concerned with entering into the risk compensation debate of effective legislation; rather it seeks evidence of the psychological processes that operate when people drive. In this respect, the risk compensation literature can provide some intriguing insight. The discussion here therefore focuses on primary effects on drivers' behaviour and not wider secondary attitudinal influences that are also discussed within the literature (see OECD, 1990)

Instead of analysing overall crash statistics, another way of determining whether drivers compensate for a change to their environment is to measure the difference an independent variable makes to drivers' behaviour. Hedlund (2000, p84) summarises that studies like these 'typically find no effects for measures to protect occupants in the event of a crash (such as seatbelts) but may find effects for measures that attempt to prevent crashes by improving vehicle performance (such as better brakes or tyres).' Examples include Rumar, Berggrund, Jernberg and Ytterbom (1976) who reported on the safety benefits of driving in Sweden with studded tyres, whereby they offered greater traction to the road. They found that drivers of cars with studded tyres drove faster than drivers using conventional tyres which somewhat negated the safety benefits. Similarly, research into the safety benefits of Anti-lock Braking Systems (ABS) found that drivers with ABS drove with shorter headways than drivers without (Sagberg et al., 1997). Further, analysis of the installation of road lighting in Norway also found that once installed, drivers increased their speed and decreased their concentration which compensated for the safety benefits of lighting the roadway in the first place (Assum et al., 1999). Due to results like these, risk compensation has also been termed 'behavioural adaptation'.

As Hedlund (2000) noted, behavioural adaptation is not found in response to all safety measures. The majority of studies on the introduction of airbags conclude that the airbags were not found to have any significant effect on driver behaviour (Sagberg et al., 1997). The question this phenomenon therefore raises is: why do some accident countermeasures demonstrate a change in driver behaviour whereas some do not?

The answer to this would seem to involve understanding driver behaviour as a whole, as simple alterations in a driver's environment, not just safety changes, can also cause behavioural changes. For example, drivers' estimation of speed can be altered by the level of internal car noise (Horswill & McKenna, 1999; Evans, 1970a,b). Meanwhile, the speed at which drivers chose to drive can be influenced by minor alterations to road width on a simulator (Lewis-Evans & Charlton, 2006). Further, it is also reported that drivers will pull out into smaller gaps between vehicles when driving a vehicle with increased acceleration (Evans & Herman, 1976). The question is not simply 'what accident countermeasures cause behavioural adaptation?', it is more appropriate to ask: what is the difference between factors that alter driver behaviour and factors that do not?

Lund & O'Neill (1986) argue that the difference between factors that will influence drivers' behaviour and those that will not, is perceptual and sensory feedback. ABS, studded tyres, internal car noise, road width, acceleration and lighting are all factors that will influence direct sensory feedback about immediate conditions to the driver. Conversely, airbags give no direct feedback to the driver about current driving conditions. Similarly, seatbelts, which also do not give sensory feedback of the current driving environment (under normal conditions), also do not appear to influence drivers' behaviour (Evans, 1991; Lund & Zador, 1984), although the seatbelt debate is complicated as putting on a seatbelt gives feedback regarding general safety (Adams, 2007). It would appear reasonable to assume that factors which do not give the driver any sensory feedback about current driving conditions would have little influence over their immediate behaviour. However, the converse of that is to appreciate that factors which do feed back to the driver will therefore alter their behaviour. If this reasoning is to be considered then there would be important implications for driver modelling.

Without a change in behaviour to accident countermeasures such as airbags, Wilde's (1982) theory appears flawed, as many have already noted (Evans, 1986; Haight, 1986; O'Neill & Williams, 1998; Wilde et al., 2002). In addition, if sensory and perceptual feedback influences behaviour then one must consider a feedback loop as being an essential component of any driver behaviour model. If such feedback really influences drivers' behaviour then it is critical that the psychological processing of such feedback is understood, which at present it is not. Despite the initial insight given by Hulbert (1957), Michaels (1960) and Taylor (1964) and their skin conductance studies, no model prior to 2000 had gone beyond suggesting that subjective risk was important. Attempting to explain how subjective risk is processed and how it influences drivers' behaviour is still to be understood.

### 2.4: Defining risk

Before exploring how subjective risk might be processed, it is important to clarify what is actually meant by 'subjective risk' and how this might relate to, or differ from, objective risk. Objective risk has previously been defined using a common dictionary definition (Brown & Groeger, 1988). In this regard it is essentially the ratio between some measure of unwanted consequences versus some measure of exposure to the situations under which the unwanted consequences are possible. A further dictionary definition of 'objective' could also be utilised however,

"relating to external facts, as opposed to internal thoughts or feelings"
(Chambers 21st Century Dictionary, 1996, p943)

In comparison, 'subjective' is defined as:

"based on personal opinion, thoughts, feelings, etc"
(Chambers 21st Century Dictionary, 1996, p1405)

Appreciating the difference in definitions is important because the clarity between the two concepts of risk can become murky when discussed in driver behaviour literature.

Traditionally, objective risk is relatively straightforward. External facts regarding the number of crashes, injuries and deaths per year are annually published (see DfT, 2007a as an example). These statistics are often measured across the number of drivers in a certain sub group (i.e. young drivers) or by number of miles driven, which gives an indication of the objective risk of being crash involved, injured or killed when driving. Despite the publication of such statistics, knowledge of them is low and drivers' ratings of their chances of being crash involved are vastly inaccurate (Groeger & Brown, 1989; McKenna & Crick, 1992). There is therefore a distinction between actual objective risk and drivers' perception of their objective risk.

A person's perception of his/her objective risk is actually a personal opinion. By the definitions given above, these views are therefore actually subjective risk estimates of the objective risk of driving. An individual's subjective judgement of objective risk can only be based on what he/she personally knows and by the proportion of times a particular behaviour has resulted in a negative consequence. Unlike the objective risk established from official fatality figures, drivers are more likely to rely on experience of undesirable consequences such as feelings of danger, discomfort, property damage, injury or delay (Groeger & Brown, 1989). Subjective risk estimates of objective risk on the road are therefore more important when modelling driver behaviour than actual objective risk itself, however, this confuses the matter of defining what exactly subjective risk is.

To clarify this situation, subjective risk has been defined in two forms. First there is the definition, already given, of a 'subjective risk estimate'. This is a driver's cognitive judgement about the objective probability of being crash involved (Fuller, 2005a). For the remainder of the thesis, this will be referred to as drivers' 'objective risk estimate'. Second, there is 'feeling of risk' which refers to the experience, sensation and perception of risk or potential risk elicited by circumstances in a driver's environment. This clarification of definitions has been noted by several authors (Haight, 1986; Summala, 1986; Fuller 2005a). Groeger and Brown (1989, p156) explain how the interaction of these definitions of risk are important in understanding driver behaviour:

> "Feelings of subjective risk are generated by the driver's assessment of the objective risk [estimate] associated with a particular situation and the driver's assessment of his/her ability to avoid these undesirable consequences"

This process is often termed ‘Risk Perception’ or ‘Hazard Perception’ and is an important higher order skill required for safe driving.

**2.5: Hazard perception**

Acknowledging the sensation of something risky in the driving environment is essentially the same as stating that a potential hazard has been perceived. Hazard perception is a key task in driving as avoiding collision could be argued to be the primary task when controlling a vehicle. Like Groeger and Brown (1989), Deery (1999) states that hazard perception involves two elements: driving skill and subjective experience (see Figure 2.4). In his model of the process of drivers’ response to hazards, it can be seen that once a hazard has been acknowledged, these two elements are weighed up before the outcome behaviour is produced. What can also be seen in the model is a list of bullet points denoting where novice drivers are different from experienced drivers. These points are based on research that suggests novice drivers have much inferior hazard perception skills when compared to more experienced drivers (Mayhew & Simpson, 1995). Such skills include detecting, recognising and dealing with hazards; attending to the right things at the right time; dealing with multiple tasks; and matching one’s actual skills with the demands of the task (Deery, 1999).

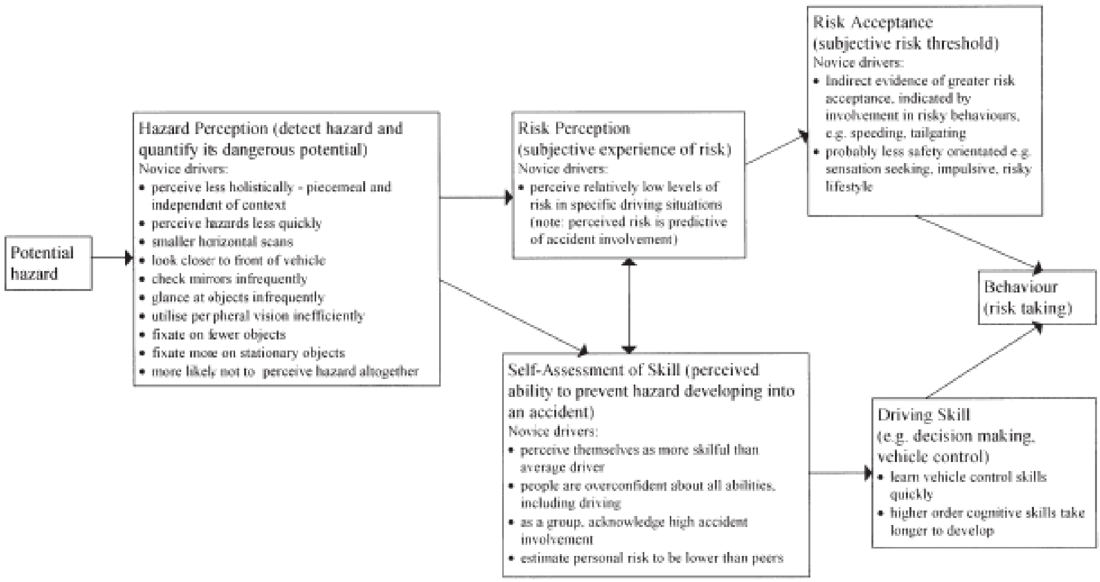



*Figure 2.4: Model of hazard perception process (Deery, 1999)*

It has been further reported that young drivers are relatively poor at identifying distant hazards, although they score similarly to older drivers when identifying near hazards (Brown, 1982). This finding is supported by research into visual scanning strategies which finds that novice drivers display a smaller range of horizontal scans of the road environment; check their mirrors less often; fixate on fewer objects and fail to use peripheral vision to their full advantage (Mayhew & Simpson, 1995; Underwood, 2007). It is suggested, therefore, that novice drivers see hazards on the road less holistically and concentrate on obvious danger rather than potential danger (Milech, Glencross & Hartley, 1989; Deery, 1999; Rundmo & Iversen, 2004). In addition, novice drivers have also been found to be slower to notice potential hazards and more likely to actually fail to notice them at all (McKenna & Crick, 1997). This would consequently appear to be a key area when investigating the plight of novice drivers. If experienced drivers are better than novice drivers then this would suggest it is a learned development. Understanding the way that subjective risk is processed may therefore provide insight into the processes that underlie the learning of hazard perception.

### 2.6: Overestimated ability

Whilst hazard perception would seem to be a crucial element for the study of young/novice drivers, another related element could be equally as important. In Chapter One it was noted that over-confidence in ability was an important influence on young/novice driver crash risk (see page 28). Brown (1982) refers to this over confidence in ability and suggests that it can almost completely explain young drivers' overrepresentation in crashes. Whilst all drivers rate themselves better than the average driver (Waylen, Horswill, Alexander & McKenna, 2004), young and novice drivers' overconfidence is more likely to lead to riskier behaviour (OECD, 2006). The reason behind over-confidence is believed to be a lack of maturity in young drivers and a licence system that rewards the mastery of basic driving skills for novices. McKenna (1993) found that overestimated ability was due to an 'illusion of control' rather than simply being optimistic and assuming one to be lucky in dangerous circumstances.

This overestimation leads to a lack of calibration between drivers' objective risk [estimate] and subjective risk [feeling of risk] (Kuiken & Twisk, 2001). When a hazardous situation develops on the roadway, it places demands on drivers' abilities inappropriate for their actual skill level. Gregersen (1996) demonstrated this phenomenon whereby young drivers in Sweden were given training in a Skid Car to improve their car handing skills in critical situations. This group of drivers became more confident in their overall driving ability yet their on-the-road driving skills were no better than another group of drivers who had not received the training. In contrast, the second group in the study had received 'insight training' which focused on making the driver aware of the fact that his/her own skills in braking and avoidance in critical situations may be limited and unpredictable. These drivers had a much better calibration between their rated and actual driving skill than the drivers who had been trained with car handling skills. With regards to the current chapter, it is therefore important that any model of driver behaviour can include, adapt and demonstrate the difference between a drivers actual and perceived ability.

## 2.7: Driver behaviour modelling – post 2000

### *2.7.1: A theoretical model of responding to risk on the road (Grayson, Maycock, Groeger, Hammond and Field, 2003)*

Based on the significance of the risk and hazard perception literature, research was funded by the Department for Transport in the UK to establish a better understanding and the relationship with crash involvement. Unlike traditional models of driver behaviour, Grayson et al.'s (2003) model is a simple four part model aimed at offering insight into the way drivers respond to risk. Despite not being a holistic model of driver behaviour, it is considered here due to the significance of informing how drivers process risk. The basic tenet was the proposal that drivers differ in accident liability due to differing abilities at an individual level. It was therefore assumed that the way a driver responded to risk would ultimately inform of their accident liability.

The four components to be tested involved Hazard Detection; Threat Appraisal; Action Selection and Implementation. Grayson et al. (2003, p3) succinctly describe the interaction of these four components:

> ‘the model starts with the necessary component of detecting that a hazard is present, and where failure to detect the hazard will have the consequence of increasing risk to potentially serious levels. Having detected the hazard, the driver needs to appraise the threat in the hazard, for example, whether it is seen as something requiring corrective or evasive action, or as something that might even be regarded as a challenge.
>
> Once a driver has decided that a hazard must be responded to, there is the need to decide what response is appropriate in the circumstances. Finally, even if the correct course of action is selected, the driver must implement that course of action correctly. Detecting a hazard, assessing it correctly, and selecting an appropriate course of action will still not avoid a potential accident situation if the skills required for that course of action are not available.’

Each component was initially explored using a specialised Computerised Assessment of Driving Skills (CADS) which incorporated a battery of tests. A sample of 404 drivers completed tests for all four components. The measures of Hazard Detection included judgements of traffic scenes, spatial reasoning and decision making. For Threat Appraisal there were ten separate measures involving personality, impulsiveness, and driving style. Action Selection tests involved Raven’s Matrices, reaction times and verbal reasoning. Meanwhile, Implementation tests included tracking, co-ordination, visual and auditory skills. In addition to these measures, the researchers collected background information of driving experience and accident involvement.

Based on the CADS results, an on-the-road behavioural assessment was carried out on a representative sample of one hundred of the original participants. Participants drove their own cars and were observed during a sixteen kilometre (10 miles) drive by a former driving instructor. As a further supplement to the CADS results, a questionnaire was carried out, although a disappointing 1,375 responses from an initial sample of 10,000 drivers were returned.

The overall results of these combined measures found the model to demonstrate statistical integrity and reliability. A further significant finding was that there were clear links between the CADS results and the on-the-road study, which was further related to the accident data elicited from the survey which added validity to the model.

The results of the laboratory section of the study demonstrated that the four stages of responding to risk were strongly inter-related. Another key finding was that the majority of the model variables were of a general psychological nature rather than driver skill based. The results from the on-the-road study were particularly intriguing. There was evidence that speed choice was a consistent trait in that someone who drives faster or slower than average on one type of road will do it on all roads. However, it was younger and less experienced drivers who demonstrated this pattern most consistently, suggesting a lack of differentiation between road types. Young and inexperienced drivers who drove fast were also found to be poor at setting appropriate speeds for the conditions, a problem not noted for experienced drivers. Furthermore, multivariate analysis also demonstrated that experience was more important than age in explaining differences in on-the-road speeds. This would therefore support the evidence presented in Chapter One, that driving experience is more influential than age at reducing drivers' crash risk.

Grayson et al.'s (2003) study was a large scale multi-institutional piece of research. As such, considerable academic and research experience was used in incorporating strong methodological techniques and powerful statistical analysis. The results are important in demonstrating that how drivers interact with hazards on the road is essentially linked to their overall driver behaviour and accident liability. However, the model itself is somewhat limited in discussion of any further or external influences over drivers' behaviour, hence it does not satisfy the second criteria outlined in the introduction of this chapter (see page 39). The authors suggest the results be used to develop driver assessment procedures based on the CADS test battery. While this would be a valid extension of the report, it does not offer a route from which to further explore the psychological nature of driving or learning to drive and therefore does not fit with this chapters third criteria either. Therefore, while the results of this work are appreciated and acknowledged in the current thesis, it is worth considering other recent driver behaviour models.

### *2.7.2: The Monitor model (Vaa, 2004)*

Between 1998 and 2002 the Norwegian Research Council and the Norwegian Public Roads Administration funded the Institute of Transport Economics (TOI) to research and report on ‘Driver Behaviour Models’. The reasons for the research were threefold: first, that there has been a lack of satisfactory driver behaviour models; second, there is much disagreement regarding the theoretical basis for understanding driver behaviour and third, that there is a lack of detail of the information processing and decision making involved in the driving task (Vaa, 2001a). Addressing these issues was ambitious but the work led to the formation of a model based on the best ideas of previous models and modern neurological research. It would also appear that the project led the researchers to build driving behaviour from its foundations.

There is an emphasis on human evolution within the published papers of the project (Vaa, 2001a,b; 2004; 2005). It is argued that survival is mankind’s most inherent motivation and in order to survive, we have developed information processing systems that can adapt to changing environments. The car, being a relatively recent addition to the human environment in evolutionary terms, has brought with it a two-sided adaptation. Whilst a human must adapt their evolved processes in order to simply control a car, the car itself is extending the organism and eliciting propensities in humans that may otherwise have been hidden or repressed (Vaa, 2005). Road rage towards strangers, the feeling of status and the expression that a car allows are all examples of how the car extends the organism. In fact it has been reported that one sixth of drivers have actually used the car to frighten others and have accelerated when a pedestrian enters a pedestrian crossing (Varhelyi, 1996). Meanwhile, Vaa (2000) reports of cases whereby drivers have used the car as a weapon to either hurt or kill people or themselves, therefore, the integration of the car and the human could be considered somewhat of a mismatch. However, when the number of humans killed in road crashes is compared to the distance driven, it becomes clear that, in fact, humans have adapted relatively successfully to the car. Estimations suggest that of six people driving 14,000kms each year for 65 years, only one will experience a single injury accident (Bjornskau, 2003). This being the case, it is evident that the evolved processes utilised when driving are exceptionally impressive.

Somewhat based on the premise that driving relies on information processing that did not evolve for that purpose, the research from the Institute of Transport Economics recounts the psychophysiological driver behaviour studies of Taylor (1964), as discussed previously in this chapter. A review of driver behaviour modelling dismisses Wilde's (1982) Risk Homeostasis Theory, except for the idea of a homeostatic target level. Meanwhile it praises the skin conductance work of Taylor (1964) and the attempt by Naatanen and Summala (1974) to integrate this into the zero-risk model. The role of Taylor's (1964) findings is clearly influential in the model and the key aspects of Taylor's work are summarised by Vaa (2001a, p6) as follows:

- SCR rate can be adopted as a measure of subjective risk as it seems unlikely that frequent occurrences of SCR could be caused by any other factors than those involving some slight perceptible risk
- SCR rate is an appropriate variable of subjective risk as it is also analogous to a tension or anxiety level.
- Driving is a self-paced task governed by the level of tension or anxiety which the driver wishes to tolerate.
- If SCR rate is raised, a slowing of pace is called for, if there are few hazards, the pace is quickened until they reappear
- If perceived hazards are removed or reduced, a driver will simply readjust his behaviour to restore his anxiety level.

The stimulating enquiry in relation to the sensation of anxiety and risk suggested by Taylor's (1964) skin conductance study led Vaa to investigate current neurological theory.

Vaa (2005) argues that given mankind's deepest instinct is survival, man must possess a specialised system that is constantly aware of the environment and potential threats. It is suggested that the physiological design of the human being has evolved to observe and identify danger or potential danger. The state of the body and its senses are therefore the key to monitoring the environment as they constantly inform the organism of its wellbeing. Biological processes in the body are already known to be homeostatically controlled, like temperature, thirst and hunger, and the message they use to influence a person to act is feelings (Hayward, 1997). Could the body's perception of external risk therefore have the same influence over a person's behaviour?

Antonio Damasio and colleagues would argue that it does. Damasio's (1994; 1999, 2003) neurological research has led to the postulation of theory that relies on appreciating the role of feelings and emotions in a way that has been previously ignored. The essence of Damasio's (1994, 2003) argument is that emotions and feelings allow a relationship between internal state and external behaviour. The perception of the environment therefore has huge bearing on a person's internal state and will in turn influence their behaviour. This is termed the 'functional balance' but is defined in the body as a 'target feeling' or 'best feeling' (Damasio, 2003). Applying this research and theory to the realm of driving, Vaa (2005) suggests that it is not a target level of risk that is important in mediating driving behaviour but a target feeling.

Extending the neurological theory is the concept of the 'Somatic Marker Hypothesis' (SMH) (Bechara & Damasio, 2005). The SMH is somewhat of a threat avoidance monitor that detects, through previous experience, that certain elements in the environment are converging into something threatening or dangerous. For example, if a situation develops into something hazardous, a feeling will be produced of heightened arousal or fear. This feeling will be marked against that scenario so that should that scenario be built again in the future, the body can respond quicker to avoid it, hence a somatic ('soma' being Greek for body) marker. The role of feelings in the information processing loop is therefore crucial. Charlton (2000, p100) describes somatic markers in the following way:

> "The somatic marker mechanism is the way in which cognitive representations of the external world interact with cognitive representations of the internal world - where perceptions interact with emotions."

When the theory is contiguously positioned with risk compensation and hazard perception literature, the picture is intriguing. Vaa (2004, 2005) therefore promotes the Monitor Model (see Figure 2.5) as a means of bringing the two areas of study together. It is stated that 'The monitor is nothing less than the whole of the body, the whole organism. The boundaries of the monitor (solid line) corresponds to the boundary of the body.' (Vaa, 2004, p iv). Out-with the body are general factors such as the road environment, vehicles and other road users. Within the body, these factors all input to an undefined (within the English papers, although this may be defined in the full Norwegian report) 'sensory storage'. Further internal influences of motivation including personality, motives, interaction patterns and 'other' factors are acknowledged. Sensory storage and motivations then input themselves into Damasio's (1994) Somatic Marker Hypothesis whereby feelings and emotions connected to the driving environment, through experience, are then involved in the conscious and unconscious decision making process and behavioural response. The decision and behavioural response will depend upon the 'target feeling' of the driver as the system will work to homeostatically control this.

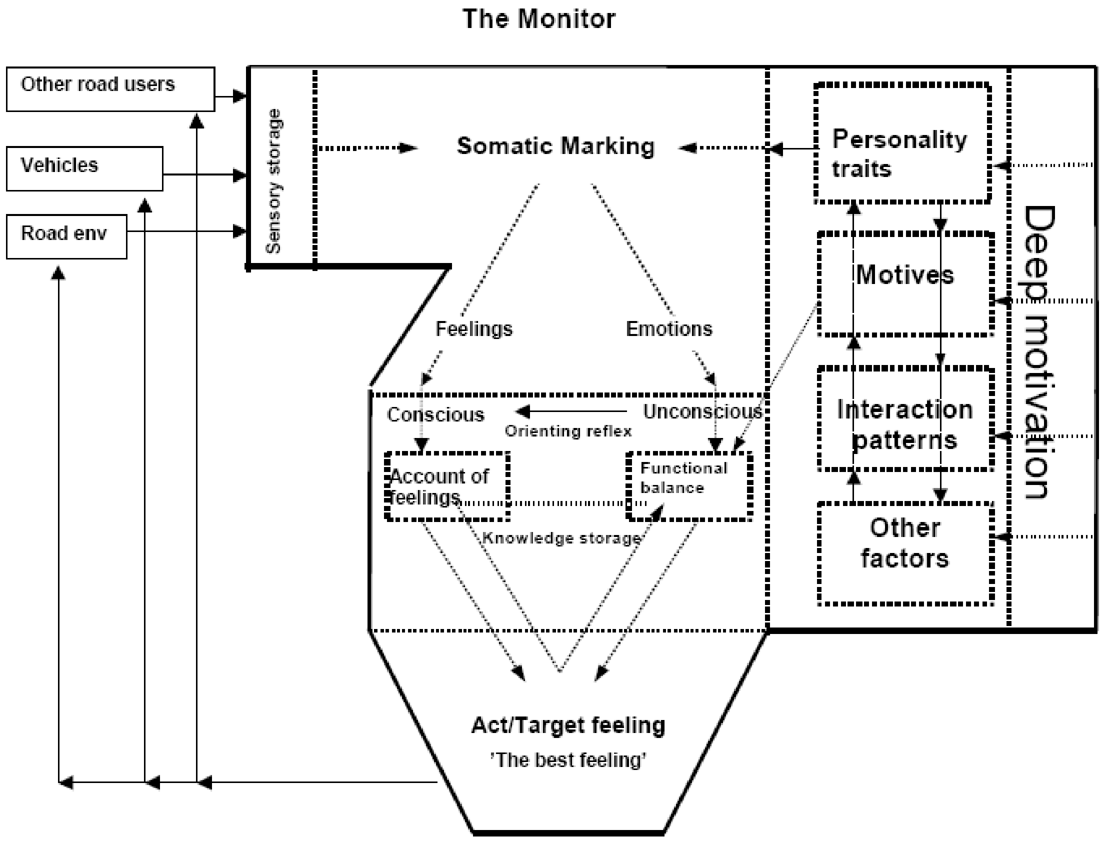



*Figure 2.5: The Monitor Model (Vaa, 2004)*

It is of note that objective risk or even subjective risk estimate are not included in this model and that simply the feeling of risk is the singular most important component. This therefore deviates from Wilde's (1982) proposal of risk perception but could be used to theoretically explain the results of the skin conductance experiments of Hulbert (1957), Michaels (1960) and Taylor (1964). There is also an influence of Naatanen and Summala's (1974) zero risk model, although it may be assumed that the current 'monitor' is constantly appraising the environment rather than only after a risk threshold has been breached.

A further assumption about the model is that it has the potential to explain novice drivers' poor performance on hazard perception tests, poor visual scanning and high accident rates. The somatic marker hypothesis (Damasio, 1994) is based upon learning from experience of potentially dangerous scenarios. If a novice driver has not been exposed to such scenarios then they cannot have learned from them. As the somatic marker hypothesis (Damasio, 1994) is central to this model then it would suggest such a process would be necessary to accurately determine the 'target feeling'.

Unfortunately, having to make assumptions regarding the detail of the model is one of the consequences of the language barrier. Whilst a summary report and several conference papers exist, the full report has so far only been released in Norwegian. Finer details such as definitions and explanations for the role of elements like the 'orienting reflex' and 'knowledge storage' are not covered in the summary. In addition, further research based on this model has also not been forthcoming, possibly due to the lack of translated publication. Although the model satisfies the criteria set out at the beginning of the chapter, without full detail of the model and without any supportive research it is therefore not ideal as the basis for the current research.

The theory does however bring driver behaviour modelling up to date and the fresh approach taken by the researchers is to be admired. There is some overlap between the model proposed by Vaa (2004) and the final model to be discussed with regards the inclusion of a neurological influence. The coincidental support that the two theories provide for each other may suggest a convergence of thinking towards the future of driver behaviour research.

### *2.7.3: The Task-Capability Interface (TCI) model (2000a, 2005a)*

Fuller (1984; 1988) has a history in driver behaviour modelling, having previously published the risk-avoidance model. This model was based on the premise that making progress towards a destination and avoiding hazards are the two principal motivations for a driver. The conflict between these two motivations formed the conceptual basis for the model. The logic behind the model was the perception that driving rarely involves progressing in a straight line unimpeded to a destination;

instead it involves repeatedly negotiating obstacles and potential hazards, therefore having to avoid threat. However, the model suffered similar denouncement to that of Naatanen and Summala (1974) in which it was difficult to test some of the concepts meaning it was criticised for lacking specificity regarding the internal mechanisms, which prohibited validation (Michon 1989; Van der Molen & Botticher 1988; Ranney, 1994).

Similar to this earlier model (Fuller, 1988), Fuller (2005a) presents a model that is a logical representation of the driving task but which is capable of adapting and appreciating the intricate nature of driving behaviour. The current author's graphical representation of the model can be seen in Figure 2.6.

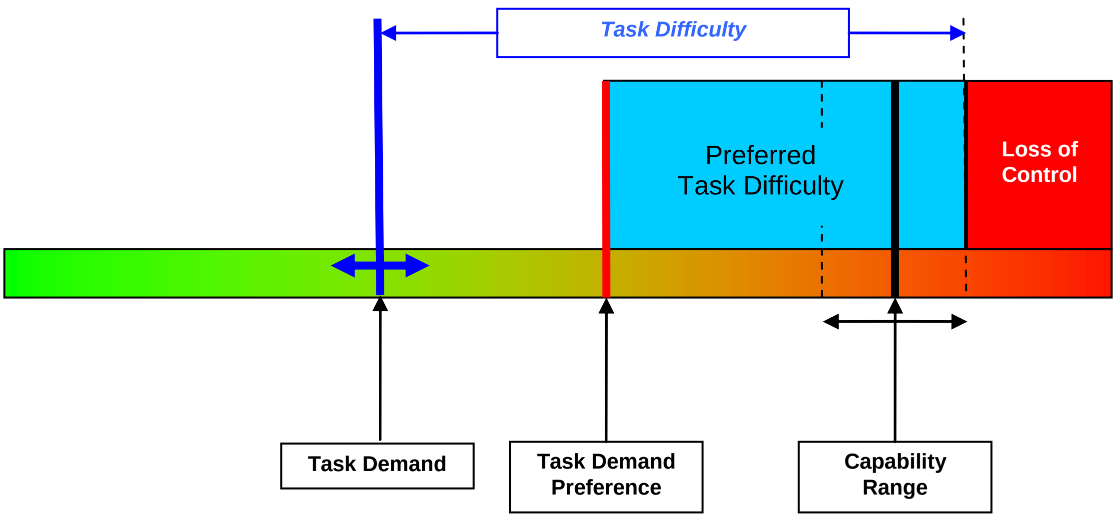



*Figure 2.6: Authors illustration of the Task-Capability Interface model*

The model starts with the self-evident fact that loss of control will occur when the demand of the driving task becomes greater than the capability of the driver. The capability of the driver is constrained by a driver's personal characteristics which creates a Capability Range. This range will have its foundations in a driver's experience and training but may also be mediated at any time by factors such as fatigue and stress. Meanwhile, Task Demand is influenced by many on-the-road factors that can make it somewhat unpredictable. However, one of the most important influences over task demand is managed by the driver, speed. Driving is a self-paced activity, hence, speed has a crucial role to play in the maintenance of the gap between Task Demand and Capability. A change in speed will have a direct influence on the demand of the driving task. This control over speed allows a driver to maintain a preferred level of Task Demand and therefore within a preferred range of Task Difficulty. The influences over Task Demand, Capability and Preferred Task Demand are shown in Figure 2.7.

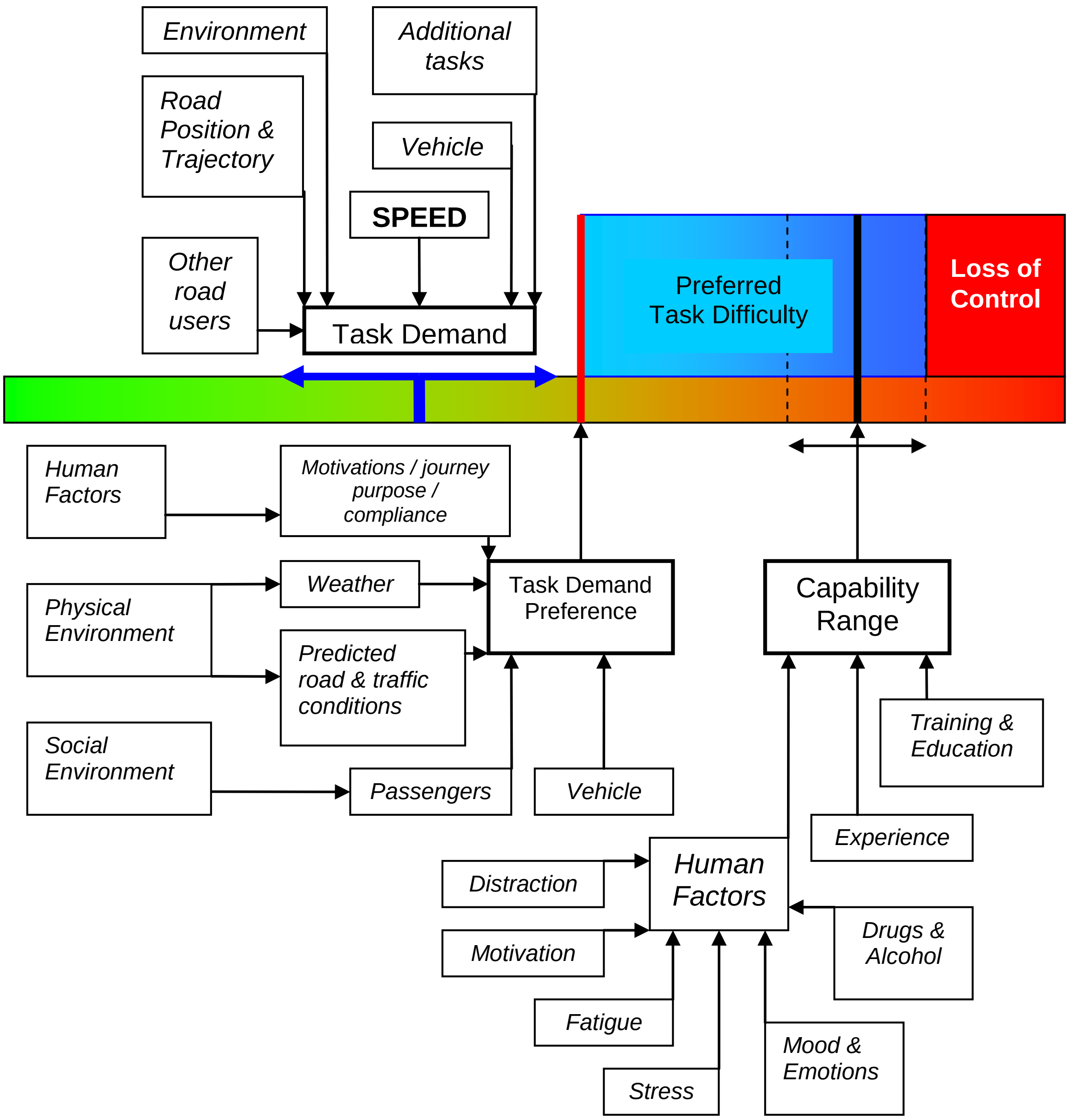



*Figure 2.7: Authors illustration of the Task-Capability Interface model with influences*

*2.7.3.1: Task Difficulty*

Task Difficulty is simply the real-time gap between level of Task Demand and level of Capability. Task Difficulty is inversely proportional to this gap as when the gap decreases, Task Difficulty increases. It could otherwise be termed the driver's safety margin (Summala, 2005). As Task Demand approaches Capability the driver will experience that the task of driving is becoming progressively more difficult and the safety of the individual is more at risk. Fuller, Bates, Gormley, Hannigan, Stradling, Broughton, et al. (2007) suggest how this concept can be explained in real terms:

> "As an example, young male drivers aged 18-21 years, whose capability is impaired because they have consumed alcohol and whose driving task demand is elevated because they are speeding, feature in 40% of all loss-of-control fatal crashes involving their age and sex group (Laapotti and Keskinen, 1998)." (p20)

The concept of Task Difficulty has been described before in terms of driver workload (deWaard, 2002) and in the 'law of cognitive capacity' whereby as cognitive capacity approaches its limits, the accident rate increases (Elvick, 2006). Summala (2005) also discusses a similar relationship between task demand and capability whilst citing Jex (1988):

> "Task workload has sometimes been described as a margin between task demands, on one hand, and physiological or motivated capacity, on the other hand, such that physiological capacity sets the absolute limits while motivated capacity may vary considerably below the physiological capacity" (p389)

It would therefore appear that there is movement towards a common explanation of task difficulty. Summala's (2005) quote also supports Fuller's (2005a) suggestion of a capability range which could possibly be refined to include motivated and physiological capacity.

It has further been suggested that the concept of Task Difficulty provides an operational definition of ‘hazard’ as a ‘hazard’ can only develop out of the interaction between the driver (capability) and the environment (task demand) (Fuller et al., 2007). In fact, Fuller (2005a,b) extends the process by further conceptualising the Task Difficulty Homeostasis.

*2.7.3.2: Task Difficulty Homeostasis (Fuller, 2005a,b; Fuller & Santos, 2002)*

The Task Difficulty Homeostasis asserts that drivers drive so as to maintain a level of Task Difficulty within a preferred range. Dependent on the capability of the driver, individual motivations and the goals of a particular journey, a driver will possess a range of task difficulty within which they will comfortably operate (Fuller, 2005a). Summala (2005) would otherwise describe this as a driver’s “comfort zone”. The driver will therefore drive in such a way as to maintain experienced task difficulty within that range. Manipulation of speed is seen as the primary mechanism for achieving this, although variations in effort or undertaking or dumping other secondary tasks may also be used, for example, making or ending a mobile phone call. A representation of this process can be seen in Figure 2.8.

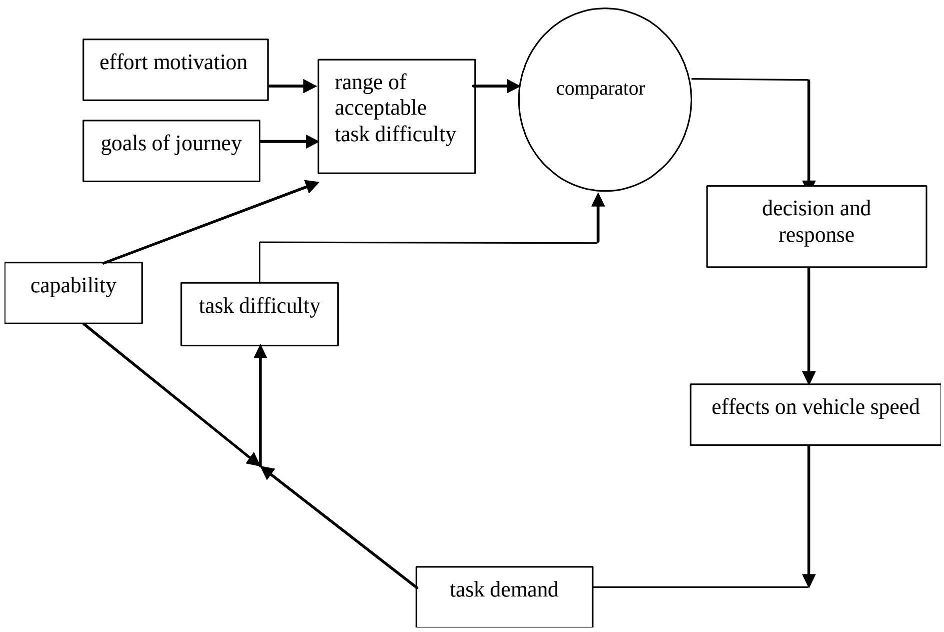



*Figure 2.8: Illustration of Task Difficulty Homeostasis (Fuller, 2005b)*

Theoretically, this concept is different from Wilde's (1982) risk homeostasis theory as there is no suggestion that objective risk influences the homeostatic control. Instead it would appear that the homeostatic control is measured by the subjective 'experience' a person has when driving; a proposition not dissimilar to Vaa's (2004, 2005) suggestion of a 'target feeling'.

*2.7.3.3: Support for the Task Difficulty Homeostasis*

There is significant empirical support for this process with speed and other factors being used as homeostatic controls. As noted earlier in the section on risk compensation (see page 47), studies suggest that changes in drivers' environment can cause them to compensate through increased or decreased speed (Lewis-Evans & Charlton, 2006; van Driel, Davidse & Maarseveen, 2004; Smiley, 2000). In Lewis-Evans & Charlton's (2006) study of experienced New Zealand drivers, the road width was subtly manipulated on a simulator. All drivers drove on four sections of road that were technically identical other than minor differences in road width. The results indicated significant effects of road width on participants' speeds, such that narrow roads were associated with lower speeds while wider roads were associated with higher speeds. Interestingly, when interviewed about what influenced their driving on the four sections of road, not one participant stated that the width of the road had any bearing on their driving.

Further experimental evidence can be found in Hogema, Veltman and van't Hof (2005). In a study of the effects of road lighting and workload on drivers' behaviour, they found physiological measures of workload (blink rate and heart rate) to increase when road lighting was switched off. Further to this, drivers mean speed was significantly reduced when driving without lighting compared to driving with it. The addition of a secondary task (a continuous memory task) resulted in slower speeds both with and without lighting, although the reduction was more exaggerated when driving without lighting. These findings would support the concept of task difficulty homeostasis, whereby the demand of the task is increased towards drivers' capability without lighting and with the inclusion of a secondary task; in turn the driver responds by reducing their speed.

On the other hand, earlier research into road lighting and driving behaviour demonstrates that the relationship between task demand, or workload, and behavioural homeostatic responses may not be as simple as the studies noted above suggest. Folles, IJsselstijn, Hogema and Van der Horst (1999) tested the effects of 'dynamic public lighting' whereby the amount of lighting of the roads was dependent on the traffic and weather conditions. The experiment included a reduction of 20% of normal lighting in good conditions and an increase of 100% in bad conditions. Similar to Assum et al. (1999), when the road lighting was initially installed and before the experiment began, there were driver behavioural changes whereby average speeds increased. In comparison with these base measures, a reduction of 20% of lighting in good conditions found no behavioural change, however, surprisingly, there was also no change in behaviour when road lighting was doubled in bad conditions like rain. In the rain, drivers' average speed did not increase under better lighting conditions although it had reduced in comparison to normal driving conditions. This suggests that specific environmental changes under certain conditions will not influence drivers' behaviour and could raise a question mark over the universality of the task difficulty homeostasis. Alternatively, it could be explained that in poor road conditions, like rain, the reduction in speed was more important to the sensation of task difficulty than the lighting of the roadway.

In a similar way, Hogema et al. (2005) found that whilst a change in road lighting or performing a secondary task altered drivers' speed, it did not influence their headway, suggesting again that adaptation of speed is possibly the key element within drivers' control, as Fuller (2005a,b) alludes to. The concept of a 'range' of task difficulty in which a driver is willing to engage is also supported by this research. Gregersen and Bjurulf (1996) suggest that speed changes do not always fully compensate for a change in task demand. It is doubtful that a behavioural change is going to be an exact response to a change in the environment but behavioural change to maintain experienced risk within a safe 'range' would appear sensible.

Further evidence to support the role of speed change as a response to a change in task demand has come from various research methodologies. Larsen (1995) measured free speeds of drivers on different 50km/h sections of road way and reported that the highest mean speeds were associated with the sections that the researcher had previously rated as the easiest. Survey evidence also supports that drivers state that they drive slower in conditions of increased task demand such as in fog, heavy rain and on unfamiliar roads (Campbell & Stradling, 2003). In a variety of studies, it is also evident that the modern use of mobile phones impacts on drivers speed, attention and conversational abilities (Liu & Lee, 2005; Parkes & Hooijmeijer, 2000; Luke, Smith, Parkes & Burns, 2005). This arena of research would also support the concept of the task difficulty homeostasis as the impact of conversing on a mobile phone when driving has been demonstrated to be detrimental to both activities. Whilst the obvious concern for safety due to driving when conversing on a mobile phone (with and without hands-free attachments) has been discussed (Burns, Parkes, Burton, Smith & Burch, 2002), research has also focused on the impact driving has on the conversation leading Luke et al. (2005, p378) to state:

> "The fact that conversation performance is generally worse while driving and talking, either to a passenger or on a hands-free kit, suggests that driving interferes with conversation."

*2.7.3.3: Applying the Task Difficulty Homeostasis to Novice Drivers*

As noted earlier in the chapter, there are key differences between novice and experienced drivers. The key differences noted were an underestimation of hazards on the road (see page 52) and an overestimation in ability (see page 53). For the TCI and the Task Difficulty Homeostasis to be a valid representation of driving, they have to be able to demonstrate an adaptability to represent this interaction. Fuller et al. (2007) discusses this interaction in terms of the discrepancy between objective and subjective realities.

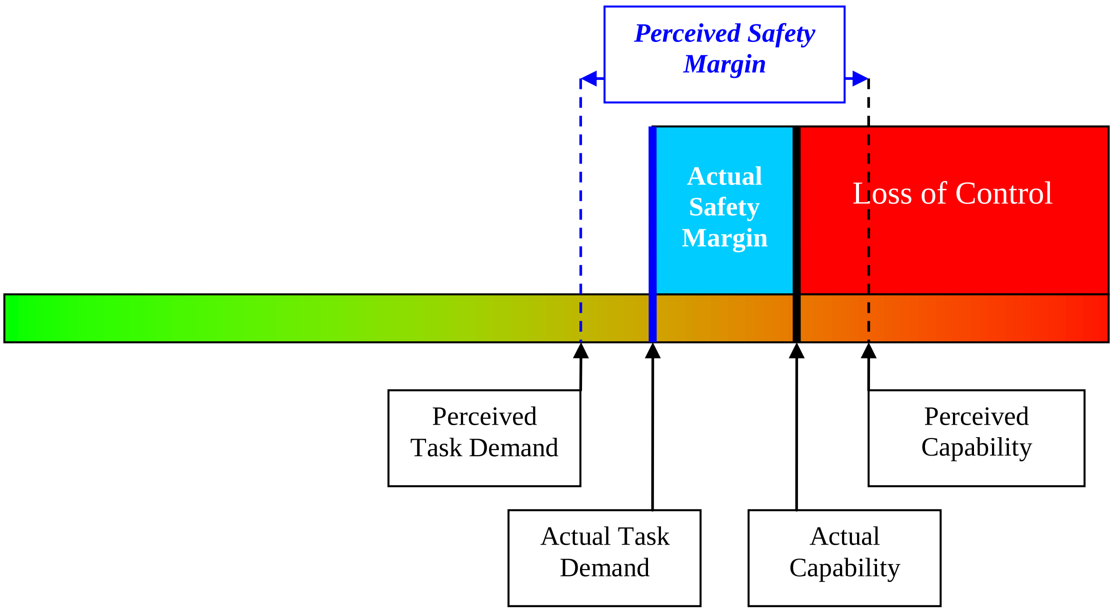



*Figure 2.9: Representation of the discrepancy between actual and perceived task demand and driver capability*

As demonstrated in Figure 2.9, a driver who overestimates their capability would demonstrate a perceived level of capability that is at odds with their actual capability. Similarly, if the required demands of the driving task (i.e. hazards) were not noticed, the perception of task demand would be far removed from that of actual task demand. The consequence is a significantly reduced safety margin, squeezed from both sides, probably without the realisation of the driver. In such circumstances, an unexpected incident on the roadway would leave a driver with less time to respond than they perceived they originally had. This calamitous misperception of capability and task demand appears to quite accurately describe the characteristics of young inexperienced drivers and their poor calibration, in line with other literature (Gregersen & Bjurulf, 1996; Deery, 1999; Kuiken & Twisk, 2001; Lyman & Twisk, 1995). An updated version of the task difficulty homeostasis can be seen in Figure 2.10.

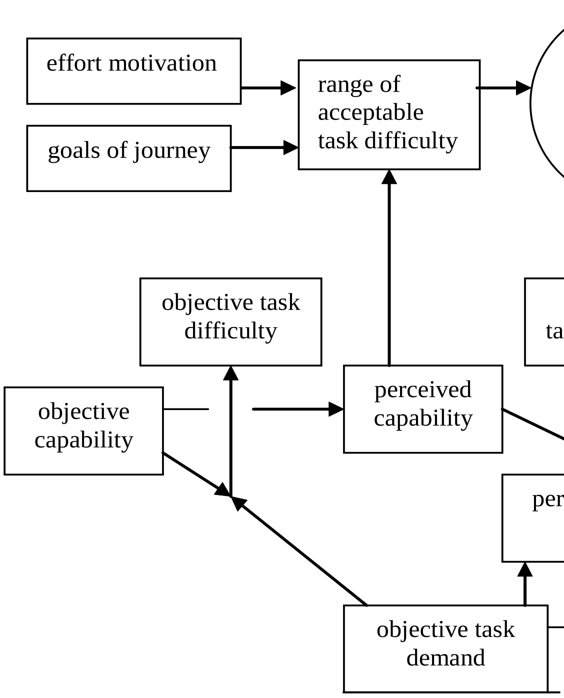



*Figure 2.10: Updated representation of the Task Difficulty Homeostasis, distinguishing between actual and perceived capability, task demand and task difficulty (Fuller et al., 2007)*

The Task-Capability Interface model and Task Difficulty Homeostasis therefore demonstrate adaptability in being able to represent the problems that existing research associates with young and novice drivers. The first two criteria determined at the beginning of the chapter have therefore been met by this model. First, the model is up to date and grounded in current literature; second, the model can demonstrate adaptability to represent the many factors that may influence drivers' behaviour. The final criterion was that any model utilised in the thesis should provide the potential to explore new areas of driver behaviour that are not yet understood.

Similar to both Wilde (1982) and Naatanen and Summala (1974), Fuller's (2005a) model utilises the idea of a feedback of risk assessment to a 'comparator', the decision making area, which then leads to a behavioural response. In essence, the comparator is therefore the core concept within the model. Without understanding what happens within this section, the model, and our understanding, can not be advanced. There are clues from risk compensation and hazard perception literature as to how a 'comparator' may influence a behavioural response but this remains to be investigated. How does a driver actually sense and evaluate how difficult and/or safe the driving task is at any particular moment? How does this influence the ensuing decision & behavioural response? The Task-Capability Interface Model and Task Difficulty Homeostasis provide the foundations for understanding the task of driving and its many influences, but to understand if experienced and inexperienced drivers evaluate the driving task differently, it must be understood what is going on in the 'comparator'.

The TCI suffers from the same criticisms that previous motivational models of driver behaviour have faced whereby it is difficult to test the validity of the theoretical concepts that underlie it. However, the literature reviewed above appears to support many of the concepts, suggesting further investigation of the comparator section would be worthwhile. In support of this, the initial findings of Fuller, McHugh and Pender (2008a) appear to compliment the clues given by the risk compensation literature and hazard perception literature. Fuller et al. (2008a) found drivers to appreciate the demand of the driving task in terms of how they feel rather than how they calculate the chances of collision or loss of control; leading to the suggestion that this was a new agenda for research (Fuller, 2005b). The findings were in strong support of the research by Vaa (2001b; 2005) and the discussion cited the same neurological theory used by Vaa (2004) in the Monitor Model. The Task-Capability Interface therefore meets the third criterion by providing the basis from which further scientific enquiry can explore an area of driver behaviour not yet understood.

## 2.8: Chapter Two Summary

The aim of Chapter Two was to further explore the psychological nature of driving so as to better understand the higher risk associated with being a young novice driver. In doing so, an appropriate driver behaviour model was sought that could provide a suitable framework from which to lead enquiry in the current thesis. Three criteria were determined for a model to be appropriate: (i) the model should be up to date and grounded in current literature; (ii) the model should be adaptive enough to accept and integrate a multitude of influences on the driver; (iii) the model should provide the potential to explore new areas of driver behaviour that are not yet understood.

### *2.8.1: Early Driver Behaviour Modelling*

Although driver behaviour modelling lost its momentum after initial early interest, there appears to be a re-emergence based on lessons learned from the historical models. Motivational models like Wilde's (1982) risk homeostasis theory and Naatanen and Summala's (1974) zero-risk theory were discussed. The structure of both models incorporated a behavioural feedback loop involving a monitoring of risk that fed into a decision making process and behavioural response. Unfortunately, neither model provides a satisfactory explanation for how risk is monitored by the driver. Some clues to how risk might be monitored, and the inspiration for these models, were studies carried out using skin conductance measures of anxiety (Hulbert, 1957, Michaels, 1960; Taylor, 1964). These studies suggested drivers' demonstrated psychophysiological increases in anxiety relatively frequently when driving, that were related to observable traffic events.

**The early skin conductance studies (Hulbert, 1957, Michaels, 1960; Taylor, 1964) provided the first evidence that there are psychophysiological reactions when driving. Whilst the early driver behaviour models based on this research failed to adequately incorporate this notion, the physiological evidence that drivers are appraising risk in some form whilst driving is still a key indication of the psychological processes involved when driving.**

### *2.8.2: Risk Compensation*

The area of Risk Compensation or Behavioural Adaptation is especially interesting as it gives further clues to the psychological processes involved when driving. Studies measuring a direct behavioural effect of a change to drivers' environment find some factors do elicit changes and some that do not. It is therefore important to understand what the common difference between these factors is. Lund and O'Neill (1986) suggest that direct perceptual and sensory feedback to the driver is the common difference between factors that will (e.g. lighting) and will not (e.g. airbags) cause behavioural adaptation. If such feedback really influences drivers' behaviour then it is vital that the psychological process of such feedback is understood, which at present it is not.

**Despite the insight given by the early skin conductance studies, comprehending how subjective risk is processed and how this may influence drivers' behaviour is still to be understood. Risk compensation literature suggests that perceptual and sensory feedback may be an important influence.**

### *2.8.3: Hazard Perception & Overestimated ability*

Extending research on risk is the area of Hazard Perception. This area of research has been crucial in demonstrating differences between novice and experienced drivers. Deery (1999) notes that hazard detection is dependent upon two factors: risk perception and self-assessment of skill. With regards to risk perception, novice drivers are found to perform worse than experienced drivers on almost all tests demonstrating a trend to look for obvious near hazards. Experienced drivers tend to search more holistically and into the distance for potential hazards.

There are also differences between experienced and novice drivers regarding their self-assessment of skill. Novice, particularly young and novice drivers, demonstrate an overconfidence in their abilities that is more likely to lead to riskier behaviour (OECD, 2006). This overestimation of ability leads to a lack of calibration between drivers' perceived risk and the actual risk in any particular situation, therefore, when a hazardous situation develops on the roadway, it may place demands on drivers' abilities inappropriate for their skill level.

**The difference between novice and experienced drivers with regard to their hazard perception skills is another clue to understanding the psychological process involved in determining risk. It suggests that hazard perception is a skill learnt through the experience of driving. Further evidence of this being a learned process is the notion that inexperienced drivers are poorly 'calibrated', which conversely suggests that experienced drivers are 'calibrated'. This poses the question: how does a novice driver become calibrated?**

### *2.8.4: Driver behaviour modelling - post 2000*

Discussion of modern models of driver behaviour demonstrates a convergence of research. Grayson et al.'s (2003) theoretical model of responding to risk on the road was discussed due to the importance in demonstrating that how drivers' assess and respond to hazards is an indicator of their overall driver behaviour and accident liability. Meanwhile, Vaa's (2004) monitor model comes from a different research perspective and essentially strives to explain how drivers assess risk on the road. **Through evaluation of previous driver behaviour modelling and modern neurological theory, Vaa (2004) suggests that feelings and emotions are involved in the assessment of risk and influence driver behaviour.** This re-birth and extension of the early skin conductance studies and has been well received (Summala, 2005; Fuller, 2005b). Grayson et al.'s (2003) model failed to satisfy the second and third criteria as defined earlier. On the other hand, Vaa's (2004) model satisfied all criteria but given a language barrier in appreciating the full report and a lack of empirical testing of the model, it was decided that consideration of a further model was necessary. **The essence of the theory behind the Monitor model (Vaa, 2004) is also discussed within the literature supporting Fuller's (2005a) Task-Capability Interface (TCI).**

The TCI model (Fuller 2005a) has a traditional structure similar to RHT and zero-risk model in that it incorporates a feedback loop with a decision making area, leading to a behavioural response. This model matches the earlier defined criteria in that it is up to date and supported by current research; is adaptive to appreciate a multitude of influences on a driver and provides the potential to explore new areas of driver behaviour that are not yet understood. **The comparator section of the model, which lies between feedback and decision and behavioural response, is the model's main area of weakness. Investigating how drivers process feedback from the environment and how this influences their behavioural response is therefore a key area that is not yet understood. Until we can fully comprehend this process, the model remains theoretical only and our appreciation of the psychological processes underpinning novice drivers can not be addressed.**

Chapter Three looks to re-test Fuller et al.'s (2008a) experimental study of the Task-Capability Interface model extending our knowledge and understanding of its processes.

# Chapter Three

## Study 1: Replication and extension of Fuller, McHugh and Pender (2008a)

## Chapter Three Outline

## 3.1: Introduction

### *3.1.1: Task difficulty and risk in the determination of driver behaviour (Fuller et al., 2008a)*

Chapter Two concluded by suggesting that further investigation into the Task-Capability Interface (TCI) (Fuller, 2005a) would be a good basis to improve understanding of the psychological processes that underlie driving behaviour. In testing the model, Fuller et al. (2008a) present two studies that explore three key hypotheses which the TCI's concepts elicit. The findings of these studies have been previously discussed in line with the theoretical implications (Fuller, 2005a) and as promotion of future research objectives (Fuller, 2005b). As noted in the discussion of the TCI in Chapter Two, the basis of the model is the interaction between task demand and capability which gives rise to the concept of task difficulty. Processing of task difficulty is performed through a feedback loop and the use of speed is seen as the primary control mechanism for the driver. The three key hypotheses defined were therefore:

I. Task difficulty will be systematically related to speed
II. Ratings of the likelihood of collision (i.e. objective risk estimate) will be independent of speed until task demand approaches capability
III. Feelings of risk will be zero (or close to zero) and stable until speed pushes task demand close to driver capability (Fuller et al., 2008a)

Fuller et al.'s (2008a) first experiment used thirty volunteers with full driving licences to test the hypotheses. Three sections of road (residential; country and dual carriageway) were filmed from a driver's perspective in clear daylight conditions at 30 mph. Each section was around 300 metres in length and involved no other road users. The driving sequences were then digitally altered so that footage of each road type could be presented at different speeds, for example, the same section of residential roadway could be shown to participants from 20mph up to 60mph at 5mph increments. Participants viewed the clips of each road type, at the different speeds from slowest to fastest, and rated them on the following questions:

How difficult would you find it to drive this section of road at this speed?

| Extremely easy | | | | | | | | | extremely difficult |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

How much risk would you experience driving this section of road at this speed?

| No risk | | | | | | | | | maximum risk |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Imagine you had to drive this section of road at this speed every day for the next month (i.e. 30 times). How many times do you think you would have an accident or lose control of the vehicle?

Hypothesis I was supported as speed was strongly associated with ratings of task difficulty on all road types. Hypothesis II was also supported as ratings of objective risk estimate, on all road types, remained at zero until some threshold was reached, from which point ratings rose with increases in speed. The threshold at which ratings would rise from zero varied between participants. Hypothesis III was not supported. Feelings of risk did not track the objective risk estimate as predicted. At slow speeds, feeling of risk ratings rose whilst objective risk estimates remained at zero, on all road types. The surprising result was that feeling of risk ratings appeared to track task difficulty ratings. In fact, the Pearson correlation coefficient between task difficulty ratings and feeling of risk ratings across all road types was 0.81 ($p<.001$). Graphical representation of the ratings can be seen in Figure 3.1.

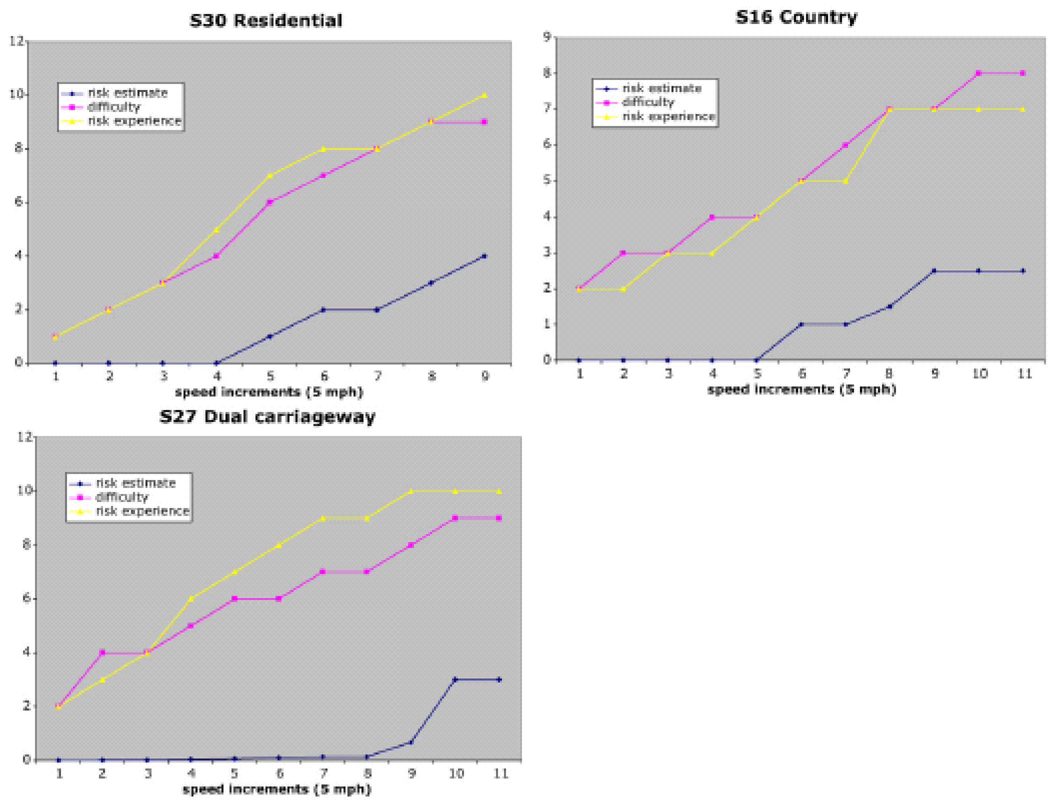



*Figure 3.1: Exemplar of three participants' ratings of Task Difficulty (pink), Feelings of Risk (yellow) and Objective Risk Estimate of an Accident or Loss of Control (blue) from Fuller et al. (2008a)*

To verify these results, a second experiment was conducted involving forty participants with full driving licenses. The same clips were used although there were minor differences to experiment one. The ten-point scale used on the questionnaire was reduced to a seven-point scale, thought to be more reliable (McKelvie, 1978) and an additional question was added:

> Imagine this section of road with other road users present. If you were to drive on this road at this speed every day for a month (i.e. 30 times), how many times do you think you would crash?

In respect of the additional question, no notable differences in responses as a whole were found but there were some individual response differences. After the clips had been viewed, the participants were also asked for the speed at which they would prefer to drive, if driving comfortably. Interestingly, the average preferred speeds for each road type were all lower than the average threshold at which objective risk estimates would rise from zero, thus suggesting a theoretical marker at which task demand was approaching capability. Although the additional elements of experiment two were of interest, the main purpose of the second study was to verify the findings from experiment one. The results of experiment two demonstrated similar results for all hypotheses including the originally surprising finding that feelings of risk ratings were tracking task difficulty ratings; this time to the significant order of 0.98 ($p<.001$) (Fuller at al, 2008a).

Both studies therefore supported the prediction from the TCI model that task difficulty ratings would be highly correlated with speed. The unexpected finding, however, of the relationship between task difficulty and feelings of risk has two implications. First, it suggests that the experience of risk (feeling of risk) when driving is not the same as the probability of an accident or loss of control (objective risk estimate). This is important as it draws a distinction between the processing of both forms of risk. Further, Fuller et al. (2008a) state that ratings of feelings of risk and task difficulty were 'virtually substitutable' (p19), which theoretically suggests only one requires to be processed to inform of the state of the other. The second implication develops this line of enquiry and suggests that feelings of risk may be involved in the information processing feedback loop that influences behavioural response. If task demand were to approach capability, the motivation to take aversive action (i.e. reduce speed) may be the increasing sensation of feeling risk. As results suggested that feelings of risk track task demand even at slow speeds, this would appear to be a continuous assessment; which contradicts the concept of risk appraisal suggested by the zero-risk model (Summala & Naatanen, 1988).

### *3.1.2: Critique of Fuller et al. (2008a)*

Before the results can be discussed as providing such an important insight into driver behaviour, the experiment must be reviewed. A critique of the study would focus on the reliability and validity of the results; the potential order effect of the stimuli and the questions; the measure of objective risk estimate and the participant sample used. Reliability has been somewhat demonstrated through replication (Fuller et al., 2008a; Lynn, 2006) although external validity could be enhanced through the use of new stimuli. The order effect of the stimuli (slow speeds to fast speeds) has been shown to be minimal when speeds are randomised (Lynn, 2006), although question order and road type order has not been controlled for. With respect to measuring objective risk estimates, it is debatable whether using the probability of collision is beneficial over the probability of loss of control. As it is postulated within the TCI that a loss of control will occur when task demand exceeds capability, it could be suggested that the probability of loss of control may be a better measure.

The participant sample used by Fuller et al. (2008a) is also an important consideration. There is little information about participants' driving history given in Fuller et al. (2008a), although reference is made to an unpublished graduate thesis which discusses further driver behaviour measures (McHugh, 2002). Fuller et al.'s (2008a) first experiment explains that twenty-eight of the thirty participants were undergraduate or post-graduate students with an average age between 23 and 24 years old. The second experiment involved unspecified volunteers but with an age range of 18 to 55 years (Fuller et al., 2008a). The participants' driving experience is therefore unknown but could have an important influence on the results. Driver behaviour literature (e.g. Deery, 1999; Underwood, 2007) often reports perceptual differences by experience level for issues such as hazard perception and visual scanning, hence, clarification of any influence of experience here is vital. Further, if there was a differentiation of response by experience level, it may offer insight into the processes utilised by novice and experienced drivers to determine risk and task difficulty.

### *3.1.3: The present study*

The current experiment therefore sought to replicate the original research (Fuller et al., 2008a) whilst addressing the key criticisms. In order to do this a larger participant sample was sought to enable comparison of learner, inexperienced and experienced drivers and a driver behaviour questionnaire was constructed to gain background information for each participant. Newly produced video clips were created to potentially enhance external validity through the use of different stimuli. Of these, an additional country road section was included to test responses to a straight country road and a bendy country road. Research into motorcyclists' behaviour reports that straight and bendy sections of road are appraised differently (Broughton, 2008). Whilst this distinction may only apply to motorcyclists, it was considered an interesting addition to the current study. Research with motorcyclists has also highlighted enjoyment as a potentially related factor with the TCI model (Broughton, 2008). It is reported that riders' enjoyment is linked to task difficulty and at high levels of task difficulty, riding ceases to be pleasurable (Broughton, 2008). Again, whilst this research may not apply to car drivers, the theoretical background is worthy of exploration (see Broughton, 2007), hence, the current study added the question, '*how enjoyable would it feel to drive this section of road at this speed?*' The inclusion of this question is purely investigatory, although it could be postulated that after some speed threshold, a negative relationship will ensue between task difficulty and enjoyment, whereby as task difficulty continues to increase, enjoyment will decrease.

Counterbalancing of the questions and the presentation of road types was utilised to reduce any response bias. Meanwhile, a question measuring the probability of loss of control from previous large scale research was incorporated as the measure of objective risk estimate (Sexton, Hamilton, Baughan, Stradling & Broughton, 2006). The response to this question was also made more sensitive by using a scale of 0-100 rather than 0-30, as used in the original paper. A further change to the experiment by Fuller et al. (2008a) was that participants were asked to state their maximum speed for driving each road type, rather than their 'preferred speed'. It was considered that this may demonstrate a driver's maximum acceptance of task demand and therefore reveal a greater understanding of his/her minimum accepted safety margin.

In summary, the central aim of the present study is to replicate Fuller at al (2008a) and further advance our understanding of any potential findings. To do this, different levels of driver experience (learner, novice and experienced) were to be tested on four road types: residential, straight country, bendy country and dual carriageway.

### *3.1.4: Hypotheses*

Based on the results of Fuller et al. (2008a), and the discussion above, the following main hypotheses were proposed:

- *I. Task difficulty and feelings of risk ratings will be associated with speed and each other*
- *II. The probability of loss of control ratings (objective risk estimate) will rise in relation to speed only after some threshold is reached*
- *III. There will be a difference in response by experience level to either task difficulty, feelings of risk or the probability of loss of control*
- *IV. At higher speeds, enjoyment will be negatively related to task difficulty whereby as task difficulty increases, enjoyment will decrease*

## 3.2: Method

### *3.2.1: Design*

To test for drivers' appraisal of task difficulty, enjoyment and risk in relation to speed, participants were shown video clips of a car driving at different speeds on the same section of road, from the driver's perspective.

A 4x9 repeated measures design was used to gain participants' ratings of task difficulty, feeling of risk, enjoyment and probability of loss of control (objective risk estimate) across nine different speeds. This design was repeated for four types of road: Residential, Straight Country, Bendy Country, and Dual Carriageway.

For each road type, the same clip was shown to participants nine times but was digitally altered to represent different speeds. Although each road type had nine clips, the speed range was dependent on the type of road, as shown in Table 3.1. The speeds were spaced at 5mph increments.

*Table 3.1: Speed range across different road types. Clips set at 5mph increments*

| | No. of Clips | Speed Range (MPH) |
|---|---|---|
| **Residential** | 9 | 20-60 |
| **Straight Country** | 9 | 30-70 |
| **Bendy Country** | 9 | 30-70 |
| **Dual Carriageway** | 9 | 60-100 |

Previous research demonstrated that the order effect of video clips is minimal (Lynn, 2006), therefore, to give the experiment environmental validity it was decided to remain with participants viewing slow-to-fast for each road type. To control for any order effect arising due to the order of the road type or the order of the questions, counter balancing was utilised. The road type order was set out as Residential; followed by Straight Country; followed by Bendy Country; followed by Dual Carriageway. Half of the participants viewed the road types in this order and half in reverse order.

Similarly, the questions were originally set out asking for ratings of task difficulty; followed by feeling of risk; followed by enjoyment; followed by probability of loss of control. Half of the participants answered in this order and half answered with the order reversed.

There were therefore four conditions under which participants carried out the experiment:

1. Normal order Questions - Normal order Road Type
2. Normal order Questions - Reverse order Road Type
3. Reverse order Questions - Normal order Road Type
4. Reverse order Questions - Reverse order Road Type

Experience groups were evenly split across each of these conditions with 10 learner drivers in each condition; 13 inexperienced drivers in each condition and 15 experienced drivers in each condition. To test if the order in which the stimuli was presented influenced participants' responses an analysis of variance was performed but found no significant difference between these four conditions on any road type (Residential $F(3, 148)=1.5$, p=ns; Straight Country $F(3, 148)=1.32$, p=ns; Bendy Country $F(3, 148)=1.04$, p=ns; Dual Carriageway $F(3, 148)=2.11$, p=ns).

### *3.2.2: Participants*

One-hundred and fifty two participants took part in the study. Opportunistic quota sampling was used to ensure adequate numbers of male and female, learner, inexperienced and experienced drivers were included for analysis (see Table 3.2). Experienced drivers were defined as having held a UK driving licence for three or more years; inexperienced drivers were defined as holding a UK driving licence for less than three years; with learner drivers currently seeking to learn to drive. Participants were recruited from within the Glasgow area, UK.

*Table 3.2: Breakdown of sample by experience group and gender*

| | *Learner* | *Inexperienced* | *Experienced* | Total |
|---|---|---|---|---|
| *Male* | *17* | *23* | *28* | 68 |
| *Female* | *23* | *29* | *32* | 84 |
| Total | 40 | 52 | 60 | 152 |

The mean age for learner drivers was 21.3 years (sd=3.6, range=17.9-33.4). The mean age for inexperienced drivers was 20.8 years (sd=5.4, range=17.9-52.5); whilst the mean age for experienced drivers was 29.75 years (sd=9.2, range=20.3-62).

For participants with a driving licence, the mean duration that the licence had been held was 17.31 months (sd=9.3, range=1-35) for inexperienced drivers and 118.3 months (sd=84.6, range=36-480) for experienced drivers. Learner drivers stated they had been learning to drive for an average of 16.9 months (sd=15.7, range=1-60).

Learner drivers reported that they had driven an average of 119 miles in the last 12 months (sd=97, range=10 – 350; N=26); with inexperienced drivers reportedly having driven an average of 3787 miles in the last 12 months (sd=5288, range=2–23000; N=50); and experienced drivers reporting they had driven an average of 6702 miles in the last 12 months (sd=6020, range=10–30000; N=57).

*Table 3.3: Frequency of participants who reported they had been flashed by a speed camera in the last 3 years; been stopped for speeding in the last 3 years; had points on their licence; or had been crash involved in the last 3 years.*

| | Flashed | | Stopped for Speeding | | Points | | Crash involved | |
|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No |
| **Learner** | 0 | 37 | 1 | 36 | 0 | 37 | 1 | 34 |
| **Inexperienced** | 4 | 48 | 3 | 49 | 3 | 49 | 21 | 30 |
| **Experienced** | 12 | 48 | 5 | 55 | 8 | 52 | 22 | 37 |
| ***Total*** | *16* | *133* | *9* | *140* | *11* | *138* | *44* | *101* |

Table 3.3 shows the number of participants who reported whether they had been flashed by a speed camera in the last 3 years; been stopped for speeding in the last 3 years; had points on their licence or had been crash involved in the previous 3 years. The mean number of points on drivers' licenses was 0.24 points (sd=.890, range 0-6, N=149). The mean number of active crashes (driver at fault) was 0.32 (sd=.752, range=0-5, N=145) and the mean number of passive crashes (driver not at fault) was 0.13 (sd=.339, range=0-1, N=145).

The results section (p93) will address the experimental hypotheses only hence some analysis of participants' driving history is reported here. Males reported having been involved in significantly more active crashes than females (t=2.6, df=57, p=012), although no difference was found for passive crashes. There was no difference by gender for being flashed by a safety camera, stopped for speeding or by the number of points on a licence.

There was no significant difference between the inexperienced and experienced groups on the number of times they reported being flashed by a speed camera in the last 3 years; stopped for speeding in the last 3 years or by the number of points on their licence. The inexperienced group's mean number of active crashes was 0.61 (sd=1.1) compared with the experienced group's mean of 0.25 (sd=0.5) which was a significant difference (t=2.14, df=69.1, p<.05). There was no significant difference in the number of reported passive crashes by experience group.

### *3.2.3: Materials*

A disclaimer form with written instructions was placed at the beginning of the answer booklet and can be seen in Appendix 3A.

The video clips were constructed using roads around the south side of Glasgow, United Kingdom. Footage was recorded of real time driving on different road types in full daylight. Four thirty-second clips were then extracted from the footage representing the four road types to be tested (Residential; Straight Country; Bendy Country; Dual Carriageway). Screen shots of the beginning of the clips can be seen in Appendix 3B. There were no other road users, obstacles or obvious hazards in any of the clips extracted. The clips were put together in sequences using Microsoft PowerPoint, allowing for controlled presentation of stimuli.

The answer booklet had a new page for each clip that was being rated, so that participants could not see their previous rating. The same four questions were asked on each page of the answer booklet:

How difficult would you find it to drive this section of road at this speed?

| Extremely easy | | | | | | Extremely difficult |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

How risky would it feel to drive this section of road at this speed?

| Not at all risky | | | | | | Extremely risky |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

How enjoyable would it feel driving this section of road at this speed?

| Not at all enjoyable | | | | | | Extremely enjoyable |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Imagine if 100 drivers like you, of the same age and experience, were to drive this section of road at this speed and in these conditions.  How many do you think would lose control of the vehicle?

Answer (0-100): ____________________

*3.2.3.1: You and Your Driving questionnaire*

Participants also completed a further questionnaire entitled 'You and Your Driving' which gained general demographic information about the participant and their driving attitudes and behaviours.  The 'You and Your Driving' questionnaire can be seen in Appendix 3C; a copy of the questionnaire with frequencies, mean scores and participants comments can be seen in Appendix 3D.

The 'You and Your Driving' questionnaire incorporated two sections.  The first section asked the participant questions regarding the clips they had just viewed. Fuller et al. (2008a) asked participants to state at what speed they would be most comfortable driving the section of road.  The aim of the current study was to establish a greater understanding of the limit at which drivers will drive and why they will not drive faster than their chosen speed.  As a result, the current experiment sought to explore what holds a driver back when unimpeded by traffic or obstacles, as in the current clips.  The first section therefore asked drivers for the fastest speed at which they would drive on each section of road and then asked them to select possible reasons for why they would not drive any faster on each road type. As this was exploratory, space was available for participants to give their own reasons. To read participants' comments and view the results of this section, see Appendix 3D.

Section Two asked drivers for general demographic information, driving history and current driving status. In addition, the questionnaire utilised some questions from previous research which could measure thrill seeking tendencies. The inclusion of such questions was exploratory and in addition to the central focus of the research. The questions were extracted from the larger Driver Stress Inventory (DSI) as used and discussed in Matthews, Desmond, Joyner, Carcary & Gilliland (1997). Due to time constraint within the experiment, the full DSI was not administered and only the thrill seeking questions were used as an indicator of driver thrill seeking tendencies. Space was available at the end of the questionnaire for participants' comments regarding the study and driving in general; these can be seen at the end of Appendix 3D.

*3.2.3.2: Questionnaire pilot study*

In the construction of both the answer booklet and the 'You and Your Driving' questionnaire, a pilot study was conducted to gain participant feedback before the study commenced. The procedure of the pilot experiment was the same as for the full experiment, however, at the end of the pilot experiment there was a short interview. An unstructured interview which requested opinions of the questions within both questionnaires was performed with each participant individually.

Ten volunteer participants took part in the pilot consisting of five males and five females. The average age of the pilot participants was 25.9 years (std dev = 3.66). All participants held a valid UK driving licence of which the mean period since gaining their licence was 7.0 years (std dev = 4.47).

From the interviews, suggestions of minor changes to the structure of the 'You and Your Driving' questionnaire were applied to enhance clarity. The key use of the pilot interviews, however, was to determine participants' views on which question would best measure objective risk estimate. Participants therefore answered two objective risk estimate questions for each clip, along with rating task difficulty, feelings of risk and enjoyment. The two questions used to measure objective risk estimates at this time were:

I. Imagine 100 drivers of the same age and experience as you were to drive this section of road at this speed and in these conditions. How many do you think will have an accident?

| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1-10 | 11-20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | 71-80 | 81-90 | 91-100 |

II. How many times would you have to drive this section of road at this speed before you might lose control just once?

_____________

Problems were noted with both questions. Question I was adapted from Sexton et al. (2006) but was criticised for forcing participants to make a choice of the scoring bands offered. While making it an open ended question would resolve this problem, the majority of participants were also unsure of what constituted an 'accident', as there are no other road users present within the clips. Participants reported a general preference for the terminology in question II which used the term 'loss of control' instead, however, question II was criticised as being difficult to answer by all participants. Both questions in this format were therefore excluded. The terminology of question I was altered from 'accident' to 'loss of control' and it was made an open question, as originally used within Sexton et al. (2006):

Imagine if 100 drivers like you, of the same age and experience, were to drive this section of road at this speed and in these conditions. How many do you think would lose control of the vehicle?

Answer (0-100): ____________________

The implementation of this question as a measure of objective risk estimate was verified by a senior researcher with a history of publications measuring risk and risk perception (Thomson, 2006). In conclusion of this process, the above question was chosen for use in the answer booklet as the measure of objective risk estimate.

#### *3.2.3.3: Incentives*

Participants were rewarded with a £1 National Lottery scratch card for taking part in the experiment but not the pilot study.

### ***3.2.4: Procedure***

Participants who agreed to take part in the experiment were initially screened for their current driving status by the experimenter. Based on this, each participant was given an answer booklet for one of the four presentation conditions (see Design, page 83). Once participants had read and signed the disclaimer, they were asked to read the instructions on the answer booklet. The experimenter then offered to answer any questions the participants had. The presentation started when participants pressed the space bar. A clip would start and then stop automatically, prompting the participant to answer the corresponding page in the answer booklet. The participants repeated this procedure for the nine speeds on each of the four road types. At the end of the presentation, the participants were prompted on-screen to complete the 'You and Your Driving' questionnaire. When the participants had finished, they handed the questionnaires to the experimenter and were given a £1 National Lottery scratch card in return.

### ***3.2.5: Ethical approval***

Ethical approval for the study was granted by the Psychology Ethics Board at Glasgow Caledonian University, where the experiment was performed and can be seen in Appendix 3E. It was recommended that some tick boxes were enlarged on the questionnaire to increase the clarity for participants with poor eye sight or reading difficulties. This change was accepted and the questionnaire was altered.

## 3.3: Results

### *3.3.1: Hypothesis I*

I. Task Difficulty and Feelings of Risk will be associated with speed and each other

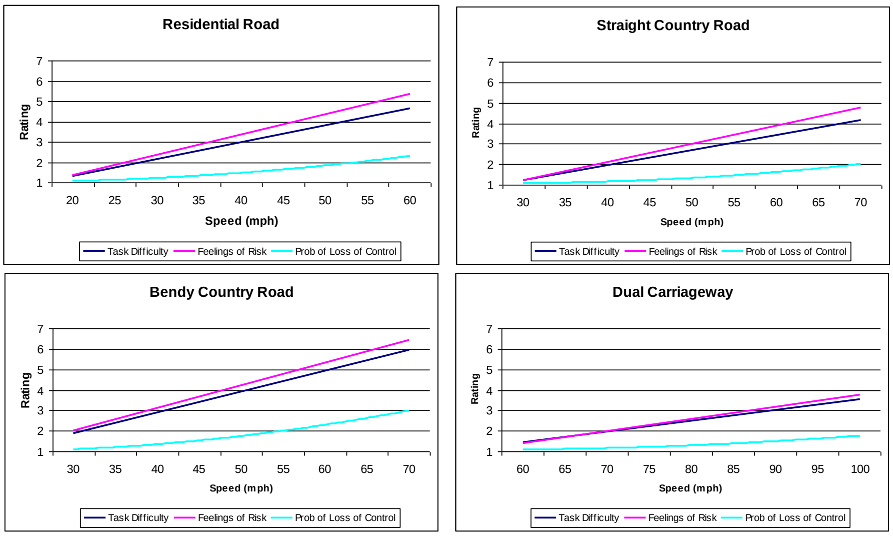



*Figure 3.2: Means plot of Task Difficulty (dark blue), Feelings of Risk (pink) and Probability of Loss of Control (light blue) across speed for the four road types*

Graphical representation of the mean scores for Task Difficulty, Feelings of Risk and Probability of Loss of Control can be seen in Figure 3.2. Ratings of Task Difficulty and Feelings of Risk appear to increase simultaneously with increases in speed on all road types. At higher speeds, however, Feelings of Risk ratings appear to be greater than that of Task Difficulty. Probability of Loss of Control ratings also demonstrate a gradual increase with speed on all road types but not to the magnitude of Task Difficulty or Feelings of Risk. Road type also demonstrates differences in the magnitude of ratings although the overall interaction remains similar.

Spearman's Rho correlation demonstrated that increases in speed were strongly associated to increases in Task Difficulty and Feelings of Risk ratings on all road types (Residential: rho=0.95, p<.001; Straight Country: rho=0.61, p<.001; Bendy Country: rho=0.71, p=.031; Dual Carriageway: rho=0.89, p=.001).

Correlation coefficients between Task Difficulty and Feelings of Risk ratings for each speed and across all road types can be seen in Table 3.4. All relationships were significant at the p<.001 level.  The data suggest that the relationship between Task Difficulty and Feelings of Risk becomes stronger as speed increases and also as the speed potential of the road type increases.

*Table 3.4: Correlation coefficients of Task Difficulty and Feelings of Risk ratings by speed.  All coefficients significant at the p<.001 level.*

| Road Type / Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** | *Co-efficient Average* |
|---|---|---|---|---|---|
| **20** | 0.62 | | | | 0.62 |
| **25** | 0.66 | | | | 0.66 |
| **30** | 0.67 | 0.65 | 0.63 | | **0.65** |
| **35** | 0.71 | 0.72 | 0.75 | | **0.73** |
| **40** | 0.70 | 0.73 | 0.79 | | **0.74** |
| **45** | 0.77 | 0.70 | 0.83 | | **0.77** |
| **50** | 0.74 | 0.83 | 0.78 | | **0.78** |
| **55** | 0.79 | 0.78 | 0.77 | | **0.78** |
| **60** | 0.78 | 0.71 | 0.79 | 0.69 | **0.74** |
| **65** | | 0.82 | 0.84 | 0.73 | **0.80** |
| **70** | | 0.82 | 0.83 | 0.77 | **0.81** |
| **75** | | | | 0.77 | 0.77 |
| **80** | | | | 0.76 | 0.76 |
| **85** | | | | 0.84 | 0.84 |
| **90** | | | | 0.83 | 0.83 |
| **95** | | | | 0.83 | 0.83 |
| **100** | | | | 0.86 | 0.86 |
| *Co-efficient Average* | 0.71 | 0.75 | 0.78 | 0.79 | |

Given the strong and significant relationship between Task Difficulty ratings and Feelings of Risk ratings, with each other and speed, Hypothesis I has been supported. The results also support the previous results of Fuller et al. (2008a).

### *3.3.2: Hypothesis II*

II. Probability of Loss of Control estimates will rise in relation to speed only after some threshold is reached

Graphical representation of the overall mean scores for the Probability of Loss of Control can be seen in Figure 3.2 above.  The trend lines demonstrate that the Probability of Loss of Control estimates remain low despite the increases in speed but that it does rise gradually on all road types. It is not apparent from the mean scores whether there is a clear 'threshold'.

The current study could determine drivers' thresholds in two ways: from the ratings data or from the participants stated maximum speed. Participants' ratings threshold was taken as the first increase in response from their baseline measures given on clip one of each road type. However, there were many participants whose ratings did not increase with speed and remained constant. These participants were excluded as no threshold could be established. The mean thresholds for the remaining participants can be seen in Table 3.5, along with participants' mean stated maximum speeds. There was no relationship between the ratings threshold and maximum stated speed on any road type.

*Table 3.5: Mean speeds in mph for ratings threshold and maximum speed by road type. Correlation coefficient between the two variables also shown (p=ns for all road types)*

| | Residential | Bendy Country | Straight Country | Dual Carriageway |
|---|---|---|---|---|
| **Ratings threshold (mph)** | **43** | **51** | **55** | **83** |
| N | 82 | 104 | 66 | 58 |
| Std. Deviation | 9.63 | 10.77 | 9.47 | 10.59 |
| **Maximum speed (mph)** | **37** | **40** | **52** | **69** |
| N | 151 | 151 | 151 | 151 |
| Std. Deviation | 8.56 | 10.05 | 12.44 | 12.26 |
| *Correlation Coefficient (p=ns)* | *0.01* | *0.10* | *0.06* | *-0.05* |

Given the large number of participants from which a threshold could not be established and given that there appears to be no obvious change in the data around the ratings threshold or the mean maximum speed, the current results do not support earlier work that reported a clear diversion from a zero rating at some threshold (Fuller et al., 2008a). Hypothesis II has therefore not been supported.

### *3.3.3: Hypothesis III*

III. There will be a difference in response by experience level to either task difficulty, feelings of risk or the probability of loss of control

*3.3.3.1: Task Difficulty*

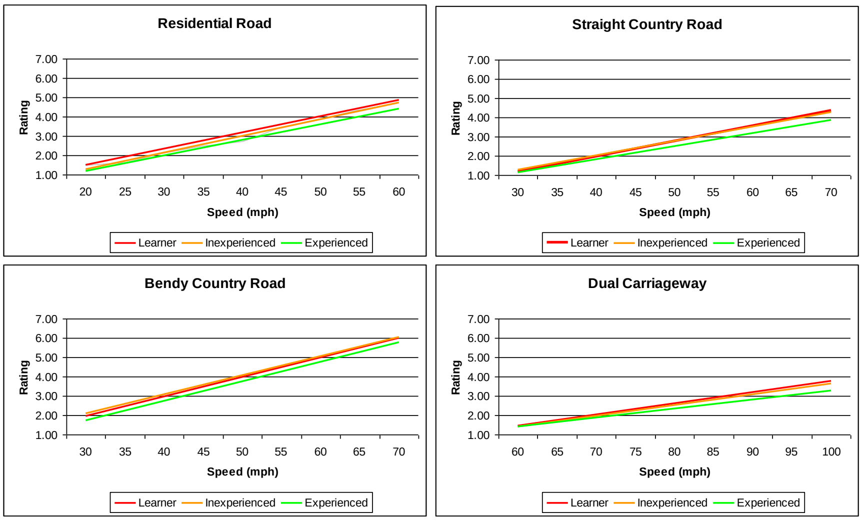



*Figure 3.3: Means plot of Task Difficulty ratings across speed for the four road types.*

Graphical comparison of Task Difficulty mean scores by experience level can be seen in Figure 3.3. The mean scores suggest little difference between the three experience groups although there is a minor trend across all road types suggesting experienced drivers' mean ratings are slightly lower than that of learner and inexperienced drivers.

Repeated measures Multivariate Analysis of Variance (MANOVA) was performed to test for differences in Task Difficulty ratings at all speed levels by experience. The assumption of "sphericity" was examined, but this assumption was not met, therefore, in reporting results, the Greenhouse-Geisser statistic is used. There was no significant difference between the experience groups ratings of Task Difficulty at any speed and on any road type (Residential: $F(5, 387)=0.41$, p=ns; Straight Country: $F(5, 717)=1.01$, p=ns; Bendy Country: $F(5, 358)=0.43$, p=ns; Dual Carriageway: $F(4, 303)=1.11$, p=ns).

*3.3.3.2: Feelings of Risk*

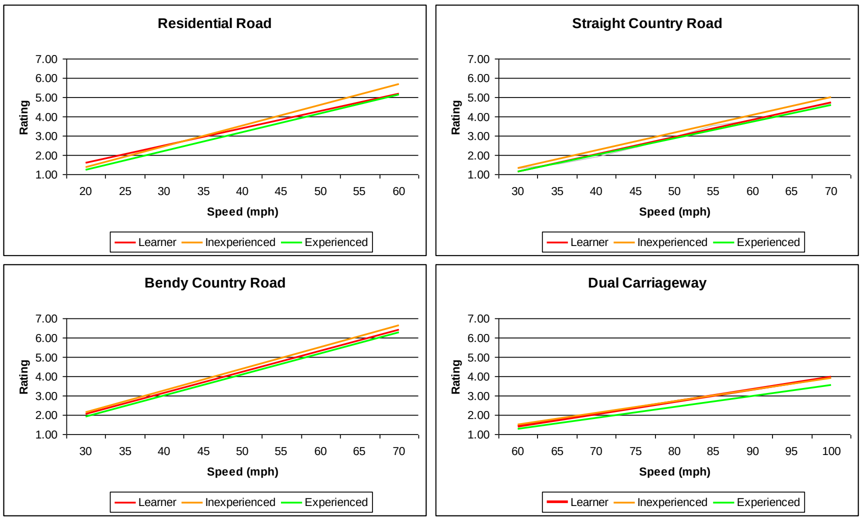



*Figure 3.4: Means plot of Feelings of Risk ratings across speed for the four road types.*

Graphical comparison of Feeling of Risk mean scores by experience level can be seen in Figure 3.4. The mean scores suggest little difference between the three experience groups although again, there is a minor trend across all road types suggesting experienced drivers' mean ratings are slightly lower than that of learner and inexperienced drivers.

Repeated measures Multivariate Analysis of Variance (MANOVA) was performed to test for differences in Feeling of Risk ratings at all speed levels by experience. The assumption of "sphericity" was examined, but this assumption was not met hence in reporting results, the Greenhouse-Geisser statistic is used. There was no significant difference between the experience groups ratings of Feeling of Risk at any speed and across any road type (Residential: $F(6, 478)=1.6$, p=ns; Straight Country: $F(5.8, 427)=0.53$, p=ns; Bendy Country: $F(6, 431)=0.66$, p=ns; Dual Carriageway: $F(4, 303)=1.11$, p=ns).

*3.3.3.3: Probability of Loss of Control*

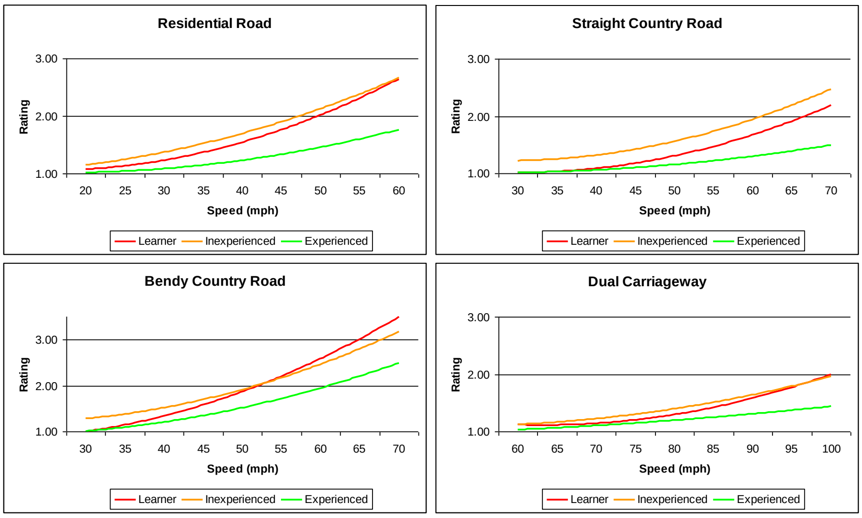



*Figure 3.5: Magnified means plot of Probability of Loss of Control ratings across speed for the four road types. Ratings re-coded into 1-7 rating scheme.*

Graphical comparison of Probability of Loss of Control mean scores by experience level can be seen in Figure 3.5. The mean scores suggest that with increases in speed the gap between the experienced group and the inexperienced and learner groups increases. Whilst the experienced group's ratings rise with speed, ratings never match the magnitude of the learner or inexperienced groups. The learner and inexperienced groups ratings demonstrate greater increases with speed and somewhat track each other. It is also of note that the inexperienced group also tend to rate the probability of the loss of control greater than that of the learner group, except on the bendy country road.

Repeated measures Multivariate Analysis of Variance (MANOVA) was performed to test for differences in Probability of Loss of Control at all speed levels by experience. The assumption of "sphericity" was examined, but this assumption was not met, therefore, in reporting results, the Greenhouse-Geisser statistic is used. There was a significant difference between the experience groups ratings of the Probability of Loss of Control across all road types (Residential: $F(3, 228)=3.7$, $p=.012$; Straight Country: $F(3, 217)=4.5$, $p=.005$; Bendy Country: $F(3, 223)=2.88$, $p=.037$; Dual Carriageway: $F(4, 304)=2.715$, $p=.029$).

Post hoc Tukey analysis was performed for each road type. For the residential road, significant differences were found between the inexperienced and experienced groups at 40mph ($p=.011$), 45mph ($p=.009$), 50mph ($p=.017$), 55mph ($p=.013$) and 60 mph ($p=.008$). There were also significant differences between the learner and experienced groups at 55mph ($p=.029$) and 60mph ($p=.030$).

For the straight country road, differences were found between the ratings of inexperienced and experienced drivers at all speeds (30mph: $p=.031$; 35mph: $p=.031$; 40mph: $p=.008$; 45mph: $p=.042$; 50mph: $p=.046$; 55mph: $p=.009$; 60mph: $p=.004$; 65mph: $p=.001$; 70mph: $p=.003$). There was also a significant difference at 40mph between the learner group and the inexperienced group ($p=.035$) and another between the learner group and the experience group at 70mph ($p=.05$).

Significant differences were also found for the bendy country road between inexperienced and experienced driver groups (35mph: $p=.015$; 45mph: $p=.019$). Whilst at higher speeds there were significant differences between the learner and experienced driver groups (60mph: $p=.046$; 65mph: $p=.029$; 70mph: $p=.044$).

For the dual carriageway, the only significant difference was found between the learner group and the experienced group at 100mph ($p=.049$).

### *3.3.4: Additional analysis comparing experience groups*

#### *3.3.4.1: Maximum speed*

There was also a difference in the maximum stated speed by experience level on all road types, as can be seen in Figure 3.6, although the differences between groups on the residential and bendy country roads were not significant. There were significant differences between the experience groups on the straight country road ($F(2, 148)=3.43$, $p=.035$) and dual carriageway ($F(2, 148)=9.24$, $p<.001$). Post hoc Tukey analysis demonstrated significant differences between the experienced group and the learner group on the straight country road ($p=.032$) and between the experienced group and both the learner ($p=.001$) and inexperienced ($p=.002$) groups on the dual carriageway.

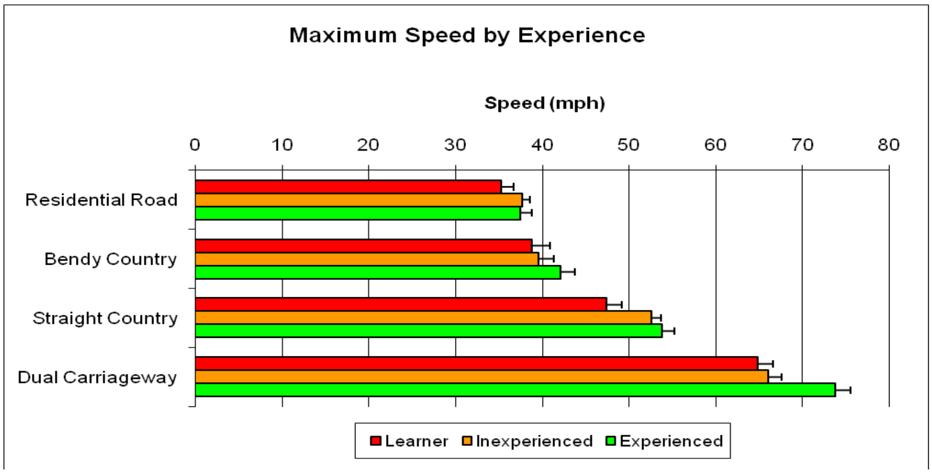


*Figure 3.6: Maximum speed comparison by experience level on each road type with standard error bars*

### *3.3.4.2: Thrill Seeking*

A comparison of thrill seeking by experience group was also considered. A thrill seeking score was established from the total score of the eight thrill seeking items in the 'You and Your Driving' questionnaire. A Cronbach's alpha of .917 suggested these items were reliable. Participants mean scores by experience level and gender can be seen in Table 3.6.

*Table 3.6 - Participants mean thrill seeking scores by experience level and gender*

| | *N* | Male | Female | **Total** |
|---|---|---|---|---|
| Learner | *38* | 24.67 | 13.61 | **17.97** |
| Inexperienced | *52* | 41.78 | 21.69 | **30.58** |
| Experienced | *60* | 32.00 | 20.97 | **26.12** |
| **Total** | ***150*** | **33.74** | **19.20** | **25.60** |

Analysis of Variance was performed to test for differences by experience group and found a significant difference (F (2, 147)=5.06, p<.01). Post hoc Tukey analysis suggests this difference is between the scores of the learner group and the inexperienced group (p=.005). No significant difference is reported between the experienced group and the learner (p=ns) or inexperienced group (p=ns).

Overall, male drivers mean thrill score was significantly higher than females mean thrill score (t=4.9, df=131, p<.001). This was the case for the learner group (t=2.28, df=24, p=.032); the inexperienced group (t=4.039, df=47.2, p<.001) and the experienced group (t=2.27, df=56.3, p=.027).

Analysis of driver violations with thrill seeking scores was performed only on drivers who had a UK driving licence, therefore learner drivers were excluded. A comparison of thrill seeking scores by driver violations found no significant difference between those who reported to have been flashed by a speed camera in the last 3 years with those who had not (t=.08, df=18.5, p=ns); those who had been stopped for speeding in the last 3 years and those who had not (t=-.21, df=8.052, p=ns) or those who had points on their licence and those who had not (t=-1.19, df=11.5, p=ns). However, there was a significant difference between the thrill seeking score of those who reported having an accident (active or passive) in the last 3 years with those who did not (t=2.32, df=89.5, p=.02).

There was a significant correlation between thrill seeking score and the statement ‘In general I enjoy driving’ (r=.346, p<.001). This was explored further in terms of drivers mean ratings of enjoyment for each road type, although there was only a significant relationship for the bendy country road (r=.202, p=.035)

In summary, hypothesis III stated that there would be a difference in response by experience level to either task difficulty, feelings of risk or the probability of loss of control. Analysis of hypothesis III suggests that whilst there was no difference between experience groups on the ratings of Task Difficulty or Feelings of Risk, there was a significant difference on ratings of Probability of Loss of Control, thereby partially supporting hypothesis III. Additional analysis of maximum speed ratings also suggested a difference by experience level on some road types and by the thrill seeking measure, although only between the learner and inexperienced group.

### *3.3.5: Hypothesis IV*

IV. At higher speeds, enjoyment will be negatively related to task difficulty whereby as task difficulty increases, enjoyment will decrease

*3.3.5.1: Residential road*

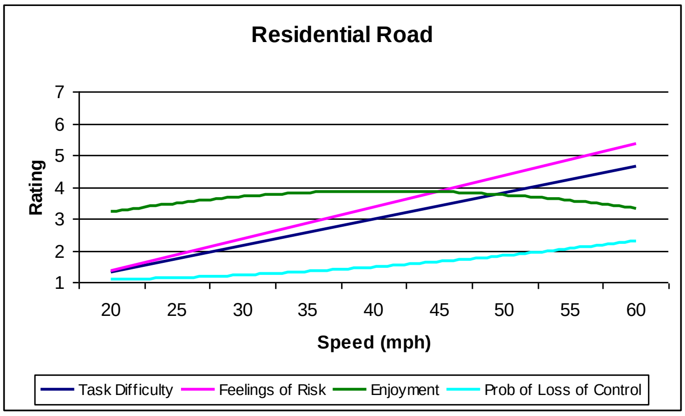



*Figure 3.7: Overall mean ratings of Task Difficulty, Feelings of Risk, Probability of Loss of Control and Enjoyment by speed for the residential road*

For the residential road, the relationship of enjoyment mean ratings across speed can be compared to task difficulty, feelings of risk and the probability of loss of control in Figure 3.7. Enjoyment appears to have an alternative relationship with speed than that of the other factors. Participants' enjoyment ratings rise from the lowest speed (20mph) until peaking at around 35-45mph before beginning to decline as speed continues to increase. The mean ratings on this road type suggest that there is a level of peak enjoyment which is higher than that of the legal speed limit (30mph). Intriguingly, ratings of enjoyment decline once feelings of risk ratings have exceeded enjoyment.

Table 3.7: Residential Road - Correlation coefficients of Enjoyment with Task Difficulty, Feelings of Risk and Probability of the Loss of Control ratings by speed (N=152)

| *Speed (mph)* | *20* | *25* | *30* | *35* | *40* | *45* | *50* | *55* | *60* |
|---|---|---|---|---|---|---|---|---|---|
| Task Difficulty | 0.13 | 0.16 | 0.09 | **0.19** | **0.18** | 0.07 | ***-0.22*** | ***-0.30*** | ***-0.41*** |
| Feelings of Risk | 0.05 | 0.15 | 0.14 | **0.18** | 0.10 | -0.03 | ***-0.23*** | ***-0.29*** | ***-0.38*** |
| Probability of Loss of Control | -0.09 | 0.09 | 0.04 | 0.16 | 0.08 | 0.07 | -0.06 | -0.11 | ***-0.26*** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Spearman's rho correlations were carried out to test for the relationship between enjoyment and all other factors at each speed level. Correlation coefficients are summarised in Table 3.7. At low speeds there are no significant correlations between enjoyment and any other factors. Where enjoyment peaks at 35-40mph, there was a significant positive relationship between enjoyment and task difficulty (35mph rho=0.19, p<.05; 40mph rho=0.18, p<.05) and feelings of risk (35mph rho=.18, p<.05). Whilst the strength of these relationships is relatively weak, at higher speeds, there are stronger negative significant relationships between enjoyment and all other factors (Task Difficulty: 50mph rho=-0.22, p<.01; 55mph rho=-0.30, p<.01; 60 mph rho=-0.41, p<.01; Feelings of Risk: 50mph rho=-0.23, p<.01; 55mph rho=-0.29, p<.01; 60mph rho=-0.38, p<.01; Probability of Loss of Control: 60mph rho=-0.26, p<.01).

Given the negative relationship between enjoyment and task difficulty from 50mph upwards, results from analysis of ratings on the residential road would provide support for hypothesis IV which stated that at higher speeds, enjoyment will be negatively related to task difficulty whereby as task difficulty increases, enjoyment will decrease.

*3.3.5.2: Bendy Country road*

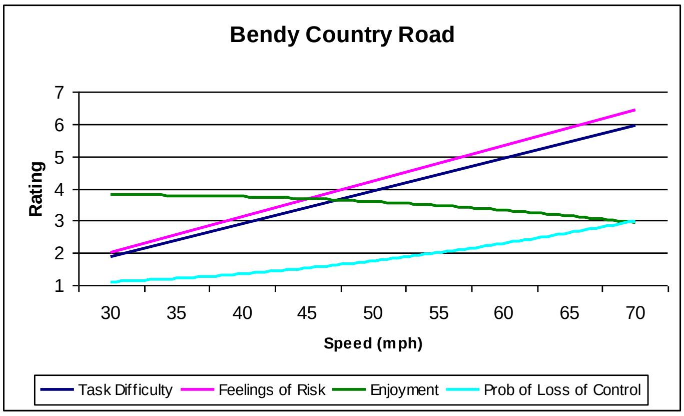



*Figure 3.8: Overall mean ratings of Task Difficulty, Feelings of Risk, Probability of Loss of Control and Enjoyment by speed for the bendy country road*

For the bendy country road, the relationship of enjoyment mean ratings across speed can be compared to task difficulty, feelings of risk and the probability of loss of control in Figure 3.8. Enjoyment again appears to have an alternative relationship with speed than that of the other factors. Participants' enjoyment ratings seem to have already peaked by the lowest speed measured and decline gradually as speed increases. Enjoyment crosses feelings of risk and task difficulty at around 45mph and as enjoyment continues to decrease, both other factors increase. Meanwhile, the pattern of probability of loss of control ratings across speed is almost the inverse of enjoyment ratings, converging at 70mph.

*Table 3.8: Bendy Country Road - Correlation coefficients of Enjoyment with Task Difficulty, Feelings of Risk and Probability of the Loss of Control ratings by speed (N=152)*

| *Speed (mph)* | *30* | *35* | *40* | *45* | *50* | *55* | *60* | *65* | *70* |
|---|---|---|---|---|---|---|---|---|---|
| Task Difficulty | -0.02 | -0.02 | **-0.17** | ***-0.28*** | ***-0.36*** | ***-0.49*** | ***-0.46*** | ***-0.52*** | ***-0.58*** |
| Feelings of Risk | 0.01 | 0.03 | -0.15 | ***-0.29*** | ***-0.38*** | ***-0.47*** | ***-0.48*** | ***-0.49*** | ***-0.52*** |
| Probability of Loss of Control | 0.00 | 0.02 | -0.04 | **-0.17** | ***-0.31*** | ***-0.36*** | ***-0.31*** | ***-0.35*** | ***-0.34*** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Spearman's rho correlations were carried out to test for the relationship between enjoyment and all other factors at each speed level on the bendy country road. Correlation coefficients are summarised in Table 3.8. At low speeds there are no significant correlations between enjoyment and any other factors. The relationship between enjoyment and task difficulty demonstrates a significant negative relationship from 40mph, increasing in strength as speed increases (40mph-70mph: rho=-0.17, p<.05 to rho=-0.58, p<.01). A similar relationship is found between enjoyment and feelings of risk (45mph-70mph: rho=-0.29 to rho=-0.52, p<.01); and the probability of loss of control (45mph-70mph: rho=-0.17, p<.05 to rho=-0.34, p<.01). The strength of the relationship between enjoyment and the probability of loss of control is lower than that of enjoyment and task difficulty or feelings of risk at all speeds.

The negative relationship between enjoyment and task difficulty increases in strength from 40mph upwards, providing evidence that the results from analysis of ratings on the bendy country road support hypothesis IV that at higher speeds, enjoyment will be negatively related to task difficulty whereby as task difficulty increases, enjoyment will decrease. It is of note, however, that a similar relationship is found with feelings of risk and the probability of loss of control ratings.

*3.3.5.3: Straight Country road*

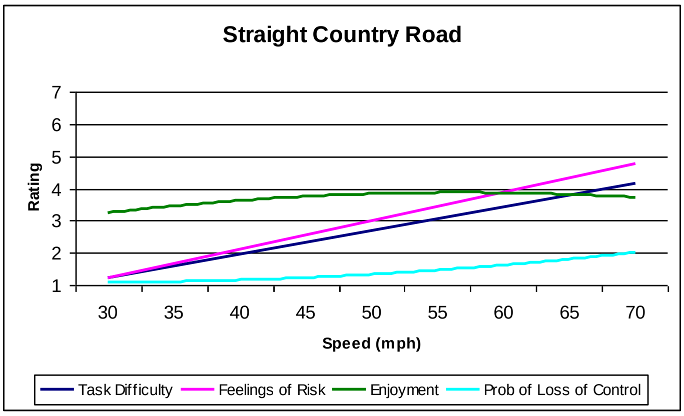



*Figure 3.9: Overall mean ratings of Task Difficulty, Feelings of Risk, Probability of Loss of Control and Enjoyment by speed for the straight country road*

Figure 3.9 shows the relationship of enjoyment mean ratings across speed compared to task difficulty, feelings of risk and the probability of loss of control. Enjoyment demonstrates a similar relationship with speed on the straight country road as that of the relationship for the residential road. Participants' enjoyment ratings rise with speed until peaking at around 55mph before declining gradually. Enjoyment crosses feelings of risk at around 55-60mph and task difficulty at around 65mph from which point, as enjoyment decreases, both other factors increase.

*Table 3.9: Straight Country Road - Correlation coefficients of Enjoyment with Task Difficulty, Feelings of Risk and Probability of the Loss of Control ratings by speed (N=152)*

| *Speed (mph)* | *30* | *35* | *40* | *45* | *50* | *55* | *60* | *65* | *70* |
|---|---|---|---|---|---|---|---|---|---|
| Task Difficulty | 0.10 | 0.06 | **0.18** | 0.05 | 0.05 | -0.04 | ***-0.25*** | ***-0.32*** | ***-0.46*** |
| Feelings of Risk | 0.08 | 0.11 | **0.20** | 0.05 | 0.02 | -0.07 | ***-0.26*** | ***-0.28*** | ***-0.46*** |
| Probability of the Loss of Control | ***0.29*** | ***0.27*** | ***0.23*** | 0.12 | 0.12 | 0.06 | -0.06 | -0.09 | **-0.17** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Spearman's rho correlations for enjoyment with all other factors across speed can be seen in Table 3.9. The table shows a minor significant positive relationship of enjoyment with task difficulty and feelings of risk at 40mph (task difficulty: rho=0.18, p<.05; feelings of risk: rho=0.20, p<.05). Significant positive correlations were also found with the probability of loss of control at low speeds (30mph rho=0.29, p<.01; 35mph rho=0.27, p<.01; 40mph rho=0.23, p<.01. At higher speeds (60-70mph), a significant negative relationship was found between enjoyment and task difficulty (60mph rho=-0.25, p<.01; 65mph rho=-0.32, p<.01; 70mph rho=-0.46, p<.01) and feelings of risk (60mph rho=-0.26, p<.01; 65mph rho=-0.28, p<.01; 70mph rho=-0.46, p<.01). A significant negative relationship between enjoyment and probability of loss of control was also found at 70 mph (rho=-0.17, p=<.05).

Given the negative relationship between enjoyment and task difficulty from 60mph upwards, results from analysis of ratings on the straight country road would also provide support for hypothesis IV which stated that at higher speeds, enjoyment will be negatively related to task difficulty whereby as task difficulty increases, enjoyment will decrease. Further, it would again appear that there is a similar relationship between enjoyment and feelings of risk, which is unsurprising given the close relationship between task difficulty and feelings of risk established in Hypothesis I.

### *3.3.5.4: Dual Carriageway*

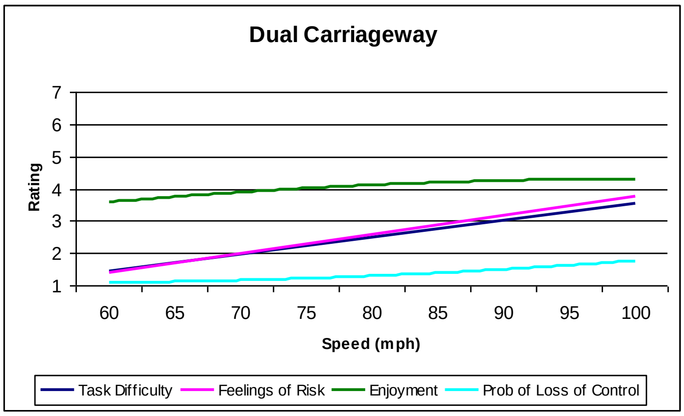



*Figure 3.10: Overall mean ratings of Task Difficulty, Feelings of Risk, Probability of Loss of Control and Enjoyment by speed for the dual carriageway*

Figure 3.10 shows the relationship of enjoyment mean ratings across speed compared to task difficulty, feelings of risk and the probability of loss of control for the dual carriageway. Enjoyment appears to rise gradually with speed reaching a plateau around 90-100mph. The speeds measured within the current study do not continue past 100mph to establish at what speed enjoyment may begin to decline. Enjoyment remains high at all speeds whilst never crossing task difficulty or feelings of risk at the speeds measured.

*Table 3.10: Dual Carriageway Road - Correlation coefficients of Enjoyment with Task Difficulty, Feelings of Risk and Probability of the Loss of Control ratings by speed (N=152)*

| *Speed (mph)* | *60* | *65* | *70* | *75* | *80* | *85* | *90* | *95* | *100* |
|---|---|---|---|---|---|---|---|---|---|
| Task Difficulty | 0.07 | 0.10 | 0.08 | 0.01 | -0.16 | -0.13 | ***-0.35*** | ***-0.34*** | ***-0.38*** |
| Feelings of Risk | 0.11 | 0.13 | 0.14 | 0.11 | -0.06 | -0.10 | ***-0.28*** | ***-0.26*** | ***-0.34*** |
| Probability of the Loss of Control | 0.05 | **0.16** | **0.16** | 0.13 | 0.04 | -0.04 | -0.11 | **-0.22** | **-0.21** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Spearman's rho correlations for enjoyment with all other factors across speed can be seen in Table 3.10. The table shows no significant relationships between enjoyment and task difficulty or feelings of risk until 90mph. From 90-100mph, there are significant negative relationships between enjoyment and task difficulty (90mph rho=-0.35, $p<.01$; 95mph rho=-0.34, $p<.01$; 100mph rho=-0.38, $p<.01$) and feelings of risk (90mph rho=-0.28, $p<.01$; 95mph rho=-0.26, $p<.01$; 100mph rho=-0.34, $p<.01$). The relationship between enjoyment and the probability of loss of control shows both a positive relationship (65mph rho=0.16, $p<.05$; 70mph rho=0.16, $p<.05$) at lower speeds and a negative relationship at higher speeds (95mph rho=-0.22, $p<.05$; 100mph rho=-0.21, $p<.05$).

In summary, hypothesis IV stated that at higher speeds, enjoyment will be negatively related to task difficulty whereby as task difficulty increases, enjoyment will decrease. The results of analysis on all road types suggest that the fourth hypothesis has been supported. At high speeds, enjoyment does appear to have a negative relationship with task difficulty. This pattern is demonstrated on all road types. The results therefore also support earlier motorcycle research (Broughton, 2007). Further exploratory analysis of the enjoyment measure can be found in Appendix 3F and includes the following:

*I. Enjoyment by experience level*
*II. Enjoyment in relation to speed by experience level*
*III. Enjoyment in relation to task difficulty and risk by experience level*

Of the further analysis, it may be noteworthy that enjoyment ratings differ slightly by experience group, although only significantly on the residential road. In addition, enjoyment levels peak at different speeds by experience group, with inexperienced drivers' enjoyment peaking at higher speeds on all road types (with the exception of the dual carriageway where no peak could be established for the inexperienced and experienced groups).

## 3.4: Discussion

The present study aimed to replicate and extend the understanding of results reported by Fuller et al. (2008a). The key finding reported by Fuller et al. (2008a) was that participants rated their feelings of risk as they would the difficulty of the task. Furthermore, both were related to increases in speed. The current results support the original findings and further validate this interaction. It was also found that this relationship was consistent across different road types and driver experience levels thus suggesting that it is not mediated by driving experience.

### *3.4.1: Task difficulty, feelings of risk and speed*

It is of interest that although the strength of the relationship between task difficulty and feelings of risk is strong even at low speeds, it appears to become stronger as speed increases. It is, however, influenced by the environment and the type of road being driven on, suggesting a relationship with speed sensation rather than with absolute speed itself. In terms of the Task-Capability Interface model (Fuller, 2005a), the increases in speed would push task demand closer towards capability and reduce the driver's safety margin. It would therefore be logical that as a driver's safety margin is reduced, the relationship between the sensation of risk and the demand of the task is required to be more exact. This could be an area for further investigation.

### *3.4.2: Objective risk estimate*

The current study did not find support for the notion that objective risk estimates will only increase after a threshold is reached. This could be for a number of reasons, although notably that the use of a differently worded question may be measuring a slightly different response. For example, the original study asked for the probability of an accident or loss of control, whereas the present study asked for only the probability of loss of control. The more sensitive measure of 0-100 compared with the original 0-30 may also have had an influence. The more sensitive scale could explain the very gradual increase of the measure which may have been disguised as a zero response in the initial experiment. Further study may wish to investigate this area further to clarify participants' responses to measures of objective risk estimate.

While no speed threshold of probability of loss of control estimate was found within the data and instead there were gradual increases with speed, probability of loss of control was not related to task difficulty in the way feelings of risk were. The key point to note is that if drivers were to use probability of loss of control estimates to deduce the risk of the driving task then they would not have accurately determined the demand characteristics of the task.

### *3.4.3: Objective risk estimate by experience level*

Previous research has also found that objective risk estimates are dissociable to other forms of risk perception, notably hazard perception (Farrand and McKenna, 2001). It is therefore intriguing that driver experience demonstrated a significant difference in response to the probability of loss of control estimate, on all road types. In addition, inexperienced drivers rated this factor similar to that of learner drivers, which was significantly different to the experienced group for the residential road, straight country road and bendy country road. On all road types, experienced drivers' ratings were lower than those of the other two groups. These findings would compliment results of previous risk perception research which also used a 0-100 scale to measure helicopter pilots objective risk estimate of potential incidents (Thomson, Onkal, Avcioglu & Goodwin, 2004). In all thirteen incidents measured, expert pilots rated the risk as lower than that of novice pilots, although only four reached a level of significance. Experts' judgements of the risky incidents were found to be more veridical suggesting that their objective risk estimates were more accurate than those of the novice pilots. It is therefore interesting in the current study that although experienced drivers' objective risk estimates are more accurate, their ratings of feelings of risk are completely different. This would further suggest that the two perceptions of risk are distinct.

### *3.4.4: Task-Capability Interface (Fuller, 2005a)*

These findings can be theoretically discussed in terms of drivers' information processing system. The TCI suggests that information processing is performed within the 'comparator' ensuing in a decision that defines drivers' behavioural outcome. The current results could therefore postulate that within the 'comparator', experienced drivers rely less on a cost-benefit analysis of the situation than less experienced drivers. Cost-benefit analysis is obviously more taxing and takes longer to process (Gilovich, Griffin & Kahneman, 2002), therefore, it would be advantageous for the driving task to become more of an automated procedure as a person gains the experience of doing so. As with learning any advanced skill, this would rely on the premise that automated and faster decision making must be learnt through experience of the task (Slovic, Finucane, Peters & MacGregor, 2004). Existing driver behaviour literature certainly advocates that there is an important learning period for drivers, which intriguingly is not during the official learner stage of the licensing system, but begins once a person gains their driving licence.

As discussed in Chapter One, research suggests initial post-test solo driver experience is crucial to the reduction of drivers' crash risk (see Figure 1.4, page 12), although it can not report exactly why (Twisk, 2006; Maycock, 2002; Maycock et al., 1991; Forsyth et al., 1995). Meanwhile, education and training of inexperienced drivers has failed to be effective as a substitute for this crucial stage (Christie, 2001). Within the early period of solo driving, it would appear that through experience of the task, drivers are continuing to learn a very important component of driving that reduces their crash risk and increases their ability to drive safely. Hence, could it be that through this experience, drivers learn to rely less on cost-benefit analysis and instead on their feelings of risk?

With feelings of risk relating to both task difficulty and speed, this method of appraising risk is worthy of further investigation. Relations between task difficulty and measures akin to feelings of risk have been demonstrated before. In the research discussed in Chapter Two (page 54) by Grayson et al. (2003), it is reported that both the initial questionnaire and practical element of the study measured participants' ratings of difficulty and danger to driving scenarios. Assuming that the measure of danger is comparable to a measure of feelings of risk, a similar relationship was found to that of the current study as these two factors were strongly correlated ($r=0.63$, $P<.001$). Furthermore, like the results of the current study, the correlation was stable across experience and age groups, which is reported with an intimation of surprise by the authors. The same significant correlation coefficient was later found from the large scale survey of 1340 participants when asked for ratings of difficulty and danger to five driving scenarios (Grayson et al., 2003).

### *3.4.5: Driver behaviour models*

The relationship between task difficulty and feelings of risk, even at low speeds, contradicts the zero-risk model and the views of Naatanen and Summala (1973), who stated:

> "…we have chosen to call this agent "Subjective Risk Monitor" instead of "Subjective Risk" to express the conception that most of the time on the road the subjective risk of the driver equals nil…" (p253)

Of course, whether a driver utilises their feelings of risk or danger at low levels can not be determined from the present study, but it has been shown that it is certainly being appraised. The results in relation to Wilde's (1982) theorising suggest that whilst he was correct to expose 'experienced risk' as a critical determinant of driver behaviour, it was incorrect to assume that this was the same as drivers' perception of objective risk. Drivers in the current study, and in Fuller et al.'s (2008a) study, rated these appraisals of risk differently. The results would, however, support Vaa's (2004) Monitor Model. Vaa purports that the human being acts as a monitor, constantly appraising his/her surroundings and drive so as to achieve and maintain a target best feeling. The current study demonstrates that feelings of risk are constantly being appraised therefore providing support for this notion. The concurrent finding that this strongly correlates with task difficulty brings the monitor model and the task-capability interface onto parallel paths, to which Fuller et al. (2007) have alluded. It is suggested that the task difficulty homeostasis could be rephrased in terms of feelings of risk, therefore implying that drivers drive so as to maintain feelings of risk within an accepted range, a very analogous suggestion to that of Vaa (2004).

Fuller (2005b) discusses the theoretical implications of the results of Fuller et al. (2008a) and points towards the neurological work of Damasio (1994, 2003), which underpins Vaa's (2004) monitor model. It is suggested that if sensations of risk provide the driver with the information required to determine the difficulty of the task, then this should influence drivers' decision making process and behavioural response. Damasio's (1994, 2003) work provides the basis to explain and support such a process. As noted within the discussion of Vaa's (2004) model in Chapter Two (page 56), Damasio (1994, 2003) advocates the role of feelings in decision making. From extensive work of patients with brain lesions, Damasio (2003) concludes that feelings and emotions provide an innate resource for the human to appraise the environment and respond adaptively. It is proposed that when certain stimuli or patterns of stimuli are sensed and have been previously associated with a feeling, that this association will unconsciously or consciously direct attentional resources, biasing decision making. The application of this theory to the realm of driver behaviour is certainly worthy of additional enquiry.

#### *3.4.6: Enjoyment*

The negative correlation between enjoyment and all other measures at higher speeds suggests that enjoyment may play some part in drivers' speed choice, although the current study could not purport to fully support this claim. Enjoyment could be as much a result of a driver's speed choice as it is an influence. The results do, however, support previous reported findings with motorcycle riders by Broughton (2007), that enjoyment is negatively related to task difficulty at high speeds.

### *3.4.7: Limitations of the current study*

The results of the enjoyment measure have inadvertently provided validation of the relationship between task demand and feelings of risk. One of the major concerns regarding the results of this experiment and Fuller et al. (2008a) is that task difficulty and feelings of risk are being examined using a common method, hence, a participant's response may be influenced by Common Method Bias (Doty & Glick, 1998). Common Method Bias occurs when the same process is used within a questionnaire to measure correlations between variables (Schwarz, Schwarz & Rizzuto, 2008), however, opinion is divided about the actual effect of Common Method Bias (Doty & Glick, 1998; Lindell & Whitney, 2001). While some argue that Common Method Bias accounts for one of the primary sources of measurement error (Podsakoff, MacKenzie, Lee & Podsakoff, 2003), others believe that the impact of Common Method Bias has been over-rated (Spector, 2006). With regards to the current study, task difficulty, feelings of risk and enjoyment were all measured with a common method. Given that participants' enjoyment ratings differ from those of task difficulty and feelings of risk suggests that any effect of Common Method Bias was minimal.

A further concern of the current study is that it suffers from the traditional problems associated with self-report questionnaires. Self-reporting involves trusting that participants are answering honestly, and that their judgement is accurate (Barker, Pistrang & Elliot, 1995). Ratings of task difficulty in the current study are not verified by any other measure and must rely on the self-report only. Similarly, analysing feelings of risk by way of self-report is also problematic. Feelings are an affective human response and are often difficult to cognitively appraise and report (Parkinson & Manstead, 1993). The results of the present study must therefore be appreciated within this methodological context. Further study could consider use of a psychophysiological response to determine a measure of emotional activity.

## 3.5: Chapter Three Summary

**In testing the concepts of the Task-Capability Interface (Fuller, 2005a), Fuller et al. (2008a) gained participants' responses of task difficulty, feelings of risk and objective risk estimate to video clips of driving sequences shown at different**

**speeds. They reported the surprising result that participants' ratings of feelings of risk tracked their ratings of task difficulty almost exactly.** Objective risk estimate, meanwhile, only increased in relation to speed after some threshold had been reached. Whilst intriguing, replication and extension of the results was required as well as addressing other areas of critique.

**The aim of Chapter Three was, therefore, to replicate Fuller et al.'s (2008a) study using new stimuli. In addressing one of the main areas of critique, participants of different driving experience were sought.** The comparison of learner, inexperienced and experienced drivers' scores was anticipated to demonstrate a difference in response to either task difficulty, feelings of risk or probability of loss of control (objective risk estimate). A further measure of enjoyment was also added to the experiment.

### *3.5.1: Experimental findings*

Results provided support for Fuller et al.'s (2008a) finding that feelings of risk, task difficulty and speed were highly correlated. There was no support, however, for the finding of a threshold after which objective risk estimate rose with further increases in speed. Possible reasons for this were discussed. Comparison of experience levels demonstrated no difference in ratings of task difficulty or feelings of risk, but did find significant differences on the measure of probability of loss of control. Meanwhile, ratings of enjoyment appeared independent of all other measures until high speeds when a negative relationship ensued as enjoyment decreased. The results of the enjoyment measure provided inadvertent validation that the relationship between task difficulty and feelings of risk was not the result of Common Method Bias.

### *3.5.2: Theoretical implications*

**Theoretically, the results of this study suggest that feeling risk may be an important part of the information processing which would take place in what Fuller (2005a,b) terms the 'comparator'. The difference in objective risk estimate by experience level suggests that novice drivers may be relying on a cost-benefit analysis of risk rather than their feelings of risk, although results suggest that novice drivers can sense risk in the same way as experienced drivers.**

**If novice drivers utilise cost-benefit analysis rather than feelings of risk then they will be poorly calibrated to the difficulty of the task.**

The results support the theoretical nature of Vaa's (2004) Monitor Model and brings the TCI into line with it. Both authors have discussed Damasio's (1994, 2003) Somatic Marker Hypothesis and its potential application to driving. Discussion of this work would therefore be the next obvious step in the current thesis's aim to investigate the psychological nature of the novice driver problem. Chapter Four will therefore provide a review of associated literature that may help explain the findings from Chapter Three and provide a further basis from which to conduct scientific enquiry.

# Chapter Four

## Exploring current theory and driving: A literature review

**Chapter Four Outline**

## 4.1: Introduction

Four results from Chapter Three stand out for further consideration and enquiry:

I. The finding that task difficulty and feelings of risk were highly correlated, similar to the results of Fuller et al. (2008a).
II. There was no difference by experience level on measures of task difficulty and feelings of risk.
III. Participants' rate subjective risk (feelings of risk) differently to subjective risk estimates of objective risk (probability of loss of control).
IV. Finally, differences were found by experience level on the rating of objective risk estimate which could suggest inexperienced drivers rely more on cost-benefit analysis of risk when driving rather than feelings of risk.

This chapter does not address these findings in order but instead will discuss literature which may assist in providing a theoretical context from which to understand them. In the summary of the chapter, these findings will be discussed in relation to the literature covered in the chapter.

The results of Chapter Three meant that the key area for further investigation in relation to the Task-Capability Interface model (Fuller, 2005a) is the Comparator (see Figure 4.1). In Chapter Two it was discussed that this was a main area of weakness for the model as it was not understood what was processed here. How does the input of task difficulty get processed and result in a decision and behavioural response? To answer this requires looking to other subject areas, like decision making research.

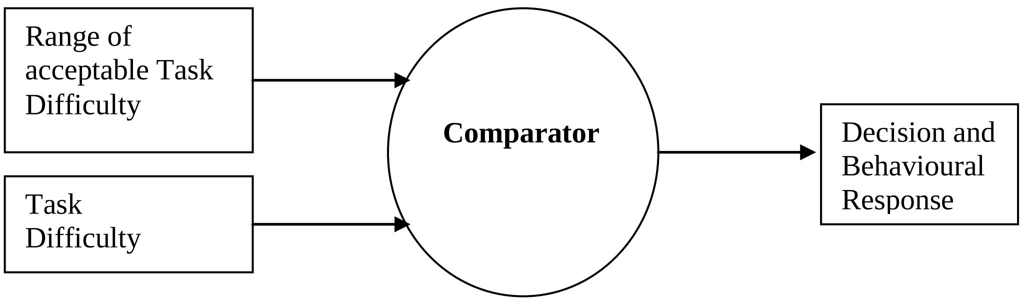



*Figure 4.1: Section of Task Difficulty Homeostasis (Fuller, 2005b), extracted from full model which can be seen on page 65*

### *4.2: Affect and Decision Making: A 'Hot' Topic*

Decision making literature long discussed decision making in terms of rationality and reasoning (Shafir, Simonson & Tversky, 1993). There was good reason for this given that much of the decision making literature was aimed at economics, whereby decisions generally have to be justified and bad decisions are financially costly (Bechara & Damasio, 2005). Within even economics, however, there has been a recent change of focus in the decision making literature. Whereas emotional involvement in decision making was originally dismissed and considered as a cause of irrationality, the field of judgement and decision making has more recently embraced the role of 'affect' (Peters, Vastfjall, Garling & Slovic, 2006).

Explaining exactly what is meant by 'affect' is not as simple as it first appears, demonstrated by the definition given by Bennett and Hacker (2003, p199):

> "Affections can be roughly subdivided into emotions, agitations and moods… Affections are *feelings*. One can be said to feel love or hate (emotions), to feel excited or astonished (agitations), and to feel cheerful or depressed (moods). But the feelings that are affections are categorically distinct from the feelings that are sensations, which unlike affections, have a bodily location and may inform one about the state of one's body. They are similarly distinct from the feelings that are modes of tactile perception, which, unlike affections, enable one to detect or apprehend features of one's environment. And they are distinct from the feelings that are appetites…"

Whilst the exact philosophical underpinnings of affect could be discussed at length, it is sufficient for the present thesis to utilise a more simplistic explanation of affect. Slovic, Finucane, Peters and MacGregor (2002) assert that affect is a state of feeling, with or without conscious recognition. It is further stated that affective responses occur rapidly and automatically. Whilst Bennett and Hacker (2003) disagree with the general use of the term affect simply representing 'feeling', it is practical for use within the current context. Further definitions of emotions and feelings will be discussed in this chapter, however, where the term 'affect' is used it will denote Slovic et al.'s (2002) simplified meaning of being a reference to human feeling.

Peters et al. (2006) define four roles that affect can play in decision making: first, affect can act as information at a moment in which a choice must be made (i.e. How do I feel about this?); second, affect serves as a common currency allowing us to compare the value of very different options, enabling complex decisions to be simplified into the value of feelings (i.e. Which option feels best?). The third role involves how different types (e.g. anger or fear) and strengths of affect can influence decisions. Finally, affect appears to function as a motivator of information processing and behavioural response. With regards to driving, it is probably the last of these roles that is of interest. Whilst drivers will make deliberative decisions relating to roles one to three, for example, regarding what car to buy and what route to take, the psychological processes involved in continuous driving are likely to be more automated. This separation of reasoned versus automated processes is something which is referred to by Slovic & Peters (2006) in relation to risk appraisal.

### *4.3: Risk perception and affect*

Slovic and Peters (2006) suggest that risk is processed in two fundamental ways: risk as analysis and risk as feelings. The 'analytic system' uses logic and normative rules, such as the probability calculus and risk assessment. It is relatively slow requiring effort and conscious control (Slovic et al., 2004).

> "The 'experiential system' is intuitive, fast, mostly automatic, and not very accessible to conscious awareness. The experiential system enabled human beings to survive during their long period of evolution and remains today the most natural and most common way to respond to risk. It relies on images and associations, linked by experience to emotion and affect (a feeling that something is good or bad). This system represents risk as a feeling that tells us whether it is safe to walk down a dark street."
> (Slovic et al., 2004, p311).

In relation to driving, it would not be out of place to reword the last sentence as, 'This system represents risk as a feeling that tells us whether it is safe to continue driving at a certain speed'. These two definitions of risk assessment could be applied to the findings from Chapter Three whereby risk measured by feelings was found to be distinct from risk measured as probability. It could further explain how novice drivers may rely more on the analytic system whereas experienced drivers are able, by way of their experience, to determine risk by the experiential system. A comparison of factors involved in the Experiential and Analytic systems can be seen in Table 4.1.

*Table 4.1: Comparison of the Experiential and Analytic systems from Slovic et al. (2004)*

| Experiential System | Analytic System |
|---|---|
| 1. Holistic | 1. Analytic |
| 2. Affective: pleasure-pain oriented | 2. Logical: reason oriented (what is sensible) |
| 3. Associationistic connections | 3. Logical connections |
| 4. Behavior mediated by "vibes" from past experiences | 4. Behavior mediated by conscious appraisal of events |
| 5. Encodes reality in concrete images, metaphors, and narratives | 5. Encodes reality in abstract symbols, words, and numbers |
| 6. More rapid processing: oriented toward immediate action | 6. Slower processing: oriented toward delayed action |
| 7. Self-evidently valid: "experiencing is believing" | 7. Requires justification via logic and evidence |

Epstein (1994) believes these two systems work in parallel and refers to affect as being subtle feelings which are intimately associated with the experiential system. It is further stated that affect has a major motivating factor in behavioural response – a position supported by other authors including LeDoux (1996) and Zajonc (1980). Zajonc (1980) was one of the earliest proponents of affect in decision making and argued that affective reactions to stimuli in our environment are often the very first, occurring automatically and subsequently guiding information processing and behaviour.

Slovic et al. (2002, 2004) claim that central to the experiential system is 'the affect heuristic'. The affect heuristic simply refers to the way in which a feeling that has been previously associated with a stimulus will influence a person's judgement the next time they encounter that stimulus. An experiment by Denes-Raj and Epstein (1994) demonstrates the experiential system and affect heuristic in an empirical setting. Participants were given the chance to win $1 by simply picking a red bean from a bowl of white beans. In a small bowl of beans 10% of the beans were red, whereas in a large bowl of beans, only 5% were red. Despite the fact that participants had a lower ratio chance, there was a tendency to pick from the large bowl.

Participants reported that although they knew that the probabilities were against them, the larger bowl made them feel like they had a better chance. The authors, and Slovic et al. (2002, 2004), suggest that the positive affect associated with winning influenced participants behaviour and demonstrated that there is a difference in rational deliberative judgement and affect biased judgement that influences behavioural outcomes. Similar experimental evidence of affect influencing risk perception has been found (e.g. Alhakami & Slovic, 1994, Jenni & Loewenstein, 1997; Finucane, Alhakami, Slovic & Johnson, 2000) and can be seen summarised in Slovic et al. (2002, 2004). A criticism of the affect heuristic, however, is that the majority of support is laboratory based, which could be a reason why Slovic et al. (2004) promote the Somatic Marker Hypothesis (Damasio, 1994) as neurological support for the affect heuristic. As noted in Chapters Two and Three, both Vaa (2004) and Fuller (2005b) have promoted the investigation of the Somatic Marker Hypothesis as applied to driving.

## 4.4: Background to the Somatic Marker Hypothesis (SMH) (Damasio, 1994)

The background to the development of the Somatic Marker Hypothesis is based on clinical reports of patients with damage to certain brain regions. It is therefore of interest to consider the context from which the theory originated. Damasio (1994) tells of how modern day patients with inexplicable disorders led to the realisation of the importance of the historical tale of Phineas Gage.

### *4.4.1: The story of Phineas P. Gage*

In 1848, Phineas P. Gage, a twenty-five year old construction foreman, was working on building a new railway across Vermont, USA. Gage was apparently a very thorough man who took his job seriously and was a good leader of his men (Harlow, 1868). It was noted that he was 'the most efficient and capable' man employed by the Rutland & Burlington Railroad Company (Harlow, 1868). Much of the work carried out involved clearing rocks by explosive to make a path for the railroad. This process involved drilling a hole in the rock, packing it with explosive, inserting a fuse, packing sand on top of the explosive (hence the explosion would be aimed into the rock rather than out of the hole), lighting the fuse and standing back. The tool used to pack the sand into the hole was an iron rod. The iron rod, as seen in Figure 4.2, was thirteen and a quarter pounds in weight, three feet seven inches in length and was tapered at one end starting at one quarter of an inch in diameter.

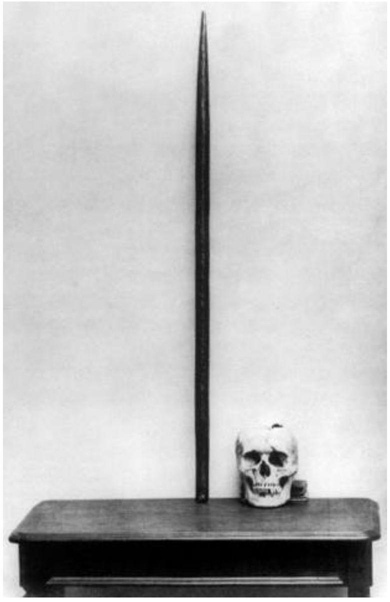


*Figure 4.2: The skull of Phineas Gage and the tampering iron, now on display in the Warren Anatomical Museum at Harvard University School of Medicine*

One afternoon at around 4.30pm, after packing a hole with explosive, Gage instructed a co-worker to fill the hole with sand and was simultaneously distracted by another worker. Turning back to his task, Gage started to pack using the iron rod – but the sand had not been added yet. A spark ignited an explosion that sent the iron rod (tapered end first) up through Phineas Gage's left cheek, through the front of his brain and out through the top of his skull (see Figure 4.3).

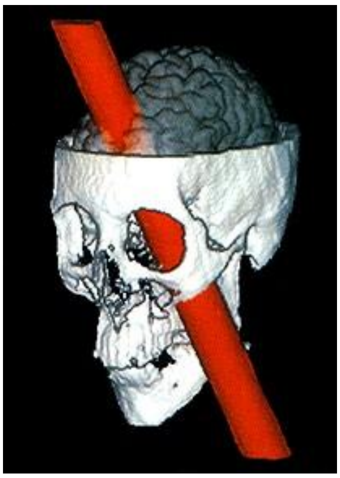


*Figure 4.3: Computer generated model of the impact of the injury to Phineas Gage (Damasio, Grabowski, Frank, Galaburda & Damasio, 2005)*

Amazingly, Gage was chatting to co-workers and locals about what happened only hours later and was pronounced cured in less than two months. However, while the wound may have physically healed, Phineas Gage would never be the same. After this incident Gage went back to work but friends and colleagues soon reported that 'Gage was not Gage'. His job was terminated and this onset a sad tale of the next thirteen years whereby he moved around holding jobs for only short periods of time and even searched as far as Chile to find happiness. Unfortunately, his life ended in San Francisco in 1861, not long after falling to the social depths of being a circus exhibit along with the iron rod that he had kept all this time.

This story and the medical transcripts were of interest to Damasio (1994) after being referred a patient with a comparable tale of social woe following surgery to a similar region of the brain damaged in Gage's accident. Using powerful computer programmes and Gage's skull, Damasio, Grabowski, Frank, Galaburda & Damasio (2005) were able to recreate the iron rod's exact angle of impact on Gage's brain hence locating the exact area damaged, as can be seen in Figure 4.3. Damasio et al. (2005) concluded that the iron rod caused most damage to the left hemisphere on the anterior sectors of the frontal lobe. Of most interest was that damage was caused to the ventromedial prefrontal region which has been linked to normal decision making in other research (see Damasio, 1994).

### *4.4.2: Elliot*

The patient mentioned above is named 'Elliot' in the book 'Descartes' Error: Emotion, Reason and the Human Brain' (Damasio, 1994). The story given by Damasio (1994) regarding Elliot's life runs somewhat similar to that of Gage. Elliot had been a good husband and father, had a responsible job in business and was a role model figure for his children and colleagues (Damasio, 1994). Sadly, severe headaches were diagnosed as a meningiomas brain tumour growing on his frontal lobe. Surgery removed the tumour and some surrounding brain tissue and was successful. Similar to Gage, the ventromedial sector of the frontal lobe had been damaged. Elliot suffered no hindrance in physical movement, memory or language – but family and work colleagues reported that 'Elliot was not Elliot'.

Elliot went back to work with all previous knowledge intact, but could not be counted on to carry out the appropriate action when required and his job was terminated. Other jobs came and went. Out of work, Elliot went ahead with strangely risky business ventures and lost his family's life savings. Elliot appeared to have an inability to heed advice from friends and family and a divorce ensued, followed by another. Elliot became a drifter, much like Gage almost 150 years earlier. To compound Elliot's problems, he was refused social security because he did not appear to suffer any clinical disability (Damasio, 1994).

Previous institutions had failed to find any problems with Elliot on a battery of standard intelligence tests. Damasio (1994) further found that Elliot performed superior or average on all subtests of the Wechsler Adult Intelligence Scale. No problems were found in tests of perceptual ability, past memory, short term memory, new learning, language or arithmetic abilities. Another test used to detect damage to the frontal lobe region, the Wisconsin Card Sorting Test, also failed to find any irregularities. Finally the Minnesota Multiphasic Personality Inventory (MMPI) was administered and again found no irregularities (Damasio, 1994). That Elliot had passed all clinical tests presented a dilemma: what was Elliot's problem and how could it be measured and understood?

A lengthy discussion with Elliot apparently provided some enlightenment (Damasio, 1994). Whilst Elliot talked through the recent tragic events of his life, he did so without emotion, describing scenes in the role of a dispassionate, uninvolved spectator. Damasio (1994, p44) writes:

> "Elliot was exerting no restraint whatsoever on his affect. He was calm. He was relaxed. His narratives flowed effortlessly. He was not inhibiting the expression of internal emotion resonance or hushing inner turmoil. He simply didn't have any turmoil to hush."

Investigation into cognitve moral and social judgement found that Elliot could perform perfectly normally. With knowledge of moral and social judgement confirmed, it was concluded that Elliot was to *know* but not to *feel*. If Elliot's problem was that he simply could not process emotion, how had this led to a deterioration of his ability to make the right choices in life?

Drawing on separate evidence throughout history, like Phineas Gage, Damasio (1994, 2003) compiled medical reports of patients that elicited similar stories after damage to the ventromedial prefrontal area of the frontal lobe. As the result of neurological investigation, Damasio (1994, 2001, 2003) concludes that there appears to be a collection of systems in the human brain that are dedicated to the goal-orientated thinking process we call reasoning, and to the response selection we call decision making, both with a special emphasis on the personal and social domain. Further to this, the same collection of systems is also involved in emotion and feeling, and is partly dedicated to processing body signals (Damasio, 2003).

Other authors have since reported dealing with patients similar to those discussed by Damasio (1994, 2003). Dimitrov, Phipps, Zhan and Grafman (1999) report another case of a patient with similar impairments to Phineas Gage in their paper 'A Thoroughly Modern Gage'. Stone (2005) reports of experiences with patients who tell tales of making poor judgements. Patients suffering damage to frontal lobe regions, specifically the orbitofrontal or ventromedial prefrontal cortex (VMPF) areas, are often reported to make inappropriate comments and jokes, particularly sexual ones, make poor choices in personal relationships and have difficulty with the pragmatics of conversation (Stone, 2005; Eslinger & Damasio, 1985; Bechara & Damasio, 2005, Miller & Cummings, 2006). Support for the role of this brain region in social processing has been found through research with monkeys with the finding that monkeys who are 'socially well tuned' and exhibit displays of cooperation and grooming have extremely high numbers of serotonin-2 receptors in the ventromedial frontal lobe and the amygdala. For monkeys who are reported as being non-cooperative and antagonistic, the opposite is true (Raleigh & Brammer, 1993).

The result of dealing with patients, like Elliot, and the consequent research led Damasio (1994) to formulate the Somatic Marker Hypothesis.

**4.5: The Somatic Marker Hypothesis (SMH) (Damasio, 1994)**

The somatic marker hypothesis evolved to explain the failings of the patients described above. Their failure to make advantageous decisions and an inability to recognise emotion suggested a defect in a socio-emotional system that signals the potential consequences of an action and subsequently assists in the selection of an advantageous behavioural response. Deprived of an emotional input into decisions, these patients must rely on a cost-benefit analysis which degrades the speed of deliberation and the adequacy of the choice (Damasio, 2003).

Before describing the theory, it is important to note that Bechara and Damasio (2005) define that emotions and feelings are different in terms of physiological make up. An emotion is defined as 'a collection of changes in body and brain states triggered by a dedicated brain system that responds to specific contents of one's perceptions, actual or recalled, relative to a particular object or event' (Bechara & Damasio, 2005, p 339). An 'emotionally competent' stimulus will cause a change in somatic (bodily) state ranging from endocrine release, heart rate change and muscle contraction to facial expression, freezing, and fight or flight. Physiological responses will lead the brain to respond by releasing neurotransmitters through the central nervous system, activate somatosensory maps or modify the transmission of signals from the body to the somatosensory regions (Bechara & Damasio, 2005).

> "The ensemble of all these enacted responses in the body proper and in the brain constitutes an *emotion*. The ensemble of signals as mapped in somatosensory regions of the brain itself provide the essential ingredients for what is ultimately perceived as a *feeling*, a phenomenon perceptible to the individual in whom they are enacted (Damasio, 1999, 2003)"
> (Bechara & Damasio, 2005, p339)

Damasio (1994, 2003) argues that the basis of the SMH is that unconscious processes occur before reasoning and a cost-benefit analysis takes place. If, for example, a situation appears to be developing that could advance into something threatening or dangerous, a feeling of unpleasantness will be produced in the body (i.e. a gut feeling). Damasio (1994, 2003) labels this a 'Somatic Marker'; 'soma' being Greek for 'body'. It is a marker because this bodily feeling will be marked against the developing scenario so that the organism will learn that should this scenario begin to be built up again, the body can respond earlier (Damasio, 1994, 2003). This process is what has been labelled the Somatic Marker Hypothesis (SMH) (Damasio, 1994). Damasio (1994, p174) states:

> "Somatic markers (SM) are a special instance of feelings generated from emotions. Those emotions and feelings have been connected by learning to predicted future outcomes of certain scenarios. When a negative SM is juxtaposed to a particular future outcome the combination functions as an alarm bell…SMs may operate covertly (without coming to consciousness)"

The process put forward by Damasio (1994, 2003) is one of an evolved socio-emotional learning system that is utilised by humans to avoid danger within their environments. It would therefore appear likely that if such a socio-emotional process does exist then it could easily be applied to the driving scenario. As noted in earlier chapters, the basic task of driving involves the constant management of speed and direction in order to avoid collision. To do this, a driver must therefore predict how the current circumstances may change and whether action must be taken to alter speed choice or direction. An automated process would be advantageous in reacting earlier to predict and alter behaviour. As stated in the quote, the automated process is a learned development linking feelings to predicted future outcomes; this could theoretically explain why drivers require on-the-road driving experience to reduce crash risk. It would also complement the findings from Chapter Three that inexperienced drivers possibly rely more on conscious appraisal of risk rather than more automated processes learned by experienced drivers. Is it possible that inexperienced drivers have simply not had the opportunity to *learn* to associate 'somatic markers' with hazardous driving situations?

#### *4.5.1: The induction of a somatic state*

A somatic state can be induced by either a primary or a secondary inducer (Damasio, 2003). Primary inducers are innate or learned stimuli that cause positive or negative states. The introduction of a primary inducer into the environment will automatically trigger a somatic response, like encountering a snake whilst out walking. In addition, primary inducers are also concepts or knowledge that through learning and association can automatically elicit an emotional response (Bechara & Damasio, 2005). Given that driving is a relatively new human behaviour in evolutionary terms, it could be assumed that primary inducers when driving must be learned. The concept of a 'near miss' may be the type of scenario whereby a somatic state is associated with cues in the environment which preceded the event, although the process may be even more refined than this.

Secondary inducers are essentially memories, imaginations and thoughts that can induce a somatic response when brought to conscious attention. For example, the recollection of a 'near miss' may trigger the same physiological reaction of anxiety that was apparent at the time of the event.

Bechara, Damasio and Damasio (2003) suggest that the ventromedial prefrontal cortex (VMPC) and the amygdala are critical substrates in the neural system necessary for triggering primary and secondary inducers. The frontal lobes are considered by some to be an emotional control centre (Bechara & Damasio, 2005). There is no other part of the brain where lesions can cause such a wide variety of symptoms (Kolb & Wishaw, 1990). The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behaviour (Stuss & Knight, 2002). The executive functions that the frontal lobes have been associated with include the ability to recognise future consequences from current actions, anticipation, emotion regulation, reasoning and decision making and adaptiveness to new situations (Stuss & Knight, 2002). In humans, the frontal lobes are uniquely large in proportion to other areas of the brain when compared with other primates (Passingham, 2002).

The amygdala is an almond shaped structure that is located in the medial temporal lobes. The amygdala is seen as an important area in determining instant emotional responses (LeDoux, 1996). It is argued that the amygdala is an area that has evolved to provide humans with the 'fight or flight' response (Bechara & Damasio, 2005). Research suggests that this area processes emotional responses and information about reward and fear, passing on information to the prefrontal cortex, hippocampus and the sensory cortex (LeDoux, 1996).

## 4.6: The Iowa Gambling Task (IGT)

In order to provide empirical evidence for the somatic marker hypothesis, a colleague of Damasio's developed a laboratory based gambling task to mimic everyday decision making (Bechara, Damasio, Damasio & Anderson, 1994). The key feature of the Iowa Gambling Task (IGT) is that a person must forgo short-term gain for long-term profit. The task simply requires participants to select a card from one of four decks for 100 trials. Each card elicits a financial gain or loss, and unknown to the participant the decks are fixed with net gains and losses per ten cards, as can be seen in Figure 4.4. While the gain per card is high in decks A and B, a single loss is also large, resulting in a net loss per ten cards, therefore, these are considered disadvantageous 'risky decks'. The gain in decks C and D is not as large as decks A and B but the losses are much lower, hence, over a period of time choosing from these decks will result in profit. Decks C and D are referred to as advantageous decks (Bechara & Damasio, 2005). Bechara et al. (1994) claim that the task requires participants to utilise 'intuitive' decision making processes as cognitive calculation of financial gain or loss from the decks is impossible.

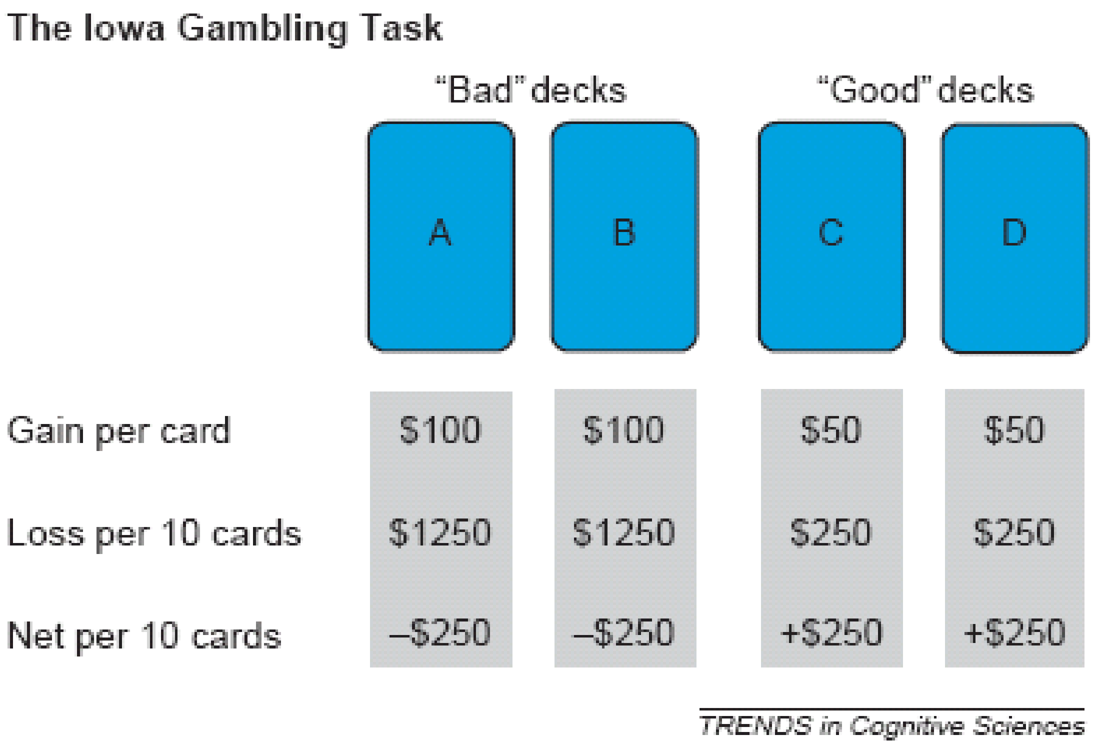



*Figure 4.4: Example of the Iowa Gambling Task and the gain and loss ratios (Bechara, Damasio, Tranel & Damsio, 2005)*

In the original version, participants would sit at a table with the four visibly identical decks of cards in front of them. Participants were then given $2000 facsimile US bills and told that the aim was to maximise their profit and avoid losses (Bechara et al., 1994). Participants were not informed how many trials (card turns) the experiment would entail although it was terminated after 100 trials. A similar computerised version has also been developed (Bechara, Damasio & Damasio, 2000).

A series of IGT experiments from 1994 on (Bechara et al., 1994; Bechara, Tranel, Damasio & Damasio, 1996; Bechara, Damasio, Tranel & Damasio, 1997; Bechara, Damasio, Damasio & Lee, 1999, Bechara et al., 2000) have provided much of the support and debate that surrounds the Somatic Marker Hypothesis. The earliest of these experiments was a tentative comparison of patients with ventromedial lesions (VM patients) with a control group and another group of patients with brain damage outside the VM area (Bechara et al., 1994). The experiment found that VM patients chose more from the disadvantageous decks and less from the advantageous decks than the control group. Patients with damage outside of the VM area performed similarly to healthy participants (Bechara et al., 1994).

Later experiments sought to retest these results and investigate them further. Bechara et al., 1997, 1999) compared control participants with VM patients and patients with amygdala lesions. The behavioural results demonstrated that after early sampling from all decks, the control group started to select primarily from the advantageous decks and avoid the disadvantageous decks. On the contrary, VM and amygdala patients failed to deviate away from the bad decks and continued to select from them throughout the experiment. The behavioural results can be seen graphically in Figure 4.5. The results of the VM and amygdala patients were intriguing because it was symbolic of their poor decision making in real-life.

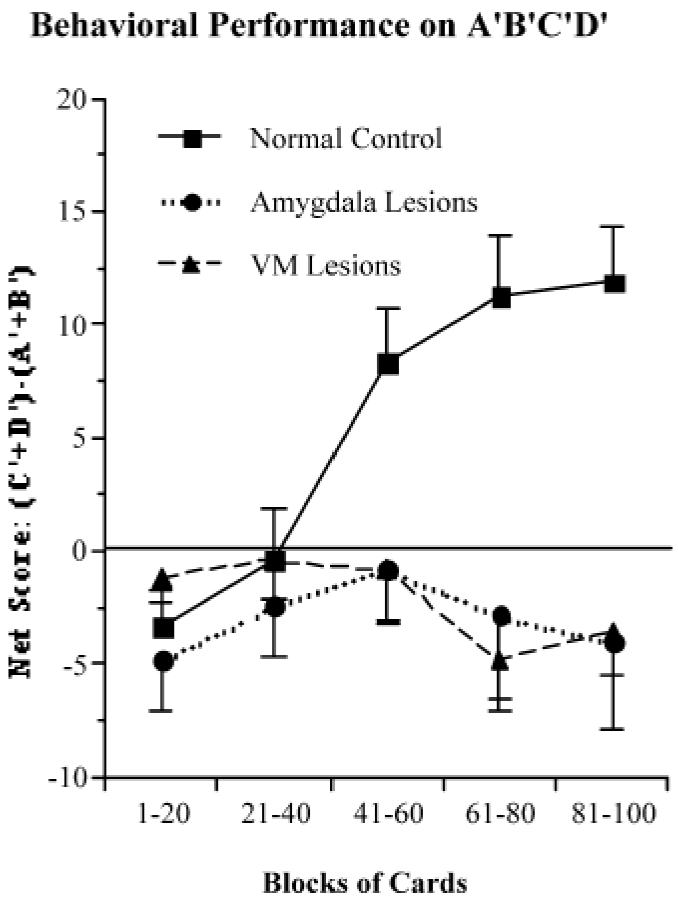



*Figure 4.5: Participants behavioural results (advantageous deck selections minus disadvantageous deck selections) as summarised in Bechara and Damasio (2005)*

In order for the experimenters to test for the role of emotion in decision making during the IGT, skin conductance response (SCR) was measured (Bechara et al., 1999). Skin conductance has been commonly used as a measure of minute physiological changes that can demonstrate an emotional or psychological response through the sympathetic component of the autonomic nervous system (Dawson, Schell & Filion, 2000) (further discussion of skin conductance can be found later in this chapter, page 139). Between card selections there were two distinct five second periods where SCR was measured: reward or punishment period and anticipatory period, as shown in Figure 4.6. Once a card selection was made, control participants demonstrated SCRs to a reward or punishment, as measured by the area under the SCR curve (Bechara et al., 1999). VM patients also demonstrated SCRs to reward or punishment, although amygdala patients failed to generate SCRs to reward or punishment (Bechara et al., 1999). These results supported the SMH as it suggested that amygdala patients were unable to create new sensations to pass onto working memory. Meanwhile, VM patients can create the sensation to reward or punishment through the amygdala but are unable to associate it with a future consequence.

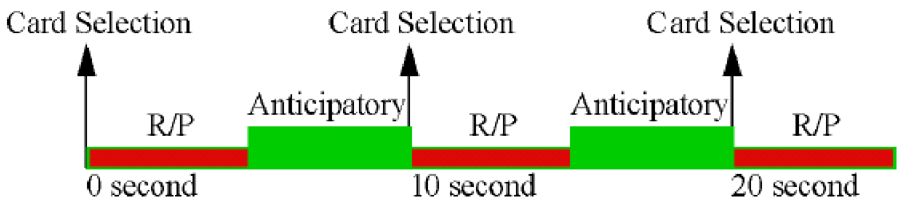



*Figure 4.6: Time periods from which physiological data was analysed by Bechara and Damasio (2005). The reward/punishment (R/P) period was measured as a response to a card selection, while the Anticipatory period was measured as the period of pre-selection of the next card. Both periods were 5 seconds in length.*

As healthy participants became experienced with the task, they began to generate SCRs in anticipation of selecting a card (Bechara et al., 1997, 1999). In addition, these SCRs were greater before picking a card from the risky decks. Conversely, VM and amygdala patients failed to elicit SCRs in the anticipatory area. These results suggested that healthy participants were learning somatic markers towards the decks. Further, this was claimed to have influenced participants' behaviour as healthy participants began to avoid the risky decks and choose from the advantageous decks. The failure of VM and amygdala patients gave further support to the brain structures involved in the SMH. The SCR results to both the reward and punishment area and the anticipatory area can be seen in Figure 4.7 below.

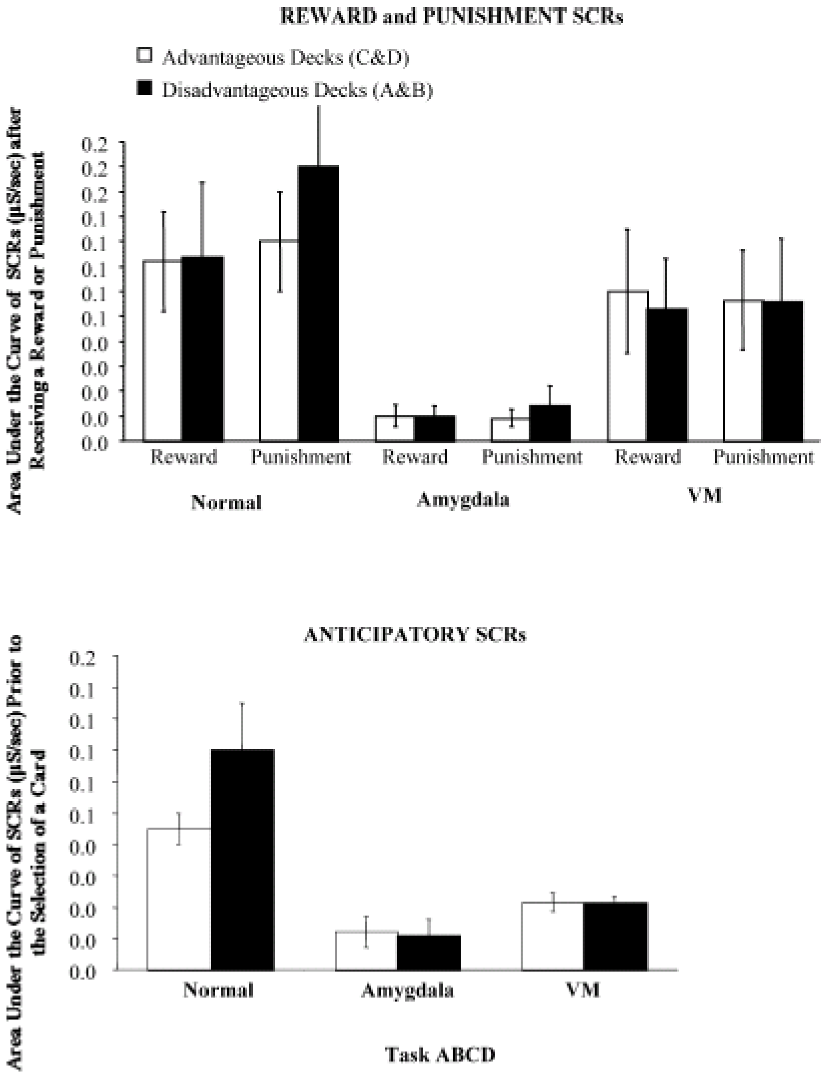



*Figure 4.7: Mean SCRs for the reward and punishment period (top) and anticipatory period (bottom) comparing participant groups when selecting from both the advantageous and disadvantageous decks (Bechara & Damasio, 2005)*

A further experiment on the basis of these results sought to separate whether or not participants were consciously aware of their bias towards the good decks or whether this bias was unconsciously led (Bechara et al., 1997). In this experiment, control participants were compared with VM patients in the same way as previously reported, however, after every tenth card, participants were asked to declare everything they knew about what was going on in the game (Bechara et al., 1997). In analysing participants' responses, four distinct stages of the game became apparent:

- **Pre-punishment Period:** After sampling from all four decks, and before encountering any losses, all participants preferred decks A and B (the risky decks). No significant SCRs were generated.

- **Pre-hunch Period:** After encountering losses in decks A or B, usually by about card 10, control participants began to generate anticipatory SCRs to decks A and B, but yet by card 20 they could not report any clue about what was going on.

- **Hunch Period:** By card 50, all control participants began to express a "hunch" that decks A and B were "riskier" than C and D. All control participants generated anticipatory SCRs whenever they pondered a choice from the disadvantageous decks. None of the VM patients generated anticipatory SCRs or expressed a "hunch".

- **Conceptual Phase:** By card 80, seventy percent of controls expressed knowledge about why, in the long run, decks A and B were bad and decks C and D were good. They continued to avoid the bad decks and they also continued to produce anticipatory SCRs when they considered sampling from the bad decks.

(adapted from Vaa, 2001a)

As participants' were demonstrating anticipatory SCRs before being able to quantify why they were choosing from advantageous decks, the researchers concluded this was support for the covert operation of somatic markers (Bechara et al., 1997). The IGT therefore presents empirical evidence to support the SMH by not only finding support for the role of emotion in decision making but also in demonstrating the key areas of the brain involved in such processing. Further, the learning of somatic markers in healthy participants had also been demonstrated.

Use of the IGT out-with Damasio's Iowa laboratory has been popular and used in diverse areas such as psychopathy (high psychopathy scorers performed poorly), acutely manic patients (who demonstrated slower learning), schizophrenic patients (who demonstrated a preference for the disadvantageous decks), heavy marijuana users (who demonstrated a preference for the disadvantageous decks) and patients with a history of suicide (who also demonstrated a preference for the disadvantageous decks) (Mahmut, Homewood & Stevenson, 2008; Clark, Iversen & Goodwin, 2001; Ritter, Meador-Woodruff & Dalack, 2004; Whitlow, Liguori, Livengood, Hart, Mussat-Whitlow, Lamborn et al. 2004; Jollant, Bellivier, Leboyer, Astruc, Torres, Verdier et al., 2005). The next section will consider the strength of using the IGT as a basis for supporting the SMH.

**4.7: Strengths and Weaknesses of the IGT**

As noted, the greatest strength of the IGT is that whilst healthy participants perform advantageously on the task, patients with damage to the brain regions cited within the SMH perform disadvantageously (e.g. VMPFC and amygdala). In addition, these results have now been replicated away from the Iowa laboratory (see Dunn, Dalgleish & Lawrence, 2006, p246-248 for a summary table). A further strength is that the IGT is relatively robust to changes in the way it is administered. Similar behavioural results are reported whether using the manual or computerised version of the task (Bechara et al., 2000). Bowman and Turnbull (2003) also demonstrated that the same behavioural pattern is produced when real money is used instead of facsimile money; or when time delays are introduced (Bowman, Evans & Turnbull, 2005).

Another important area of support for the IGT is that it appears to demonstrate lifespan development changes. Performance on the task improves with age into adulthood (Crone & van der Molen, 2004; Kerr & Zelazo, 2004) whilst also demonstrating slight deterioration into older age (Denburg, Tranel & Bechara, 2005; Denburg, Cole, Hernandez, Yamada, Tranel, Bechara et al., 2007). On the other hand, some results have not been quite so clear. Overman (2004) reports that adolescent men picked on the basis of long term gain only, which is not concurrent with the sensation seeking tendencies associated with males of this age (Steinberg, 2008). Meanwhile, Evans, Kemish and Turnbull (2004) report that higher levels of education and intelligence are associated with inferior performance on the IGT, although, this could be argued to distinguish standard intelligence from social intelligence.

Despite the strength of the IGT, there are some important weaknesses to consider, starting with methodological issues. For example, the way in which the decks are labelled advantageous and disadvantageous is problematic in the early stages of the experiment (Maia & McClelland, 2004). If a person has selected twice from a ‘risky’ deck but gained on both occasions, then this deck would be rightly perceived as advantageous and a further selection from this deck would be justified. The experiment, however, would code this as a disadvantageous decision. Another methodological criticism of the IGT is the way in which physiological data is measured when in the anticipatory area (Dunn et al., 2006). Participants have time to deliberate over their choice of deck, therefore, the physiological measure may not relate to the actual deck chosen but instead the attentional shift across decks.

One of the major areas of criticism surrounding the IGT is aimed at the claim that emotional responses, especially in the pre-hunch period, were symbolic of unconscious bias. Maia and McClelland (2004) argue that the broad, open questions used by Bechara et al. (1997, 1999) were not specific or sensitive enough to elicit all the conscious knowledge that participants held about the game. Maia and McClelland (2004) tested twenty healthy participants on the IGT stopping them at pre-determined points of the game, similar to Bechara et al. (1997), however, the questions they used were more in-depth and direct. The results suggested that participants' advantageous performance was nearly always accompanied by verbal reporting of qualitative and qualitative understanding. Given that participants may have earlier conscious awareness of the decks they are selecting from raises question marks over the claim that SCRs are unconsciously biasing decision making. Maia and McClelland (2004) report that the IGT can be performed advantageously through conscious, explicit knowledge alone and it is therefore inaccurate to claim that unconscious emotional signals are required to perform advantageously. They state:

> "Our point is therefore not to claim that we have ruled out nonconscious biases as possible contributors to behaviour in the IGT but only to suggest that there is no need to invoke such biases to explain participants' behaviour" (Maia and McClelland, 2004, p 16079)

As pointed out by Dunn et al. (2006), the debate over whether unconscious bias plays a role in decision making reflects a long running and larger debate over 'implicit' and 'explicit' processing. Shanks (2005) provides a comprehensive review of this literature and argues that the debate has suffered due to inappropriate measures. It would appear that, similarly, the use of the IGT may not be the best measure due to participants having time to deliberate over their decisions. With reference to Slovic et al.'s (2004) analytical and experiential methods of risk appraisal, it is difficult for the IGT to clearly separate the two as participants have the potential to utilise both an experiential response (i.e. I did well when choosing that deck the last time) and an analytical response (i.e. over x number of cards from that deck I have made y but lost z). This presents a problem for the IGT and led Dunn et al.'s (2006) review to conclude that whilst there is support for the SMH and the IGT, the use of other tasks to determine the presence or absence of somatic markers is necessary.

Bechara, Damasio, Tranel and Damasio (2005) responded directly to the results and criticism posed by Maia and McClelland (2004). Their defence is summarised by the following quote:

> "The central feature of the SMH is not that non-conscious biases accomplish decisions in the absence of conscious knowledge, but rather that emotion-related signals assist cognitive processes even when they are non-conscious."
> (Bechara et al., 2005, p 159)

The argument is therefore not that there are necessarily two completely distinct systems of decision making, conscious and unconscious, but that even where cognitive decisions are made, unconscious biases aid in the deliberation of possibilities (Damasio, 2003). An example that may support Bechara et al.'s (2005) claims could be that of the competition between man and computer at chess. In 1997, Garry Kasparov, the World Chess Champion of the previous 12 years, competed against IBM's Deep Blue computer in a series of chess matches. The official website offers the following comparison of the two players:

> "Deep Blue can examine and evaluate up to 200,000,000 chess positions per second. Garry Kasparov can examine and evaluate up to three chess positions per second.
>
> Garry Kasparov uses his tremendous sense of feeling and intuition to play world champion-calibre chess. Deep Blue is a machine that is incapable of feeling or intuition."
> (research.ibm.com, 2001)

Kasparov won the first of six games, with Deep Blue winning the second. Three draws were then followed by a final victory for Deep Blue (Hsu, 1999). In terms of the time to make a decision, chess is not dissimilar to the IGT whereby cognitive deliberation is likely to be used before each move. Neither game involves fast automated decisions. The comparison of processing power between the computer and

Kasparov is, however, remarkable and the human system must make up for this in some way. While mental imagery and chunking are common cognitive methods used in chess (see Waters & Gobet, 2008) it is unlikely that this alone accounts for the disparity in processing power between the computer and Kasparov. It is therefore possible that the use of 'feeling and intuition' aids conscious and unconscious decision making by biasing judgement towards only advantageous outcomes, as Damasio suggests (Damasio, 2003). In this way, feelings can be argued to *guide* decision making and behaviour rather than *cause* it.

Another area of criticism of the IGT is the interpretation of the physiological SCR results as originally reported in Bechara et al. (1996). While there has been supportive replication of the SCR findings, especially in relation to increased SCR to the disadvantageous decks (Bechara et al., 1999; Bechara, Dolan & Hindes, 2002; Bechara & Damasio, 2002; Campbell, Stout & Finn, 2004; Tomb, Hauser, Deldin & Caramazza, 2002; Crone, Somsen, Van Beek & Van Der Molen, 2004), it is claimed that physiological responses are not necessary for successful completion of the task. For example, Dunn et al. (2004) use Crone et al. (2004) as an example of results that do not support the SMH. Crone et al. (2004) presented a slightly modified version of the IGT to ninety-six participants and then grouped them by the number of advantageous choices made (out of 100) into 'bad', 'moderate' and 'good' performers. The good group demonstrated differences between their SCRs to the advantageous and disadvantageous decks whilst there was no difference for the bad group. Regarding the moderate group, Dunn et al. (2006, p 250) suggest that:

> "Crucially, the moderately performing group (who nevertheless did successfully acquire the task) did not show any such physiological differentiation between the decks. These findings are potentially problematic for the SMH since they show that a number of participants can acquire the task without needing to generate anticipatory HR [heart rate] or SCR signals, therefore suggesting that somatic markers are not necessary or sufficient to do well in the paradigm."

This reporting of the results is slightly contentious as there was a difference noted for the moderate groups SCR measure whereby their SCR level prior to picking from the disadvantageous decks was higher than for the advantageous decks. The pattern of results was similar to the ‘good’ group although the difference was not as great. Crone et al. (2004) summarise their results in the following way:

> “the group of bad performers showed no differentiation in autonomic activity preceding disadvantageous and advantageous choices, suggesting that they received no somatic warning signals preceding risky choices. Moderate and good performers, in contrast, showed larger skin conductance activity preceding disadvantageous choices, and for good performers, both heart rate and skin conductance responses were larger when the disadvantageous choices could result in frequent punishment. These results are consistent with reports by Bechara et al. (1996, 2002) and Tomb et al. (2002), and show that for good performers risky choices are preceded by somatic warning signals.” (p538)

There is scope to argue Dunn et al.’s (2006) position that moderate players who complete the game may not need to rely on measurable somatic markers but as Crone et al.’s (2004) results stagger from the bad group to the moderate and the good group, it would appear sensible to conclude, as the authors did, that good performance on the task correlates with risky choices being preceded by a physiological response. One of the reasons for this result being difficult to interpret is that skin conductance *level* was measured rather than skin conductance *response*. Skin conductance level is a continuous measurement of a level of electrodermal conductivity, whereas skin conductance response measures change in electrodermal activity (skin conductance is discussed in more depth in the next section on page 139). There are naturally individual differences in skin conductance levels, therefore it may have been more useful to have measured the change in skin conductance response prior to a card selection.

In summary of the IGT and its strengths and weaknesses, it would appear that whilst it provides reasonable support for the Somatic Marker Hypothesis, there are some key criticisms. There are some methodological weaknesses, theoretical question-marks and ambiguity over the interpretation of the physiological results. Dunn et al.’s (2006) suggestion that other means are necessary to test the SMH is a reasonable summary. The use of physiological measures such as skin conductance is interesting and has provided much of the support for the IGT, however, the way it has been interpreted has been open to criticism (Maia & McClelland, 2004). The following section will discuss the use of skin conductance as a psychological measure in more depth.

**4.8: Skin conductance**

The terms 'skin conductance' and 'electrodermal activity' (EDA) are often used interchangeably, however, when possible, the current thesis will use the term skin conductance. The history of skin conductance can be traced back to Fere (1888) who found that when placing two electrodes on the skin and recording the current between them, the skin became momentarily less resistant to the flow of electrical current when the person was presented with sensory or emotional stimulation (Dawson et al., 2000). Fere's (1888) experiment is credited as the first to illustrate that skin conductance may be related to psychological processes, although it has been argued that there are at least seven earlier published papers (McCleary, 1950). The use of this measurement became popular in the 20th Century as demonstrated by Carl Jung's (1907) experiment using self-constructed recording equipment. In recent decades, measurement of skin conductance has been used to measure physiological responses to many forms of emotionally stimulating material (e.g. visual sexual stimuli - Costa & Esteves, 2008; concealed information – Gronau, Ben-Shakhar & Cohen, 2005). The use of skin conductance as a physiological measure is advantageous because it is relatively simple, inexpensive and is very responsive to events of psychological significance (Dawson et al., 2000).

There is a large body of research that is supportive of the use of skin conductance as a measure of emotional and arousing stimuli (Lang, Bradley, & Cuthbert, 1997; Lang, Bradley, & Cuthbert, 1998; Bradley, Codispoti, Cuthbert, & Lang, 2001). Similar to Damasio (1994, 2003), Lang et al. (1997) suggest that emotional responses, as measured by skin conductance, are evolved emotional responses in a system that motivates action and behaviour. In a study of whether emotional valence (i.e. positive or negative emotion) or arousal was most important, Bradley et al. (2001) found that skin conductance was predictive of arousal but not emotional valence. It was concluded that skin conductance provides a useful measure of arousal to stimuli with motivational significance.

### *4.8.1: Underlying mechanism of skin conductance*

The exact connection between neural processes and skin conductance is still somewhat unknown, although there appears to be a strong relationship between psychological processes and skin conductance (Boucsein, 1992; Dawson et al., 2000). What is accepted is that the sympathetic component of the autonomic nervous system is known to regulate sweat gland activity, mainly through cholinergic innervations (Dawson et al., 2000). When the sympathetic nervous system is active, levels of sweat rise generating an increase in skin conductance. When sweat glands are surgically removed, the measurement of skin conductance becomes impossible (McCleary, 1950; Quinton, 1983). Boucsein (1992, p 76) states that there is 'ample empirical evidence that sweat gland activity in conjunction with the epidermal membrane processes plays a major role in the causation of electrodermal phenomena'.

### *4.8.2: Measuring skin conductance*

Electrodermal activity can be measured either as skin conductance or skin resistance, although skin conductance is more common and will therefore be discussed here (Boucsein, 1992). Skin conductance is measured by passing a small direct current through a pair of electrodes placed on the surface of the skin (Fowles, 1981). Ohm's law states that the resistance of an electrical circuit is equal to the voltage applied between the two electrodes divided by the electrical current flowing through the conductor (the skin) (Dawson et al., 2000). Conductance is the reciprocal of resistance, hence, by using Ohm's law skin conductance can be measured. If the voltage is held constant, the conductance properties of the skin between the two electrodes can be measured (Venables & Christie, 1980).

Typically, electrodes will be placed on participants' palmer surface of the medial phalanx of the middle and index fingers, as shown in Figure 4.8. Skin conductance is measured and reported in microsiemens (μS) or micromhos, which are the same measure.

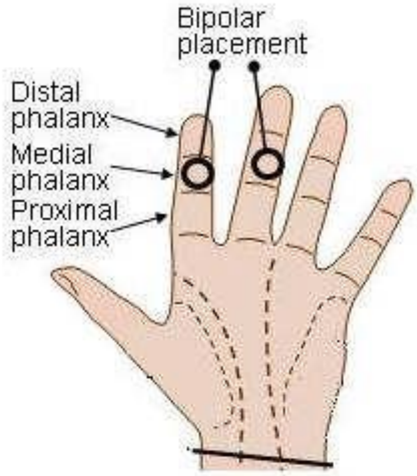



*Figure 4.8: Placement of skin conductance electrodes when measuring skin conductance*

Skin conductance can be measured as either skin conductance *level* (SCL) or skin conductance *response* (SCR), sometimes referred to as electrodermal response (EDR). Skin conductance level is generally measured throughout an experimental session allowing the level to be compared at different periods of the experiment. Changes in skin conductance level will commonly vary between two and twenty μS from one period to another (Venables & Christie, 1980). Skin conductance response measures immediate changes in conductivity and can therefore be directly linked to the presentation of a stimulus. Skin conductance responses are generally short (1-5 seconds) and relatively small (0.2-1.0 μS) (Venables & Christie, 1980).

The linking of skin conductance response to a stimulus can be complicated due to a response latency that exists between neural activity and the secretion of sweat. The exact response latency can be individual to a participant although it is generally accepted that any response starting within 1-5 seconds after the presentation of a stimulus is a valid SCR to the stimulus (Venables & Christie, 1980). Levinson and Edelberg (1985) reviewed response latency in over seventy-three experiments and concluded that response latency occurs between 1 and 2.4 seconds after stimulus presentation. Through reanalysis of experiments that originally used a 1 to 5 second latency period, Levinson and Edelberg (1985) report that by including only responses between 1 and 3 seconds after stimulus presentation increases the reliability of the responses measured. Barry (1990) conducted an experiment based on these criteria and concluded a similar finding.

Further complications with skin conductance occur due to its sensitivity as a measure. Small increases in skin conductance can occur in response to external events (e.g. a loud bang) and internal events such as changes in respiration (e.g. a large sigh or a cough) and even thoughts. Experiments will therefore often utilise measurement of a respiration belt to control for SCRs not related to the stimulus (Venables & Christie, 1980).

**4.9: Skin conductance and driving**

Within the context of driving, skin conductance is of interest as there are a handful of studies that have measured the skin conductance of drivers. Most of these studies have been purely investigatory and certainly without the knowledge of theory proposed today by Damasio (2003) and others (LeDoux, 1996; Slovic et al., 2004). The findings of these studies are therefore somewhat etched in scientific innocence, although the foresight of the authors must be admired.

As mentioned in Chapter Two, the inspiration for contemporary driver behaviour models like Wilde's Risk Homeostasis Theory (Wilde, 1982) and Naatanen and Summala's (1974) Zero-Risk model was experiments that utilised skin conductance as a measure. Hulbert (1957) and Michaels (1960) demonstrated that there were measureable autonomic responses by drivers whilst driving and that these occurred relatively frequently. Michaels (1960) reports that skin resistance responses (SRRs) were linked to observable traffic events, as measured by the experimenter, with larger SRRs relating to events with the potential to be more serious.

In somewhat of a follow up study, Taylor (1964) conducted two experiments using a total of twenty participants with varied age range and experience. Participants performed on-the-road driving, usually in their own cars, and drove set routes which incorporated most main road types. Taylor (1964) reports measuring skin conductance as both skin conductance level and skin conductance response. In reference to skin conductance response, Taylor (1964, p 442) reports:

> "It was usually possible to observe external events which could have caused the responses, and very few responses had observable causes which were not related to the external situation"

Much of Taylor's (1964) results are, however, dedicated to matching skin conductance level with other factors. It is reported that skin conductance level whilst driving is fifty times higher than when reading a book in a quiet room (Taylor, 1964). A significant correlation between skin conductance level per mile and accident rate per mile was reported, although no relationship between skin conductance level and road conditions was found (Taylor, 1964). Given the infrequency of hazardous events on the road it is unsurprising that when skin conductance levels are measured over time that they fail to elicit significant results. With the knowledge of current neurological theory, it is possible to conclude from Taylor's (1964) experiment that the most intriguing finding was the relationship between skin conductance responses and observable traffic events, which supported the earlier work of Hulbert (1957) and Michaels (1960).

Further research of driving using SCR as a measure is reported by Helander (1978). In this study, sixty Volvo drivers in Gothenburg, Sweden, were recruited to drive a Volvo around a pre-selected course of rural road which was split into four sections of geometric variance. As well as SCR, other physiological measures were taken including heart rate and electromyograms (EMGs) of two leg muscles. One leg muscle measure indicated release of the accelerator whilst the other indicated application of the brake pedal.

There are two fascinating results reported by Helander (1978). The first is that SCR and brake pressure were correlated to the order of .95, suggesting a strong relationship between psychological processes and brake application, although not necessarily a causal one. As muscle activation itself can cause an increase in skin conductance, it is difficult to determine whether the application of pressure on the brake caused the increase in SCR or whether the SCR was a measure of psychological processes. However, Helander (1978) reports that as no SCR was elicited when drivers pressed the brake while the car was stationary, the SCR was therefore indicative of psychological processing rather than physical movement.

The second finding sought to investigate the timeline of events leading to brake activation. This is a methodologically difficult task as SCR involves response latency, as mentioned in the previous section. Helander (1978) drew on the work of Johnson and Lubin (1972) and Lockhart (1972) who reported that SCR latency was approximately three seconds. By simply subtracting three seconds from the timing of SCRs, Helander (1978) reported that SCRs preceded accelerator release by 0.2 seconds and braking by 1.9 seconds. Given the uncertainty over the response latency of skin conductance response (Levinson & Edelberg, 1985), these results must be viewed with some caution. Venables and Martin (1980) reported a mean response latency of 1.9 seconds in a study of 640 'normal' participants. If this timing was applied to Helander's (1978) results, then accelerator release would precede the SCR by 0.9 seconds but SCR would still precede pressing the brake by 0.8 seconds.

In spite of these methodological problems, when Helander's (1978) results are placed within the context of the Somatic Marker Hypothesis, an intriguing picture emerges. Could this be an example of somatic markers in driving? To speculate would involve the SCR being symbolic of arousal to some environmental cue that (consciously or unconsciously) influenced a driver's decision making (i.e. to slow down) and behavioural response (i.e. to brake). This would certainly offer insight into the role of the 'comparator' within Fuller's (2005a) task-difficulty homeostasis. For methodological reasons this can only be speculated, however, it provides justification for further scientific enquiry.

On a final note, the terminology used by Helander (1978) is strangely akin to that used by Fuller (2005a,b), as demonstrated by the following quote:

> "We propose that an EDR is evoked when there is a relative increase in task demand, regardless of the initial level of task demand."
> (p486)

As demonstrated in Chapter Three, the assessment of task demand (although measured by task difficulty) is similar to the assessment of feelings of risk, meaning that the above quote could otherwise be termed: an EDR is evoked when there is a relative increase in feelings of risk.

### 4.10: Chapter Four Summary

At the beginning of this Chapter, four results from Chapter Three were highlighted for further consideration and enquiry:

I. The finding that task difficulty and feelings of risk were highly correlated, similar to the results of Fuller et al. (2008a).
II. There was no difference by experience level on measures of task difficulty and feelings of risk.
III. Participants' rate subjective risk (feelings of risk) differently to objective risk estimates of subjective risk (probability of loss of control).
IV. Finally, differences were found by experience level on the rating of objective risk estimate which could suggest inexperienced drivers rely more on cost-benefit analysis of risk when driving rather than feelings of risk.

In summary of the current Chapter, these results will now be discussed in relation to the literature covered within this Chapter.

#### *4.10.1: Affect and decision making*

Decision making literature has encountered a shift in focus within the last decade, with the role of 'affect' becoming a 'hot' topic (Peters et al., 2006). The role of emotion in decision making had long been viewed as an irrational nuisance to researchers but the tables have now turned (Bechara & Damasio, 2005). The role of emotions in decision making is now widely accepted (Peters et al., 2006).

**Slovic et al. (2004) suggest that within the area of risk appraisal, there are two forms of processing: analytical and experiential. The analytical system is essentially a cold cost-benefit analysis, whereas the experiential system relies on learned associations between experienced events and emotions. In relation to result III above, Slovic et al.'s (2004) theory could explain the reason why subjective risk (experiential system) and objective risk estimates (analytic system) were rated differently by participants. Further, as the experiential system requires experience to learn associations between events and emotions,**

**this can explain result IV whereby a difference was found between inexperienced and experienced drivers in ratings of objective risk estimate. Without having learned associations between events and emotions, inexperienced drivers would have no choice but to rely on their analytic appraisal of risk.**

***4.10.2: An evolved system of risk appraisal***

Slovic et al. (2004) argue that the experiential system of appraising risk is an evolved survival process that has allowed humans to become highly attuned to their environment. The idea of an evolved psychological process of appraising risk through learned associations between the environment and emotional cues is also the basis for Damasio's (1994, 2003) Somatic Marker Hypothesis. This theoretical stand point can help explain result II above that no difference was found by experience level on ratings of task difficulty and feelings of risk. **If the experiential system is an evolved human system of risk appraisal, then all humans must have the innate ability to appraise risk, however, it is only by experience and association that risky events will be associated with emotional cues. Inexperienced drivers therefore do not lack the ability to sense risk, but simply have not yet learned to associate risky cues in the driving environment to emotional warning signals.**

***4.10.3: Somatic Marker Hypothesis (Damasio, 1994)***

Through experiences of patients with damage to certain brain regions, Damsio (1994, 2003) devised the Somatic Marker Hypothesis. Damasio (2003) noted that deprived of an emotional input into decisions, these patients must rely on a cost benefit analysis which degrades the speed of deliberation and the adequacy of the choice. **Somatic markers are emotions and feelings that have been connected through learning to predicted future outcomes of certain scenarios. When these scenarios are encountered again, somatic markers are elicited and bias decision making towards an advantageous response. The Somatic Marker Hypothesis provides neurological support for the role of emotions in risk appraisal and decision making.**

***4.10.4: Iowa Gambling Task***

**Much of the empirical support for the Somatic Marker Hypothesis comes from studies involving the use of the Iowa Gambling Task (IGT) (Bechara et al., 1994,**

**1996, 1997, 1999, 2000; Bechara & Damasio, 2005). The IGT studies provide support for the brain regions involved in the somatic marker hypothesis (i.e. ventromedial prefrontal cortex and amygdala), the learning of somatic markers in healthy participants and the role of emotion in decision making, as measured by skin conductance response.** The strengths and weaknesses of the IGT were discussed and concluded that whilst it provides some support for the Somatic Marker Hypothesis, there are weaknesses and further support in another context would be useful. **Testing for the presence or absence of Somatic Markers in drivers could therefore be a timely test of the hypothesis.**

#### *4.10.5: Skin conductance and driving*

The main measure of somatic markers within the IGT studies was skin conductance, otherwise known as electrodermal activity (EDA). Recording of skin conductance is a useful physiological measure of arousal, which has been to be linked to stimuli with motivational significance (Bradley et al., 2001). Intriguingly, measurement of skin conductance has been used in a handful of historical driving studies which report that skin conductance responses (SCRs) were related to observable traffic events (Michaels, 1960; Taylor, 1964). Helander (1978) further reported that drivers' SCRs preceded accelerator release by 0.2 seconds and brake application by 1.9 seconds. Although there are reasons to view Helander's (1978) analysis with caution, it could be argued as being an example of Somatic Markers in driving.

Helander (1978) proposed that an SCR is evoked whenever there is a 'relative increase in task demand' (p486). As SCR is argued to be a measure of arousal (Bradley et al., 2001), not task demand, this could provide support for the remaining result from Chapter Three. Result I above states that task demand and feelings of risk were highly correlated, similar to the results of Fuller et al. (2008a). **The results of Helander (1978), Michaels (1960) and Taylor (1964) suggest that there is physiological support for the relationship between perceived task difficulty and perceived feelings of risk. These results could suggest that when driving, feelings of risk and task difficulty are one and the same thing; a position supported by Vaa (2004).**

The current chapter has therefore provided some enlightenment to the results of Chapter Three and provided scope for understanding the processes involved in the Comparator area of Fuller's (2005a) Task Difficulty Homeostasis. The next two chapters aim to empirically investigate if the theory presented within this chapter can be applied to driving and provide insight into the psychological processes involved.

# Chapter Five

## Study 2: Comparing inexperienced and experienced drivers' cognitive and psychophysiological responses to hazards

## Chapter Five Outline

## 5.1: Introduction

Chapter Four concluded by suggesting there may be evidence of psychophysiological responses being related to the task of driving (Taylor, 1964, Helander, 1978). While Helander (1978) suggested skin conductance responses (SCRs) preceded behavioural actions such as braking, Michaels (1960) and Taylor (1964) simply reported that skin resistance responses (SRRs) and SCRs were related to on-the-road events. Michaels (1960) further reported that more hazardous on-the-road events were related to larger SRRs.

This historical literature is of interest because modern theory of risk appraisal (Slovic et al., 2002, 2004) and of a socio-emotional learning system (Damasio, 1994, 2003) would cause the results of these studies to be re-interpreted. As discussed in Chapter Four, the main source of support for the Somatic Marker Hypothesis (Damasio, 1994) was the Iowa Gambling Task. This paradigm provided support for an emotional learning system as demonstrated by participants' psychophysiological results (Bechara et al., 1997, 1999). Although criticism of the interpretation of these results exists (Maia & McClelland, 2004; Dunn et al., 2006), there is still support for the role of somatic markers (Damasio et al., 2005; Bechara & Damasio, 2005); and for the role of emotions and feelings in risk appraisal and decision making (Slovic et al., 2002, 2004). In light of this, the results of Michaels (1960), Taylor, (1964) and Helander (1978) could be argued to be evidence of somatic markers in driving or at least the role of an emotional component of drivers' risk appraisal.

Given that Michaels (1960) and Taylor (1964) reported SRRs and SCRs to observable traffic events, it must be assumed that if an emotional learning system which warns of potential danger exists, then it would predict the potential of a hazard developing. The literature reviewed in Chapter Two on hazard perception (see page 52) noted that there are differences in the way that inexperienced and experienced drivers deal with on-the-road hazards (Mayhew & Simpson, 1995, Deery, 1999). Deery (1999) summarises research which suggests inexperienced drivers are poor at detecting, recognising and dealing with hazards; attending to the right things at the right time; dealing with multiple tasks; and matching one's actual skills with the demands of the task. This suggests that inexperienced drivers do not have adequate situational awareness when driving, a proposal supported by visual scanning literature.

Research into drivers' visual scanning has found that novice drivers display a smaller range of horizontal scans of the road environment; check their mirrors less often; fixate on fewer objects and fail to use peripheral vision to their full advantage (Mayhew & Simpson, 1995; Underwood, Crundall & Chapman, 2002; Underwood, 2007). In an analysis of two-thousand crashes involving 16-19 year olds, McKnight and McKnight (2003) report that the majority of accidents resulted from errors in attention, visual search, speed relative to the conditions, hazard recognition and risky behaviour. Lestina and Miller's (1994) study of crashes in California also found that inattention was the most frequently contributing factor. This failure to recognise and pay attention to hazards suggests that novice drivers are failing to correctly appraise the risk of the situations they encounter and therefore fail to respond in advance to avoid these situations.

One study that has tested both drivers' visual scanning and SCR in relation to hazard perception is Crundall, Chapman, Phelps and Underwood (2003). In this study, police drivers and a matched control group of normal experienced drivers were compared to novice drivers in response to police pursuit and emergency response videos. Police drivers demonstrated superior horizontal scanning compared to the other two groups, indicative of higher information processing rates and awareness (Crundall et al., 2003). Meanwhile, similar to previous studies (e.g. Chapman & Underwood, 1998; Underwood et al., 2002), novice drivers demonstrated longer fixation times compared with experienced and police drivers. It is reported that this is symptomatic of increased processing time required at any given point of fixation (Crundall et al., 2003).

Analysis of SCRs, which Crundall et al. (2003, p169) considered 'indicative of sudden increases in hazard awareness', found that police drivers produced significantly more SCRs than experienced and novice drivers. While experienced drivers produced more SCRs than novice drivers, the difference between the groups did not reach statistical significance. Crundall et al. (2003) state that police drivers were aware of a greater number of arousing stimuli.

A further measure was drivers' cognitive hazard ratings of the clips. It is surprisingly reported that there was no significant difference between driver groups' hazard ratings

(Crundall et al., 2003). Further, it was reported that there was no difference between groups for the number of hazards they reported. That police drivers physiologically responded to more stimuli but reported the same number of hazards as the other groups led Crundall et al. (2003, p172) to conclude:

> "It appears that the police drivers were most sensitive to the number of potentially hazardous events, at least at a physiological level, yet there is no evidence that this resulted in changes in the number of hazards reported."

These findings add further support to the argument that psychophysiological measures could be symptomatic of automated processes of risk appraisal. The results also add support to the idea that humans have two ways of appraising risk: risk as analysis and risk as feelings, as suggested by Slovic et al. (2002, 2004).

***5.1.1: The present study and hypotheses***

The current study sought to test for inexperienced and experienced drivers' hazard ratings and SCR to still pictures of safe, hazardous and potentially hazardous driving scenes. Using still pictures has the advantage that any SCR measured after presentation is likely to be directly related to the stimulus. Based on the results of Crundall et al. (2003), it is hypothesised that there will be no difference between the groups hazard ratings of safe, hazard or developing hazard pictures. In relation to the measure of SCR, it is expected that both groups of drivers will show few SCRs to safe pictures, whilst conversely, demonstrating regular SCRs to hazardous pictures. However, given the literature covered here and in Chapter Four, it is hypothesised that there will be a difference between experience groups SCRs to developing hazard pictures. In summary, the hypotheses for the current study are as follows:

I. *There will be no difference between the driver groups' hazard ratings of safe, developing hazard or hazard pictures*
II. *There will be no difference between the driver groups' SCRs to safe and hazardous pictures but there will be a significant difference in SCR to the developing hazard pictures*

## 5.2: Method

### *5.2.1: Design*

A 2 X 3 mixed design was used. The between-groups factor was driving experience (inexperienced vs. experienced) and the within-groups factor was type of situation (safe, hazard and developing hazard). Hazard ratings were taken in response to images of the three scenarios, while physiological measures included participants' skin conductance response (SCR) and respiration amplitude.

Fifteen images (5x Safe; 5x Developing Hazard; 5x Hazard) were presented at timed intervals in random order.

### *5.2.2: Participants*

Twenty-one inexperienced drivers (9 male; 12 female) and 18 experienced (10 male; 8 female) drivers of a similar age range took part in the experiment. Inexperienced drivers were defined as having held a U.K. driving licence for less than three years and experienced drivers as having held their licence for three years or more.

The mean age for inexperienced drivers was 21.7 years (sd=3.6, range=17.8-33.8); whilst the mean age for experienced drivers was 25.4 years (sd=2.9, range=20.2-31.0). Inexperienced drivers reported to have held their U.K. driving licence for a mean of 13.3 months (sd=8.7; range=1-29); while experienced drivers reported to have held their licence for a mean of 86.2 months (sd=43..3; range=36-168).

### *5.2.3: Materials*

Fifteen still images were taken, with permission, from a commercially available CD-ROM (Focus Multimedia Driving Test Success: Hazard Perception). The images were chosen to portray examples of safe, hazardous and potentially hazardous situations (5 images per category). An example of an image from each category can be seen in Appendix 5A. A pilot study was conducted to ensure that these pictures depicted situations which were safe, dangerous or ambiguous with respect to inherent risk. Twenty random volunteer participants, who all held a current UK driving licence, were asked to rate each image as either 'safe' or 'hazardous'. The mean number of participants rating the images within each category as ‘hazardous’ was: Safe 1.8 (sd=1.3); Developing Hazard 12.2 (sd=2.8); and Hazardous 18 (sd=1.0). The results of the pilot study suggested that the images in the three categories reasonably reflected safe, developing hazard and hazard scenarios.

The images were randomly presented full screen on a 19” computer monitor using Superlab 4 experiment generator software. A Cedrus RB-730 button box was used to record participants’ hazard ratings data. Participants’ SCR and respiration were measured by the Biopac MP35 system using electrodermal pre-settings with Biopac EL507 EDRS isotonic gel disposable electrodes and a respiratory belt and transducer. The SCR and respiration traces were recorded and analysed using Biopac BSL Pro software.

Participants also completed a questionnaire about themselves and their driving history. A copy of the questionnaire can be seen in Appendix 6C. Appendix 6D shows the questionnaire with overall participant mean scores and response frequencies.

An information sheet for participants detailing the experiment and a consent form can be seen in Appendix 5B.

### *5.2.4: Procedure*

Participants were asked to read the experiment information sheet and sign the consent form if they were happy to proceed with the experiment. Participants were seated approximately 60cm from the computer monitor with the button box at a comfortable distance on the desk. Electrodes were attached on the palmer surface of the medial phalanx of the middle and index fingers of the non-preferred hand. Participants were also asked to position a belt attached to a respiratory transducer around their chest and take several large breaths in order to check the recording equipment was operational and to provide a comparison respiration trace.

Participants were told that they would see fifteen images of various road scenarios. They were asked to imagine that they were the driver of the vehicle encountering these scenarios and that when the image disappeared from the screen they would be required to make a rating from 1 (safe) to 7 (extremely hazardous) for how hazardous that situation appeared to them. Each image remained on screen for 5 seconds and was replaced by a screen which prompted participants to provide a rating. This screen was displayed for 10 seconds after which the next road scene was shown. Images were presented randomly via the Superlab 4 experiment generator package.

Once all images had been shown, the electrodes and respiration belt were removed and participants were asked to complete the questionnaire.

### *5.2.5: Ethical approval*

Ethical approval for the study was granted by the Psychology Ethics Board at Strathclyde University, where the experiment was performed, and can be seen in Appendix 5C.

## 5.3: Results

### *5.3.1: Hypothesis I*

I. There will be no difference between the driver groups' hazard ratings of safe, developing hazard or hazard pictures

#### *5.3.1.1: Analysis of hazard ratings*

Figure 5.1 shows the mean hazard ratings for the driving scenarios. The increase in ratings across hazard type is statistically significant for both experienced and inexperienced drivers (Page's L trend test, $L = 230$ and $252$, respectively, $p < .01$ for both). As can be seen, both the experienced and inexperienced driver groups gave similar ratings to all categories of pictures, although specifically the developing hazard category.

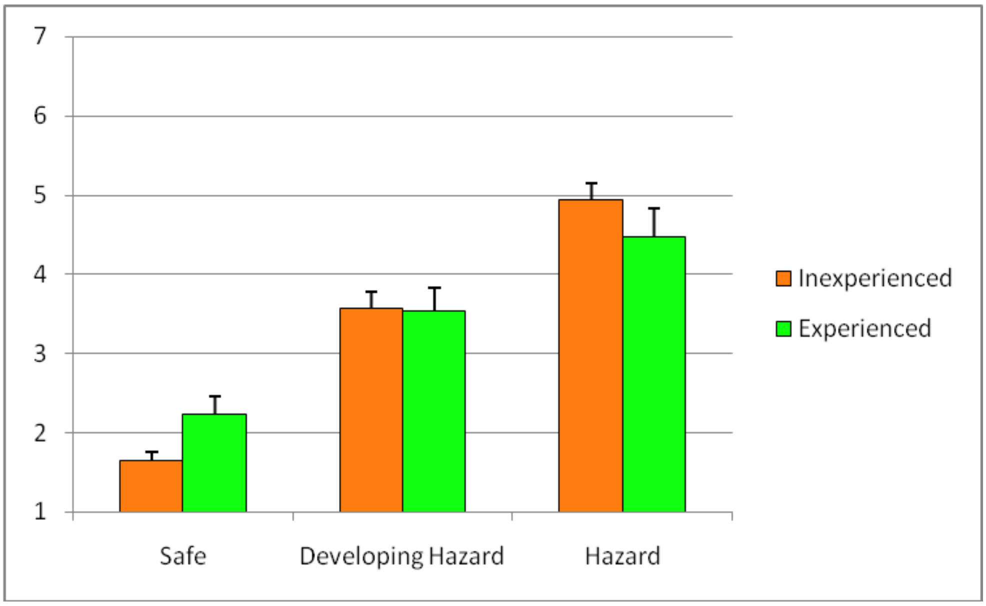



Figure 5.1: Comparison of driver groups' mean hazard ratings to safe, developing hazard and hazard pictures with standard error bars. Scale: Extremely Safe 1-7 Extremely Hazardous

A Kruskal-Wallis test (see Table 5.1) shows that only the ratings for the safe images were significantly different with experienced drivers judging the 'safe' situations as being more hazardous than the inexperienced drivers were judging them. The hypothesis that there would be no difference between the groups' hazard ratings is therefore only partially supported. However, the crucial comparison is the developing hazard condition where the mean ratings for the inexperienced and experienced driver groups are numerically almost identical and do not show a statistical difference.

*Table 5.1: Mean hazard ratings for still images by experience group with standard deviations and Kruskal-Wallis analysis. (* p<.05)*

| | **Safe** | | **Developing Hazard** | | **Hazard** | |
|---|---|---|---|---|---|---|
| | **Mean** | *Sd* | **Mean** | *Sd* | **Mean** | *Sd* |
| **Inexperienced** | **1.59** | *0.31* | **3.47** | *0.79* | **4.88** | *0.82* |
| **Experienced** | **2.18** | *0.97* | **3.49** | *1.26* | **4.4** | *1.51* |
| $\chi^2$ | 4.78* | | 0.11 | | 0.4 | |

*5.3.1.2: Hazard ratings and gender*

T-tests of gender and hazard ratings were performed and found no significant difference between males and females across any picture category for their hazard ratings (safe: $t(36)=.406$; developing hazard: $t(35)=-.979$; hazard: $t(35)=-1.58$; p=ns for all).

### ***5.3.2: Hypothesis II***

II. There will be no difference between the driver groups' SCRs to safe and hazardous pictures but there will be a significant difference in SCR to the developing hazard pictures

*5.3.2.1: Analysis of SCRs*

Before SCR data was analysed, participants' initial deep breath respiration trace was compared with their overall respiration. Any SCR that was preceded by respiration which approximated the amplitude of the initial deep breath was excluded from analysis. There were very few instances (less than 1%) where this occurred and SCR data is reported proportionately to take account of the missing data points. A SCR to a particular image was taken as any rise in trace amplitude over 0.05 µS beginning between 1 and 3 seconds after stimulus presentation (Levinson & Edelberg, 1985; Barry, 1990). A latency of 1 to 5 seconds has often been used to measure SCRs, however, Levinson and Edelberg (1985) report that using a narrower gap of 1 to 3 seconds improves the reliability of measuring only SCRs to the stimulus. The use of a 1 to 3 second latency period is supported by Barry (1990) and Boucsein (1992). Given the investigative nature of the experiment, it was considered important to ensure that any SCRs recorded as responses to the stimulus were as reliable as possible.

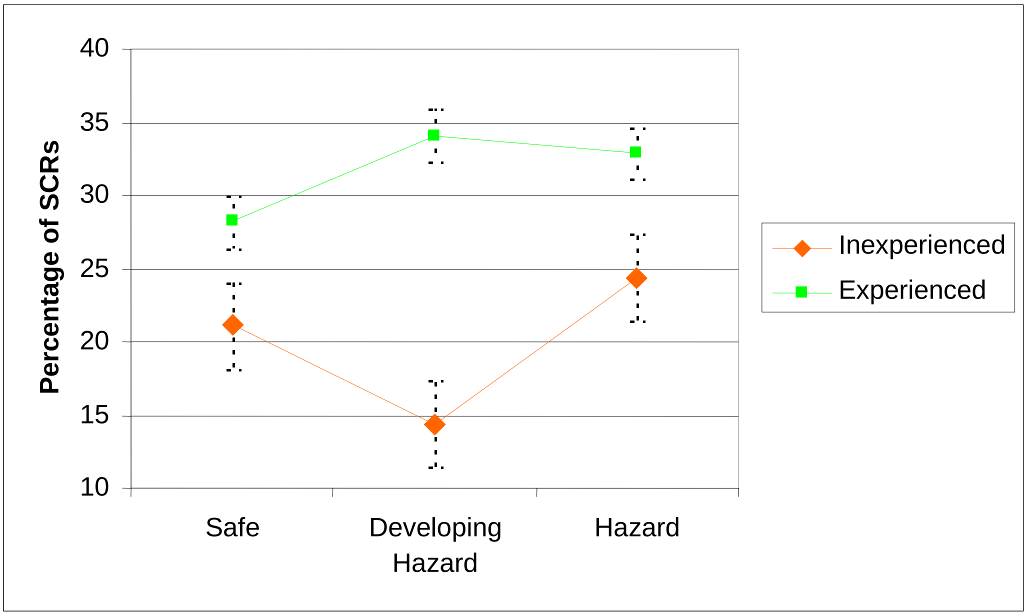



*Figure 5.2: Comparison of driver groups' SCR percentages to safe, developing hazard and hazard pictures with standard error bars*

Figure 5.2 shows the mean number of SCR responses, calculated as percentages, per stimulus item condition for experienced and inexperienced drivers. Experienced drivers numerically show more SCRs across all stimulus conditions. However, this difference is only statistically significant for developing hazard items, as shown by a Kruskal-Wallis analysis (see Table 5.2). This therefore supported the hypothesis that no difference of SCRs would be found between the groups to safe and hazard pictures but that there would be a difference to developing hazard pictures. Although the results support the hypothesis, the low percentage response across all conditions, specifically the hazard pictures, is a concern to the validity of the current stimulus method.

*Table 5.2 Mean percentage of responses showing an SCR to the stimulus item with standard deviations and Kruskal-Wallis analysis. (* p<.05)*

| | **Safe** | | **Developing Hazard** | | **Hazard** | |
|---|---|---|---|---|---|---|
| | **Mean** | *Sd* | **Mean** | *Sd* | **Mean** | *Sd* |
| **Inexperienced** | **21.1** | *20* | **14.4** | *20.4* | **24.4** | *22.3* |
| **Experienced** | **28.2** | *23.5* | **34.1** | *27.2* | **32.9** | *30.8* |
| $\chi^2$ | 0.68 | | 5.74* | | 0.47 | |

Analysis of peak to peak measurement of SCRs was also conducted and can be found in Appendix 5D. No significant difference between the groups was found for the peak to peak measure of SCRs to safe, developing hazard or hazard pictures.

*5.3.2.2: SCRs and Gender*

T-test comparisons of gender SCR scores were performed and found no significant differences between males and females across any picture category (safe: $t(35)=1.62$; developing hazard: $t(33)=1.26$; hazard: $t(30)=.17$; p=ns for all).

### *5.3.3: Results summary*

In summary, a difference of hazard ratings for safe images was found between experienced and inexperienced drivers, yet no difference was found on psychophysiological measures for these types of stimuli. A more striking pattern emerged for images depicting a developing hazard which showed almost identical ratings for cognitive estimations of risk but displayed a significant difference in number of SCRs between experienced and inexperienced drivers. Hypothesis I was therefore partially supported for the developing hazard and hazard pictures although not for the safe pictures. Meanwhile, hypothesis II was supported as no difference in SCR percentage to safe and hazard pictures was found between the driver groups, however, there was a significant difference between the groups whereby experienced drivers produced significantly more SCRs to developing hazards than inexperienced drivers.

## 5.4: Discussion

Results demonstrated that inexperienced drivers show a marked decrement in psychophysiological response to developing hazard scenarios. This is in spite of the fact that their cognitive assessment of risk for that particular type of road scene is statistically no different to that of the experienced driver group. Similar to the results of Chapter Three and Crundall et al. (2003), this suggests that emotional and cognitive components to hazard perception are dissociable and vary with driver experience.

Further evidence for this is shown in the responses to the safe images where both groups did not differ in terms of emotional response but the experienced drivers gave higher ratings of risk. These results rule out an interpretation of skin conductance response simply being a product of participants' estimation of risk and lend support for greater consideration of the potential role of emotion in driving behaviour (e.g. Vaa, 2001b, 2004; Fuller, 2005b) and in particular, the role of emotion in anticipating hazards.

### *5.4.1: Developing hazards and SCRs*

Though previous studies (e.g. Crundall et al., 2003) have examined SCRs to driving scenarios and hazards using experienced and inexperienced drivers, no previous study has specifically examined psychophysiological responses to situations where a hazard is not immediately apparent but where the scenario would indicate an increased likelihood of a hazard developing within a short time frame. It is this type of scenario where, logically, an experienced driver would benefit from an emotional signal alerting them to potential danger and, theoretically, where Damasio's (1994) Somatic Marker Hypothesis (SMH) would produce the maximum effect of emotion on behaviour. The anticipatory component of the SMH is possibly the most interesting aspect of the theory.

Though much of the data in support of the SMH has been collected using laboratory-based gambling tasks, Damasio's (1994) basis for the SMH is that the basic motive of all organisms is survival and therefore their primary task is risk monitoring (Vaa, 2004). Consequently, it might be predicted that a system such as SMH or similar should show greater behavioural effect for a potentially life-threatening behaviour such as driving and to be functionally useful should therefore be anticipatory in nature. This study was not designed to determine whether emotional responses were anticipatory in nature, however, with psychophysiological difference being found only for the developing hazard stimuli, it is suggestive of that.

### *5.4.2: peak to peak SCRs*

The current study did not find a difference in peak to peak measures of skin conductance response between groups. It is possible that real-life development of emotional markers will vary in nature to those elicited by a single session laboratory task, especially to still images. The presence or absence of a response to developing hazards is potentially more indicative of simply whether or not hazardous scenarios have been emotionally connected through discrete experiences over a significant driving timescale. Crundall et al. (2003) also reported an effect of frequency of SCRs but not amplitude, although they did not report a significant difference between inexperienced and experienced drivers. A crucial difference between the current study and Crundall et al. (2003) may be that the current study separated developing hazards and hazards whereas Crundall et al.'s (2003) study does not differentiate between hazards and developing hazards. In the current study, no difference in emotional response was found between experienced and inexperienced drivers to clearly hazardous situations; it was specifically the developing hazards that demonstrated this difference. Amalgamating responses to both types of scenario may have masked differences between novice and experienced drivers in Crundall et al.'s (2003) study. However, the result that police drivers show a difference in skin conductance response suggests that experience, and/or specialised training, may be the critical factor in developing appropriate emotional responses to hazards.

### *5.4.3: Limitations of the current study*

Whether emotion is epiphenomenal to cognitive decision making or has a causal role in guiding behaviour, as Damasio (1994, 2003) suggests, is yet to be examined in the context of driving. The current study's use of still images has the advantage of tying the psychophysiological response to a particular type of visual scene, however, its major weakness is that it lacks ecological validity, as possibly demonstrated by the low percentage SCR responses in the hazard category. Cohen (1981) reports that drivers' visual fixation patterns to still and dynamic driving scenarios vary considerably, with drivers fixating on many more factors when using dynamic stimuli. More naturalistic, dynamic stimuli may provide a beneficial avenue for investigating an emotional component to hazard awareness and avoidance.

### 5.5: Chapter Five Summary

The literature covered in Chapter Four suggested there is theory and evidence for an evolved learning system that allows humans to associate experienced events with emotional cues (Damasio, 1994, 2003; Bechara & Damasio, 2005). Skin conductance response (SCR) as a measure of emotional arousal had previously been used to provide support for this theory (Bechara et al., 1997, 1999). Meanwhile, historical driver behaviour literature that has used SCR as a measure reported finding that SCRs precede brake application and are attributable to observable traffic events (Michaels, 1960; Taylor, 1964; Helander, 1978). **The integration of current theory and this historical literature is suggestive of the role of emotional risk appraisal when driving.**

It was further discussed that research has reported differences in the way that inexperienced and experienced drivers process hazards when driving (Mayhew & Simpson, 1995; Deery, 1999), which is supported by visual scanning studies (Underwood et al., 2002; Underwood, 2007). The research suggests that novice drivers are failing to recognise and pay attention to situations which become hazardous; something which has been noted in analysis of novice driver crashes (McKnight & McKnight, 2003; Lestina & Miller, 1994).

In a study which compared novice, experienced and police drivers for visual scanning, SCR and hazard ratings, Crundall et al. (2003) reported that police drivers displayed significantly more SCRs to hazards than the other driver groups. However, when hazard ratings were compared, all drivers rated hazards the same and reported the same number of hazards. This result implies that there are two ways in which drivers appraise hazards, similar to the suggestion put forward from the results of Chapter Three and Slovic et al. (2002, 2004), as discussed in Chapter Four.

#### *5.5.1: Experimental findings*

**The current study therefore aimed to compare inexperienced and experienced drivers for their hazard rating and SCR to fifteen pictures depicting safe, developing hazard and hazard scenarios. The key result was that both driver groups rated developing hazards almost identically but that the experienced driver group produced significantly more SCRs to developing hazard pictures**

**compared with the inexperienced driver group. This suggested supporting the results of Chapter Three and Crundall et al. (2003) that there are two ways in which drivers appraise risk.**

### *5.5.2: Implications*

**As there was a difference between inexperienced and experienced drivers' SCR scores to the developing hazard pictures but not the hazard pictures, it would appear that it is within the build up to a hazard that experienced drivers may benefit from an emotional appraisal of the situation. Given that inexperienced drivers do not appear to have this appraisal, lends support to the idea that this is part of a learning system, as possibly demonstrated in the Iowa Gambling Task (Bechara & Damasio, 2005). The development of a hazardous situation when driving is the kind of scenario in which the role of somatic markers would be of maximal use (Damasio, 1994, 2003).**

Whilst there are some important implications of the results from Chapter Five, the study is weakened by the fact that driving is a dynamic behaviour, hence pictures of driving scenarios lack ecologically validity. Chapter Six addresses this issue and presents an experiment which further sought to investigate the psychophysiological processes involved in driving through the use of dynamic stimuli.

# Chapter Six

## Study 3: An investigation of drivers' psychophysiological responses in anticipation of a hazard

## Chapter Six Outline

## 6.1: Introduction

The results of Chapter Five provided support for the theoretical views of Slovic et al. (2002, 2004) and Damsio (1994, 2003) that there is an evolved human system of risk appraisal that utilises feelings and emotion, which is different from cognitive deliberation. Both inexperienced and experienced driver groups in Chapter Five rated the developing hazard scenario similarly whilst demonstrating differences in their skin conductance responses (SCRs). Differences between the groups' hazard ratings and SCRs to safe pictures demonstrated the reverse of this relationship but further supported a differentiation between cognitive appraisal and psychophysiological response.

Another important implication of the results from Chapter Five is that there is reason to acknowledge that drivers may learn by experience to emotionally anticipate hazards. Experienced drivers demonstrated significantly more SCRs to the developing hazard pictures compared to the inexperienced driver group. What makes this finding more interesting is that the two driver groups did not differ in their SCRs to hazard pictures. This provides support for the anticipatory principles of the somatic marker hypothesis and is suggestive of the learning of somatic markers through experience, as similarly demonstrated during the Iowa Gambling Task (IGT) (Bechara et al., 1997, 1999).

The major concern regarding the results from Chapter Five is that SCRs were proportionately low overall, possibly indicative of lacking ecological validity. This is unsurprising when one considers that driving is a dynamic task in which the environment is constantly changing, yet drivers were being tested by use of still pictures of driving scenes. It was suggested that future research should consider the use of more dynamic stimuli.

### *6.1.1: The present study*

The aim of Chapter Six was therefore to test the participants from Chapter Five but using dynamic stimuli instead of still pictures. In addition to Chapter Five, a further group of learner drivers were also recruited to take part. Hazard Perception video clips were purchased from the Driving Standards Agency, similar to those used in the

Hazard Perception section of the U.K. Driving Test. The clips were professionally constructed by the Transport Research Laboratory (TRL) (Grayson & Sexton, 2002). The use of hazard perception videos for research is common and often used to test for participants' speed of response or awareness (Sagberg & Bjornskau, 2006; McKenna, Horswill & Alexander, 2006; Wallis & Horswill, 2007). The current study was not looking to test participants for these criteria but simply to elicit their cognitive and psychophysiological responses as a hazard develops. Similar to the study in Chapter Five, participants SCR was to be measured as well as a continuous cognitive rating of risk by way of a slider response box. The use of the slider box to obtain cognitive hazard ratings is similar to the method used by Crundall et al. (2003) when measuring responses to police pursuits and emergency response videos.

### *6.1.2: Hypotheses*

Based on the results of Chapter Five, it could be expected that experienced drivers will demonstrate more SCRs in anticipation of a hazard compared to the inexperienced group, and also the learner group. Further, it could also be expected that whilst there will be a difference between experienced drivers and the other groups in anticipation of a hazard, that there will be no difference between the groups for their SCRs to the hazard itself. With regard to the slider hazard ratings, it would be assumed, given the results of Chapter Five and Crundall et al. (2003), that there will be no difference in hazard rating between the three driver groups. In summary, the following hypotheses were put forward:

I. Experienced drivers will be significantly more likely to produce a SCR during the period of hazard development compared to inexperienced and learner drivers

II. There will be no difference between experienced, inexperienced and learner drivers' proportional SCRs to fully developed hazards

III. There will be no differences between learner, inexperienced or experienced drivers' mean slider response during either the development of a hazard or at the time of the hazard

## 6.2: Method

### *6.2.1: Design*

A 3 (experience group) x 2 (hazard section) experimental design was utilised to test for participants psychophysiological and cognitive responses to hazard perception clips. There were three levels of driver experience being compared: learner, inexperienced and experienced. The groups were compared for their responses during defined (see Results section, page 173 for definitions) developing hazard sections and hazard sections. This design was applied to twelve hazard perception clips.

Continuous cognitive hazard ratings were taken in response to the clips, while physiological measures included participants' skin conductance response (SCR) and respiration amplitude.

### *6.2.2: Participants*

Eleven learner drivers (5 male; 6 female), 21 inexperienced (9 male; 12 female) and 18 experienced drivers (10 male; 8 female) took part in the experiment. Inexperienced drivers were defined as having held a driving licence for less than 3 years (mean=13.33 months, sd=8.86, range=1-29) and experienced drivers as having held their licence for over 3 years (mean =86.22 months, sd=43.63, range=36-168).

Participant ages were deliberately kept to within similar age ranges to minimise the effect of age. The learner driver group had a mean age of 21.7 years (sd=2.9, range=17.6-27.3); the inexperienced driver group had a mean age of 21.7 years (sd=3.6, range=17.8-33.8); and the experienced driver group had a mean age of 25.4 years (sd=2.9, range=20.3-31.0). These, and more participant details, are summarised in Table 6.1.

*Table 6.1 – Participant summary table*

| Participant Group, Number & Gender | | Age (years) | Held Full licence (Months) | Miles driven in the past 12 months | Accidents involved in as a driver (in lifetime) | Accidents involved in as a passenger (in lifetime) |
|---|---|---|---|---|---|---|
| **Total** | Mean | 23.02 | 36.64 | 3424.50 | 0.56 | 0.86 |
| **N=50 (M=24, F=26)** | Std. Deviation | 3.65 | 46.15 | 7824.40 | 1.11 | 1.31 |
| | Minimum | 17.58 | 0.00 | 10.00 | 0.00 | 0.00 |
| | Maximum | 33.83 | 168.00 | 50000.00 | 5.00 | 7.00 |
| **Learner** | **Mean** | **21.66** | **0.00** | **83.18** | **0.27** | **1.45** |
| **N=11 (M=5, F=6)** | Std. Deviation | 2.90 | 0.00 | 142.66 | 0.90 | 2.38 |
| | Minimum | 17.58 | 0.00 | 10.00 | 0.00 | 0.00 |
| | Maximum | 27.33 | 0.00 | 500.00 | 3.00 | 7.00 |
| **Inexperienced** | **Mean** | **21.69** | **13.33** | **2662.38** | **0.57** | **0.67** |
| **N=21 (M=9, F=12)** | Std. Deviation | 3.64 | 8.86 | 3784.22 | 1.25 | 0.80 |
| | Minimum | 17.75 | 1.00 | 20.00 | 0.00 | 0.00 |
| | Maximum | 33.83 | 29.00 | 12000.00 | 5.00 | 3.00 |
| **Experienced** | **Mean** | **25.41** | **86.22** | **6355.56** | **0.72** | **0.72** |
| **N=18 (M=10, F=8)** | Std. Deviation | 2.91 | 43.63 | 11940.01 | 1.07 | 0.75 |
| | Minimum | 20.25 | 36.00 | 400.00 | 0.00 | 0.00 |
| | Maximum | 31.00 | 168.00 | 50000.00 | 3.00 | 2.00 |

### *6.2.3: Materials*

Sixteen hazard perception clips were purchased from the Driving Standards Agency (DSA) under contract. A copy of the contract can be seen in Appendix 6A. The clips were developed and tested by TRL Limited for the Road Safety Division of the Department for Transport when constructing the Hazard Perception component of the current U.K. driving test (Grayson & Sexton, 2002). Grayson and Sexton's (2002) TRL report discusses finding thirty-eight hazard scenes which were able to distinguish between inexperienced and experienced drivers on their devised scoring method. Although the best clips are utilised for the official test and not available for purchase, it is understood that the clips purchased are of a similar standard. It is not possible, however, to match the clips bought with those discussed in the TRL report and the DSA were unable to confirm any reference to identify which clip was which. Of the sixteen clips purchased, four were considered of poor quality or too similar to other clips to be used in the experiment. Clips 4, 8, 9 and 14 were therefore excluded and the remaining clips retained their original identification number so as not to be confused with the excluded clips. The twelve remaining clips contained a variety of hazards and in a reasonable variety of driving scenarios. A list of the clips used with a summary of the hazards and their timings can be seen in Appendix 6B.

Each hazard perception clip was around one minute in length (range: 46.8-67.2 seconds) and involved one major hazard. The hazardous periods lasted for between 4.8 and 11.92 seconds. Although the hazard periods were roughly defined on the purchased CD-ROM, exact timing of a start point and critical moment point were defined using PowerDirector digital video editing software. The twelve clips were randomly presented full screen on a 19" monitor using Superlab 4 experiment generator software.

Participants' hazard rating was dynamically measured throughout the duration of the clip using a slider box. The slider ranged from 0 to 10 and was labelled 'Safe' at one end (0) to 'Hazardous' at the other (10). The slider was connected and measured through a Biopac MP35 system. Participants' SCR and respiration were also measured by the Biopac MP35 system using electrodermal pre-settings with Biopac EL507 SCRS isotonic gel disposable electrodes and a respiratory transducer. Biopac BSL Pro software was used to record and analyse the data.

Participants completed an updated version of the 'You and Your Driving Questionnaire', similar to that used in Chapter Three. A copy of the questionnaire can be seen in Appendix 6C. Appendix 6D shows the questionnaire with overall participant mean scores and response frequencies.

An additional element to this study was the use of the short-form revised Eysenck Personality Questionnaire (EPQR-S) (Eysenck, Eysenck & Barrett, 1985). As discussed in Chapter One (see page 26), there is evidence of a small but consistent link between certain personality characteristics and crash involvement (Ulleberg & Rundmo, 2003). More importantly, for the current study, it has been suggested that those who score high on neuroticism may be more likely to elicit SCRs (Carter &

Smith-Pasqualini, 2004). With a limited sample size, personality therefore has the potential to confound the results of the current study. The use of the EPQR-S allows for analysis of personality as a confounding variable. An example of the EPQR-S can be found in Appendix 6E.

An experiment information sheet and consent form were presented to participants at the beginning of the experiment and can be seen in Appendix 6F.

*6.2.3.1: Incentives*

The Strathclyde University Psychology Department funded recruitment of the participants allowing for £10 to be given to each participant on completion of the experiment.

***6.2.4: Procedure***

Participants were initially asked to read the experiment information sheet and sign the consent form if they were happy to proceed. Participants were seated approximately 60cm from the computer monitor with the slider at a comfortable distance on the desk. Electrodes were attached on the palmer surface of the medial phalanx of the middle and index fingers of the non-preferred hand. Participants were asked to position a belt attached to a respiratory transducer around their chest and asked to take several large breaths in order to check the recording equipment was operational and to provide a comparison respiration trace. Participants were informed that they would see twelve clips of normal driving scenarios and asked to imagine that they were the driver of the vehicle. It was not mentioned that there were any hazards in the scenes they would encounter. In order for participants to become accustomed to the slider and to check the equipment, each participant had a practice trial before they began.

When all the clips had been viewed, the electrodes and respiratory belt were removed. Participants from the learner group were then asked to complete the 'You and Your Driving' questionnaire.

Upon completion of the experiment, the participant was thanked, debriefed and given £10.

### *6.2.5: Ethical approval*

Ethical approval for the study was granted by the Psychology Ethics Board at Strathclyde University, where the experiment was performed, and can be seen in Appendix 5C.

## 6.3: Results

### *6.3.1: Definitions for SCR analysis*

For an SCR to be included in the data, it had to be equal to or exceed 0.05 μS (Dawson et al., 2000). Many studies have included SCRs which have exceeded only 0.02 μS (see Levinson & Edelberg, 1985), however, this reportedly increases the likelihood of including responses not related to the stimulus (Levinson & Edelberg, 1985). In order to increase the validity of the responses, a conservative approach to the inclusion of SCRs was taken. In order to extract data from participants' continuous SCR trace during the hazard perception clips, timing markers were required and defined.

#### *6.3.1.1: Hazard Start Marker*

The start of the hazard was defined using digital video editing equipment. This enabled the hazard perception clips to be broken down into frames with exact timings. The item that eventually became the hazard was defined and analysed for the first frame in which that item occurred. This was therefore the Hazard Start Marker as it was the first moment at which the hazard began to be built up.

This practice was followed for all clips except clip 15 where two bikers ride along a parallel road for a considerable period of time. It is only when the parallel road then joins with the driver's road that a hazard ensues. For clip 15 the hazard start marker was defined from the moment at which the junction between the two roads became visible.

#### *6.3.1.2: Critical Moment Marker*

The critical moment was defined as being the moment at which the driver in the HP clip takes avoiding action to the hazard. Avoiding action involved either braking or changing direction of the vehicle. Again, using digital video editing equipment allowed for exact timing of this moment.

*6.3.1.3: Event Period*

Preliminary analysis indicated that most drivers elicited a large SCR around the Critical Moment Marker. This was defined as an Event Response. As the critical moment was the final moment at which the driver in the clip responded to the hazard, some drivers demonstrated this event response slightly prior to the defined Critical Moment Marker. To allow for event response variation, a period of time was defined around the Critical Moment Marker. This was termed the Event Period. The Event Period started from 75% of the total hazard time for each clip to three seconds after the Critical Moment Marker. All participants' event responses fell within this period. The three seconds after the Critical Moment was included as three seconds after a stimulus is presented is a recommended response latency for SCR data (Levinson & Edelberg, 1985; Barry, 1990 – see Chapter Four, page 139 for further discussion)

*6.3.1.4: Anticipatory Period*

The knock-on effect of defining the Event Period meant an area was defined that started from the Hazard Start Marker to 75% of the total time of the hazard. This area was therefore defined as the Anticipatory Period and any responses within this area would be considered an anticipatory response to the build up of a hazard.

Due to the response latency of SCRs (Levinson & Edelberg, 1985), any response within one second of the Hazard Start was not included as this may have been caused by something which happened prior to the start of the hazard period. A demonstration of the Anticipatory Period, Event Period and timing markers can be seen in Figure 6.1.

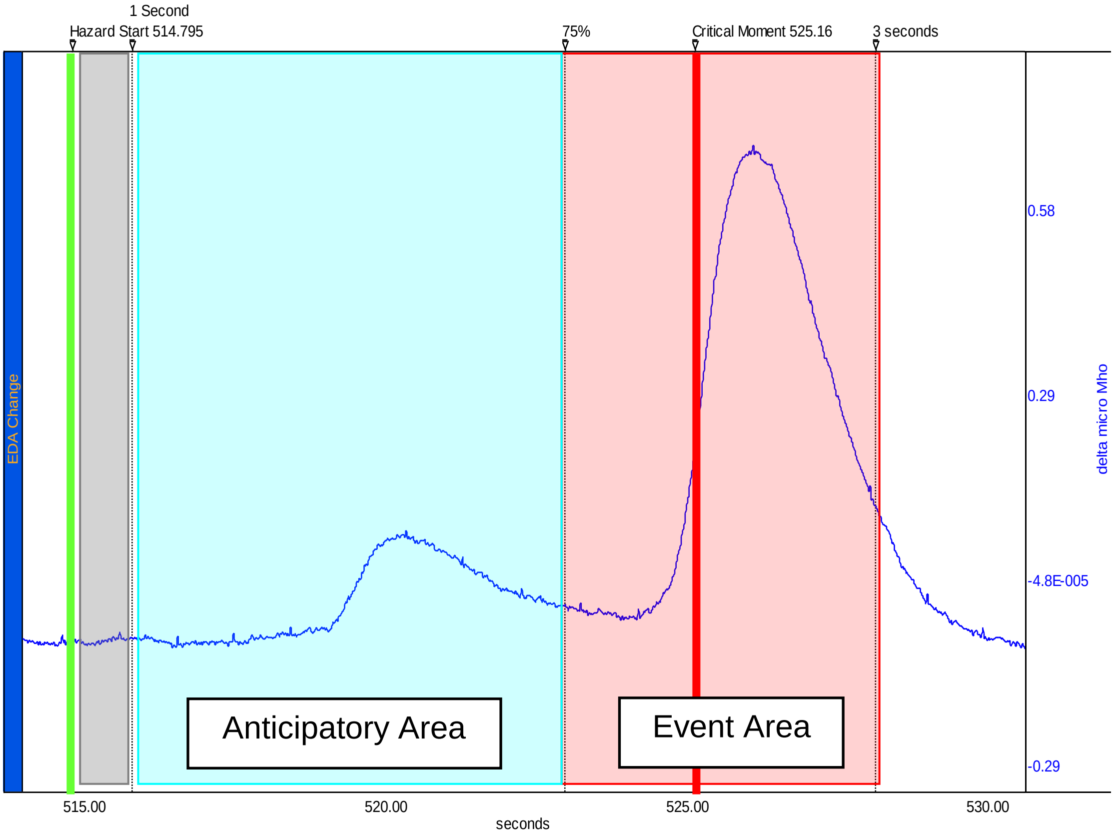


*Figure 6.1: Demonstration of timing markers and areas used to extract SCR data from participants responses*

### *6.3.1.5: Anticipatory Score*

So that the three experience groups could be compared for their frequency of demonstrating an anticipatory response, an overall anticipatory score was produced. The anticipatory score involved collating the number of clips in which a participant demonstrated a SCR response within the anticipatory area. If a participant had more than one SCR response within the anticipatory area, this was only counted as having demonstrated an anticipatory response for the purpose of the anticipatory score. All participants viewed twelve hazard perception clips and therefore had twelve SCR readings that could be coded using the above definition, however as SCR is an extremely sensitive measure, interference can cause a change in SCR that compromises the reliability of measuring a psychophysiological response. Irregular respiration (as measured by the respiration belt), sudden movement or a technical fault, were all reasons for excluding some hazard responses from the current sample. Therefore, although all participants had viewed twelve clips they may not have had valid data for all twelve clips. Table 6.2 summarises the number of excluded cases per clip.

*Table 6.2: Number of participants per clip who had a valid response or who were excluded from analysis*

| | **No. of Valid Responses** | **No. of Participants with excluded data** | **Total** |
|---|---|---|---|
| **Clip 1** | 44 | 6 | 50 |
| **Clip 2** | 44 | 6 | 50 |
| **Clip 3** | 41 | 9 | 50 |
| **Clip 5** | 46 | 4 | 50 |
| **Clip 6** | 43 | 7 | 50 |
| **Clip 7** | 42 | 8 | 50 |
| **Clip 10** | 44 | 6 | 50 |
| **Clip 11** | 45 | 5 | 50 |
| **Clip 12** | 46 | 4 | 50 |
| **Clip 13** | 41 | 9 | 50 |
| **Clip 15** | 45 | 5 | 50 |
| **Clip 16** | 45 | 5 | 50 |

The following equation was used to determine a participant's Anticipatory Score:

$$\text{Anticipatory Score} = \frac{\text{No. of valid clips with an anticipatory response}}{\text{No. of valid clips}} \times 100$$

This therefore gave each participant a proportional score of the percentage of clips that they demonstrated an anticipatory response.

### *6.3.2: Hypothesis I*

I. Experienced drivers will be significantly more likely to produce a SCR during the period of hazard development compared to inexperienced and learner drivers

#### *6.3.2.1: Analysis of Anticipatory Score*

For the analysis of the Anticipatory Score, four participants were excluded for having valid responses to fewer than eight of the twelve clips. Of these four participants, one had no valid data; two had valid data for only two clips and one had valid data for only seven clips. All other participants had data for at least nine clips. Three of the excluded participants were from the inexperienced group (1 male; 2 females) and one was from the experienced group (female).

Table 6.3 summarises the anticipatory scores for the three experience groups. A difference of mean score can be seen between the learner, inexperienced and experienced groups. While there is only a small difference between the mean score of the learner group and the inexperienced group, the experienced group score is over double that of the inexperienced group score and nearly three times that of the learner group score. Due to a wide range of scores within each group, the median score is also reported and suggests a similar but more extreme trend between the groups.

*Table 6.3: Summary of Anticipatory scores by experience group*

| Participant Group | N | Mean (%) | Median (%) | Min Score (%) | Max Score (%) | SD |
|---|---|---|---|---|---|---|
| **Learner** | 11 | 23.61 | 16.67 | 0.00 | 81.82 | 26.20 |
| **Inexperienced** | 18 | 32.19 | 25.00 | 0.00 | 80.00 | 27.34 |
| **Experienced** | 17 | 65.20 | 81.82 | 8.33 | 91.67 | 28.69 |
| **Total** | 46 | 42.34 | 36.67 | 0.00 | 91.67 | 32.43 |

Figure 6.2 shows an error bar chart which demonstrates that there is a relatively large difference between the experienced group and the inexperienced and learner groups with no overlap of the 95% Confidence Intervals. However, there was overlap of the 95% CIs between the learner and inexperienced groups.

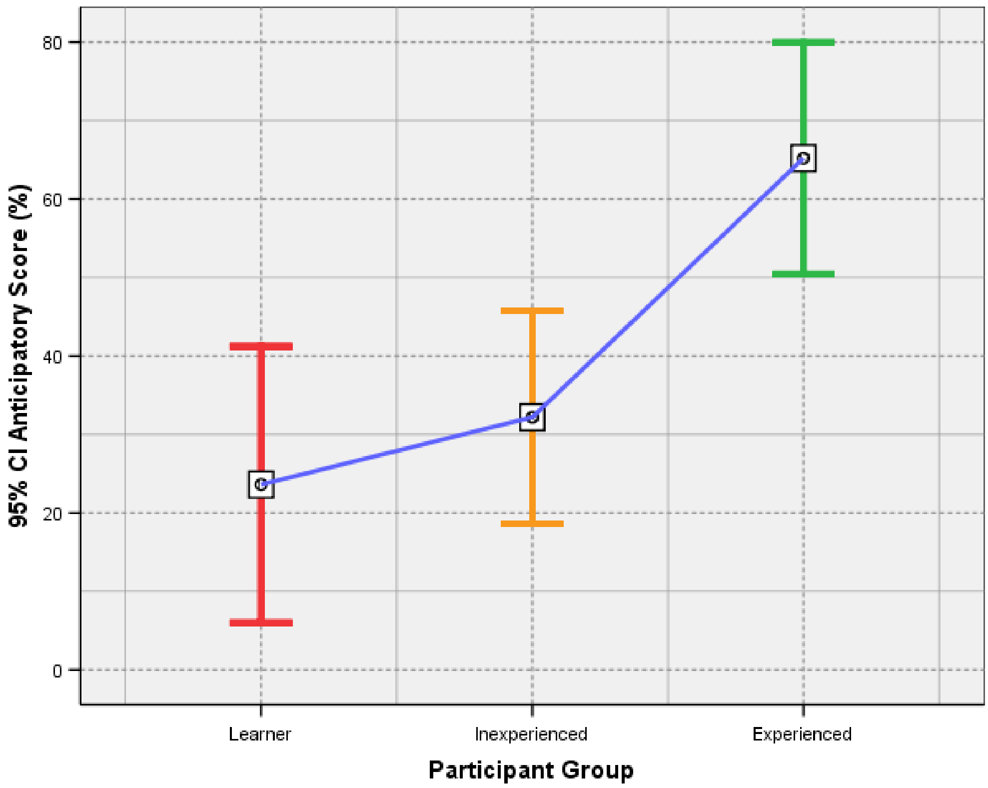



*Figure 6.2: Graph of 95% Confidence Interval of participant group's Anticipatory Scores*

A one-way Analysis of Variance was performed and suggested a significant difference between the groups ($F(2,43)=9.58$; $p<.001$). Post hoc Tukey analysis determined that significant differences were found between the experienced group and both the inexperienced group ($p=.004$) and learner group ($p=.002$), therefore supporting Hypothesis I. No significant difference was found between the learner and inexperienced groups. A Pearson correlation of the relationship between anticipatory score and the length of time a driving licence has been held (inexperienced and experienced drivers only) supported this finding by demonstrating a significant positive relationship ($r=0.44$, $p<.01$).

Due to the potential influence of age, gender and exposure when analysing data related to driving, a Univariate analysis was performed with age, gender and miles driven in the past 12 months as covariates. This demonstrated that there was still a significant overall group effect ($F(2,46)=13.55$; $p<.001$) and that age, gender and miles driven were not significant influences at the .05 level (see Table 6.4).

*Table 6.4: Univariate analysis output comparing experience groups' anticipatory scores while controlling for age, gender and miles driven in the previous 12 months*

**Tests of Between-Subjects Effects**

Dependent Variable: Anticipatory Score (%)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 19929.807[a] | 5 | 3985.961 | 5.819 | .000 |
| Intercept | 3410.701 | 1 | 3410.701 | 4.979 | .031 |
| Age | 1590.675 | 1 | 1590.675 | 2.322 | .135 |
| Gender | 830.587 | 1 | 830.587 | 1.213 | .277 |
| Miles_12mnts | 2182.021 | 1 | 2182.021 | 3.185 | .082 |
| Group | 18569.942 | 2 | 9284.971 | 13.554 | .000 |
| Error | 27400.714 | 40 | 685.018 | | |
| Total | 129783.882 | 46 | | | |
| Corrected Total | 47330.521 | 45 | | | |

a. R Squared = .421 (Adjusted R Squared = .349)

The results of this analysis provide support for Hypothesis I, however, further analysis is of interest to explain the differences found between the driver groups.

*6.3.2.2: Anticipatory score per hazard perception clip*

In case the differences noted were due to large differences on one or two clips, a comparison of experience groups was performed for each clip individually. Figure 6.3 graphically compares experience groups mean anticipatory scores on each clip.

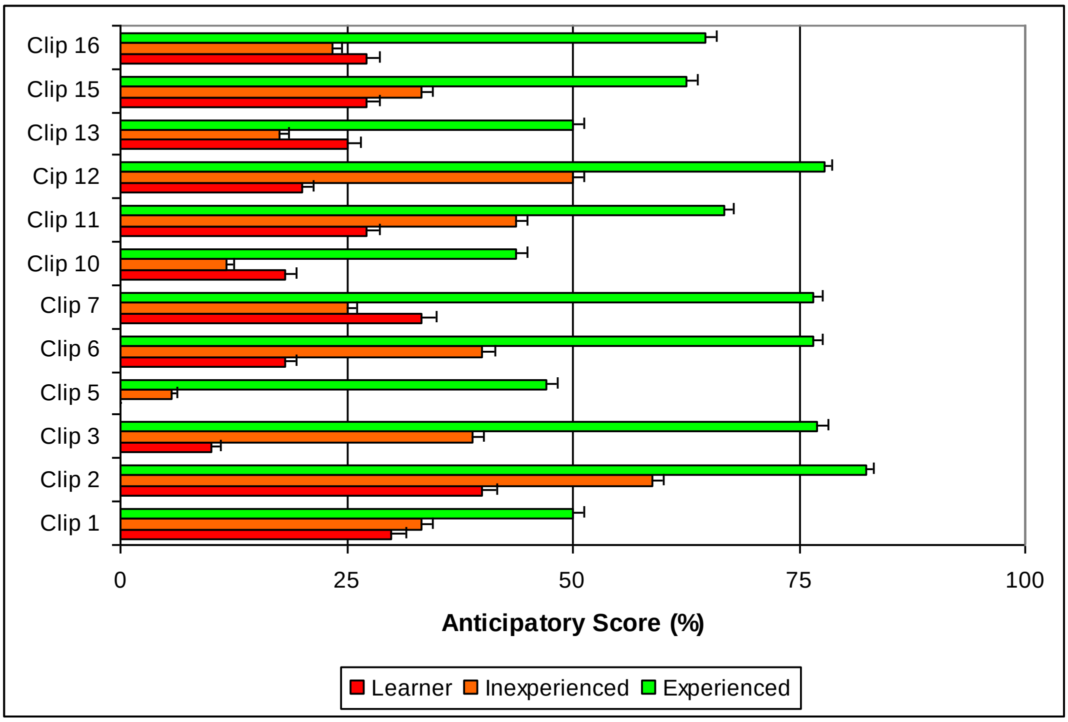



*Figure 6.3: Comparison of experience groups anticipatory scores for each clip with standard error bars*

The graph of anticipatory mean scores by clip (Figure 6.3) suggests a similar pattern is apparent on each clip whereby the experienced group scores higher than the inexperienced group, who in turn score similarly or higher than the learner group. One way analysis of variance was performed for each clip to test for significant differences between the groups. Significant differences between the groups were found for six of the clips whilst no significant difference was found for the remaining six clips. The results are summarised in Table 6.5 along with a description of the hazard involved.

*Table 6.5: ANOVA results comparing learner, inexperienced and experienced driver groups' anticipatory score by each clip*

**Significant**

| Clip | Description | df | F | Sig |
|---|---|---|---|---|
| 3 | **Pedestrian runs onto the road** without looking whilst waving a bus down | 2 | 6.630 | 0.003 |
| 5 | **Child on a bicycle** crosses the road causing a **motorbike** in front to slow down. | 2 | 7.872 | 0.001 |
| 6 | **Car pulls out** from a slip road onto **dual carriageway** in front of you. | 2 | 6.328 | 0.004 |
| 7 | **School children cross the road** at a zebra crossing near a school. | 2 | 5.849 | 0.006 |
| 12 | **On coming motorcycle pulls out** into the middle of road to pass parked car. | 2 | 6.225 | 0.004 |
| 16 | **Lorry performs a U-turn** on dual carriageway. | 2 | 4.654 | 0.015 |

**Not Significant**

| Clip | Description | df | F | Sig |
|---|---|---|---|---|
| 1 | Man comes out of house, crosses road ahead and enters passenger side of car. **Car then pulls out.** | 2 | 0.866 | 0.428 |
| 2 | **Cyclist** pulls out of junction ahead into cars path, then swerves to overtake indicating car. | 2 | 2.722 | 0.078 |
| 10 | **Man steps onto road with box from behind a van** and crosses in front of you. | 2 | 2.354 | 0.108 |

| | | | | |
|---|---|---|---|---|
| 11 | **White van** approaches and pulls out of junction on a country road. | 2 | 2.139 | 0.131 |
| 13 | **Car in front brakes** for a **cyclist**, and then overtakes them. | 2 | 1.952 | 0.156 |
| 15 | **2 motorcycles** pull out of junction onto the road ahead. | 2 | 2.546 | 0.091 |

There is no obvious distinction between the clips that were significant and those that were not. Post hoc analysis can be seen in Appendix 6G.

*6.3.2.3: Inexperienced drivers*

Inexperienced drivers' scores were analysed further. Dividing this group by number of years driving (one versus two or three years since passing the driving test) demonstrated no significant difference in anticipatory score ($t(18)=.15$, $p$=ns). However, a natural gap in exposure was evident within the group between those who had driven less than 1000 miles in the last 12 months (n=12) and those who had driven more than 1000 miles in the last 12 months (n=6). The less-than-1000-miles group had an anticipatory score of 22.36 (sd=7.2), similar to the learner group, whereas the more-than-1000-miles group had an anticipatory score of 51.85 (sd=9.1). There was a significant difference in anticipatory score between these two groups ($t(18)=-2.45$, $p=.02$).

These two inexperienced driver groups were compared to the learner and experienced groups. One-way ANOVA demonstrates that there is still a significant overall group effect ($F(3,42)=8.65$; $p<.001$) with Tukey post hoc analysis showing a significant difference between experienced drivers and both learners ($p=.001$) and the less-than-1000-miles inexperienced group ($p=.001$). No significant difference was found between experienced drivers and the more-than-1000-miles inexperienced group ($p$=ns).

Univariate analysis was performed with age, gender and miles driven in the past 12 months as covariates. This demonstrated that there was still a significant overall group effect ($F(3,46)=11.82$; $p<.001$) and that age and gender were not significant influences at the .05 level. However, miles driven in the last 12 months was significant (p=.029). Output of this analysis is shown in Table 6.6.

*Table 6.6: Univariate analysis output comparing experience groups' anticipatory scores while controlling for age, gender and miles driven in the previous 12 months. Inexperienced group re-coded by mileage (over and under 1000miles in the last 12 months)*

**Tests of Between-Subjects Effects**

Dependent Variable: Anticipatory Score (%)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 23251.970[a] | 6 | 3875.328 | 6.277 | .000 |
| Intercept | 2498.393 | 1 | 2498.393 | 4.047 | .051 |
| Age | 722.815 | 1 | 722.815 | 1.171 | .286 |
| Gender | 567.452 | 1 | 567.452 | .919 | .344 |
| Miles_12mnts | 3187.974 | 1 | 3187.974 | 5.164 | .029 |
| Group_2 | 21892.105 | 3 | 7297.368 | 11.820 | .000 |
| Error | 24078.551 | 39 | 617.399 | | |
| Total | 129783.882 | 46 | | | |
| Corrected Total | 47330.521 | 45 | | | |

a. R Squared = .491 (Adjusted R Squared = .413)

When these two groups are plotted with all driver groups a pattern emerges whereby inexperienced drivers who have driven less than 1000 miles in the previous 12 months differ little from learner drivers (see figure 6.4). On the contrary, inexperienced drivers who have driven more than 1000 miles in the last 12 months demonstrate a mid-range score between the inexperienced average and that of experienced drivers.

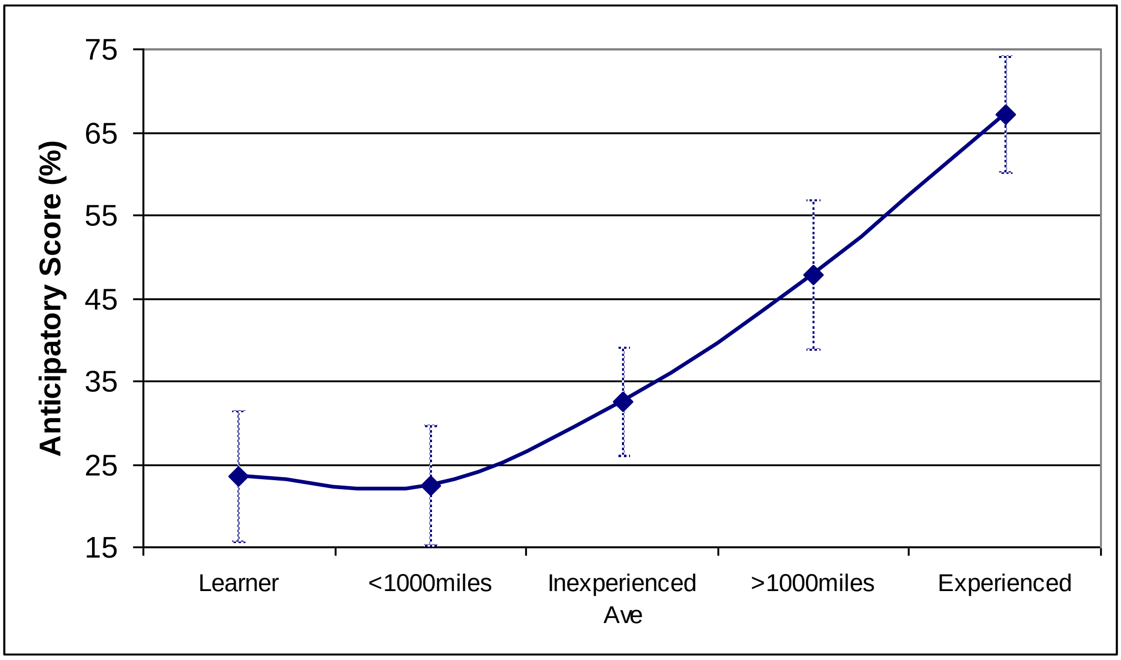



*Figure 6.4: Graph of Anticipatory Score by experience group with standard error bars*

***6.3.3: Additional Anticipatory SCR analysis***

*6.3.3.1: Analysis of SCR by peak to peak and area under the SCR*

An overall comparison of experience groups by peak to peak and area under the SCR was performed for each clip. The output of this analysis can be seen in Appendix 6H and Appendix 6I. Results found no significant difference between the groups for peak to peak or area measures on all but one clip. Clip 5 demonstrated a significant difference ($F(2,41)=4.39$; $p=.02$) for the peak to peak measure. Post hoc Tukey analysis found this difference to be between the inexperienced and experienced groups ($p=.03$), whereby the experienced group's peak to peak score was larger.

Mean peak to peak and area scores were also calculated only where an anticipatory SCR was produced (i.e. eliminating zero scores and missing values). Comparison between groups also found no difference for peak to peak ($F(2,36)=2.9$; p=ns) or area scores ($F(2,36)=2.32$; p=ns). The results of this analysis suggest it is possibly more important that there either is or there is not a SCR in anticipation of a hazard, rather than the amplitude or area of the SCR.

*6.3.3.2: Gender*

A comparison of anticipatory score by gender was conducted with mean scores summarised in Figure 6.5. The comparison of gender mean scores suggests no significant difference overall (t(44)=-.74; p=ns). Males and females show a similar upward trend as experience level increases. Females' higher score at the learner level is notable, although it is not significant (t(6.57)=-1.68; p=ns). Females also score higher in the experienced group but this is also not significant (t(14.1)=-1.43; p=ns). There is also no significant difference between male's and female's anticipatory score in the inexperienced group (t(18)=-.55, p=ns). It can therefore be concluded that anticipatory score is not mediated by gender, as also shown in earlier analysis (see Table 6.4).

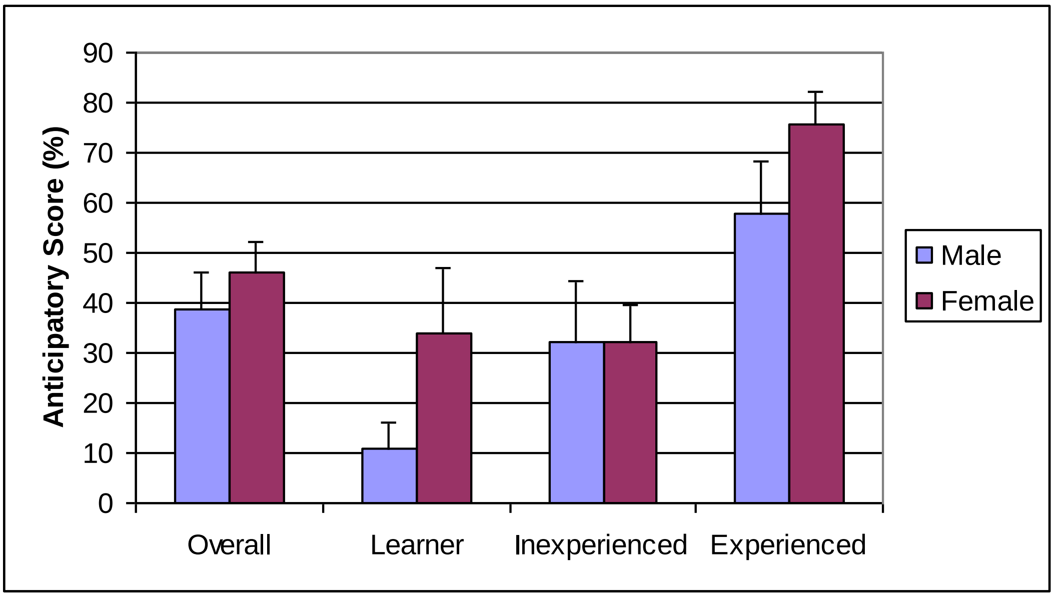



*Figure 6.5: Comparison of anticipatory mean scores by gender with standard error bars*

*6.3.3.3: Crashes and Near Misses*

It could be expected that accidents and near misses whilst travelling in a car would provide the ideal opportunity for a person to associate an emotional reaction with an on-the-road experience. Participants were therefore asked to report the number of accidents, near misses and serious near misses that they had experienced. These responses were tested for their relationship with participants' anticipatory score by way of Pearson's correlation. The correlation coefficients are summarised in Table 6.7 and suggest no relationship between reported crashes and anticipatory score or the total number of reported near misses. However, the reported number of potentially serious near misses is significantly associated with anticipatory score (r=0.35, p=.01).

*Table 6.7: Pearson correlation coefficients between anticipatory score and crashes and near misses*

| | Total number of reported crashes in lifetime as a driver or passenger | Total number of reported crashes in last 3 years | Total number of reported near misses as a driver or passenger | Total number of potentially serious near misses reported as a driver or passenger |
|---|---|---|---|---|
| ***Coefficient*** | -0.13 | -0.05 | 0.14 | 0.35 |
| ***P=*** | 0.39 | 0.71 | 0.33 | *0.01* |
| ***N*** | 49 | 49 | 49 | 49 |

### *6.3.4: Hypothesis II*

II. There will be no difference between experienced, inexperienced and learner drivers' proportional SCRs to fully developed hazards

#### *6.3.4.1: Analysis of Event Score*

An event score could be calculated in the same way in which the anticipatory score was calculated, although obviously analysing SCRs within the defined Event Area. For analysis of the Event Score, five participants were excluded for having valid responses to less than eight of the twelve clips. Of these five participants, four were from the inexperienced group (2 male; 2 female) and one was from the experienced group (female). Results demonstrate that participants in all groups were more likely to elicit an event response than an anticipatory response but that differences between experience levels remain, as demonstrated in Figure 6.6.

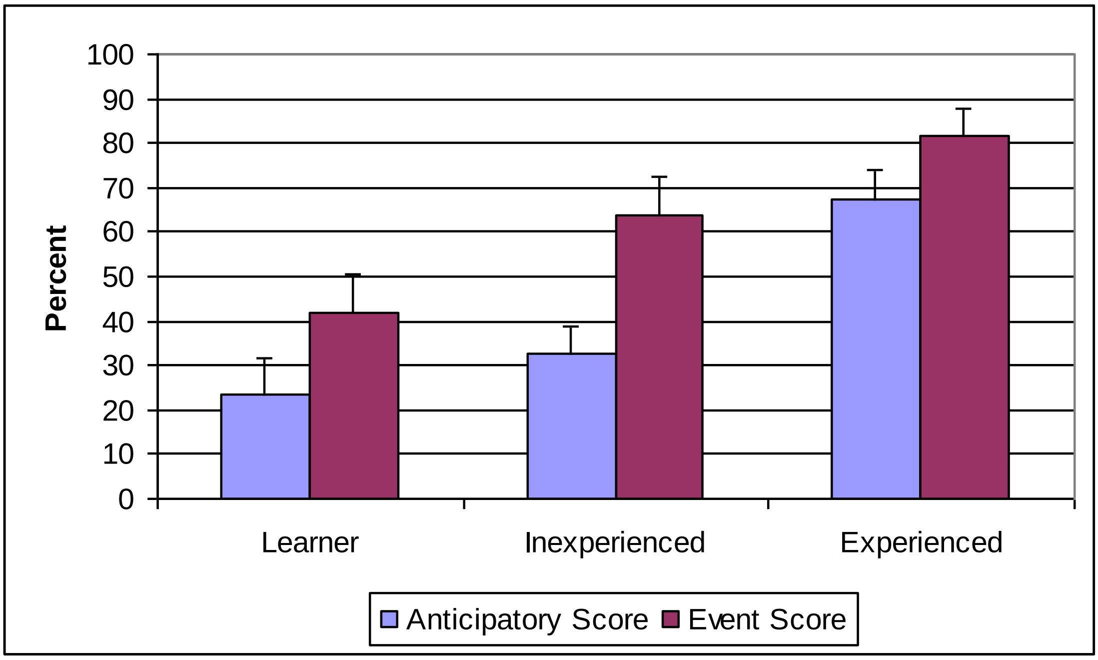



*Figure 6.6: Graph of Event Score means by experience level compared with Anticipatory score means with standard error bars*

A one-way Analysis of Variance was performed and suggested a significant difference between the groups ($F(2,42)=5.35$; $p<.01$). Post hoc Tukey analysis determined that a significant difference was found between the experienced group and learner group ($p=.006$), although not between the experienced and inexperienced groups (p=ns). No significant difference was found between the learner and inexperienced groups (p=ns). Hypothesis II has therefore only been partially supported although the result supports the finding from Chapter Five whereby no difference in SCR between the inexperienced and experienced group was found to hazard pictures.

### *6.3.5: Hypothesis III*

III. There will be no differences between learner, inexperienced or experienced drivers' mean slider response during either the development of a hazard or at the time of the hazard

#### *6.3.5.1: Slider Response analysis*

Cognitive hazard ratings were dynamically recorded via a slider which ranged from 'Safe' (0) to 'Hazardous' (10). To compare participants' hazard ratings, slider data was extracted using the same timing markers as defined for extracting the SCR data.

There were therefore two areas: anticipatory (hazard start to 75%) and event (75% to critical moment). The additional three seconds after the critical moment marker was not included for the slider analysis as the physiological delay in SCR measurement did not need to be accounted for. Using Biopac BSL Pro software, participants' mean ratings for the two periods were calculated for each clip, as well as a peak to peak measure. The mean rating provides an indication of how hazardous a participant rated this section of the clip, while the peak to peak measure indicates the amplitude change of participants' rating from the start of the period to the end.

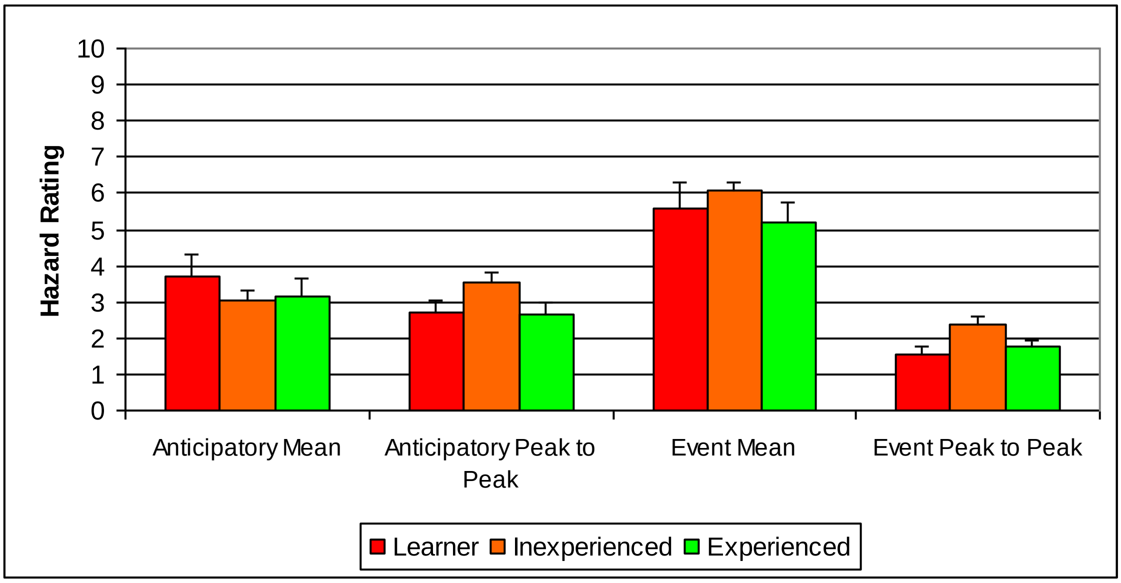



Figure 6.7: Figure of mean peak to peak and slider mean scores by experience group for the anticipatory and event areas with standard error bars

Figure 6.7 shows participants' mean scores of their mean slider rating and peak to peak rating from the anticipatory and the event areas. This graphical representation suggests little difference between the hazard ratings of the three groups, similar to the finding in Chapter Five. One way analysis of variance was performed to test for differences between the groups. No significant difference was found between experience groups for the anticipatory mean slider rating ($F(2,47)=.48$; p=ns), nor the event mean slider rating ($F(2,47)=1.02$; p=ns), therefore supporting Hypothesis III.

There was also no significant difference in anticipatory peak to peak ($F(2,47)=2.86$; p=ns), although there was a significant difference between the groups event area peak to peak scores ($F(2,47)=4.26$; $p<.05$). Post hoc Tukey analysis determined that this difference was between the learner and the inexperienced groups only ($p=.03$).

*6.3.5.2: Slider Response analysis per hazard perception clip*

To further test for any difference between the groups' slider response, analysis of scores for each clip was carried out. No significant difference was found on any clip between the groups for scores of anticipatory slider mean and event slider mean.

Anticipatory peak to peak scores found a significant difference for clip 2 ($F(2,46)=4.74$; $p<.05$) and clip 7 ($F(2,46)=4.68$; $p<.05$). Post hoc Tukey analysis found these differences to be between the learner and inexperienced groups only ($p=.01$ and $p=.02$, respectively). Event peak to peak scores demonstrated differences between the groups scores for clip 10 ($F(2,45)=6.82$; $p<.01$) and clip 16 ($F(2,46)=4.25$; $p<.05$). Post hoc Tukey analysis found this difference to be between the inexperienced group and learner group ($p=.01$), and inexperienced and experienced group ($p=.01$) for clip 10, and between the learner group and the inexperienced group ($p=.03$) for clip 16. The full output for this analysis can be seen in Appendix 6J.

*6.3.5.3: Relationship between Slider Response and SCR*

Tests for a relationship between participants' hazard ratings and their SCR demonstrate that there is no relationship in either the anticipatory or event area. Pearson correlations between participants' anticipatory SCR scores and their anticipatory slider mean ($r=.11$, p=ns) or anticipatory peak to peak scores ($r=-.07$, p=ns) found no strong or significant relationship. Similarly, in the event area, there was no relationship between participants' SCR event score and their event slider mean ($r=.12$, p=ns) or their event peak to peak score ($r=.22$, p=ns).

*6.3.5.4: Personality*

As it has previously been reported that neuroticism is related to greater likelihood of eliciting an SCR (Carter & Smith-Pasqualini, 2004), the present study therefore asked participants to complete an EPQR-S (Eysenck et al., 1985). Pearson's correlations were calculated to test for any relationship between the EPQR-S scales and the SCR measures. Correlation coefficients are summarised in Table 6.8, and demonstrate no strong or significant relationships. It can therefore be concluded that personality or neuroticism, as measured by the EPQR-S, has not been a confounding variable in the current study.

*Table 6.8: Correlation coefficients of EPQR-S scales with SCR measures*

| Correlation Coefficients | *Psychoticism* | *Extraversion* | *Neuroticism* | *Lie Scale* |
|---|---|---|---|---|
| **Anticipatory Score** | 0.10 | -0.06 | 0.14 | -0.02 |
| **Event Score** | -0.06 | 0.03 | 0.17 | 0.08 |
| **No. of Anticipatory Peaks** | -0.08 | 0.04 | 0.11 | 0.12 |
| ***N*** | *48* | *48* | *48* | *48* |

*P=ns for all*

## 6.4: Discussion

The results of the current study replicate those found in Chapter Five and further support the existence of a system that utilises emotional appraisal to anticipate hazards when driving. Experienced drivers were twice as likely to produce a SCR to developing hazards as the inexperienced drivers and almost three times as likely as the learner drivers. This differentiation was significant even when age, gender and exposure were controlled for.

### *6.4.1: Two forms of risk appraisal*

In support of the results from Chapter Three and Chapter Five, it was again demonstrated that there is a distinction between cognitive and emotional appraisal of hazards. There were no significant differences between the three driver groups mean hazard ratings either during the anticipatory area or at the time of the hazard. This is intriguing as experienced drivers produce significantly more SCRs to developing hazards compared with inexperienced and learner drivers yet show no difference in their cognitive appraisal of these same hazards. As well as supporting Slovic et al.'s

(2002, 2004) definitions of risk appraisal, these results cause concern with regards to the effectiveness of official hazard perception tests.

### *6.4.2: Hazard Perception tests*

Official hazard perception tests ask for participants to cognitively respond to hazards and therefore would not necessarily motivate novice drivers to learn emotional cues to the environment. It would appear, however, that some of the scoring methods used in hazard perception tests are able to distinguish between novice and experienced drivers (McKenna & Crick, 1991; Grayson & Sexton, 2002), although some can not (Chapman & Underwood, 1998). The reason for this may be that some scoring systems award for early detection of the hazards, hence, experienced drivers' attention is drawn to the potential hazard earlier due to their automated appraisal of the developing hazard. Whether classroom training with novice drivers involves them learning emotional appraisal of the hazards or just the cognitive awareness necessary to score well on the test is debatable.

### *6.4.3: Learners*

Another similarity to the results of Chapter Five was that there was no difference in SCR score between experienced and inexperienced drivers in response to the critical moment of the hazard, however, there was a significant difference between the experienced drivers' SCR score and the learners' SCR score. It is not clear why learner drivers should produce less SCRs in response to an obviously dangerous moment. It may be that due to their inexperience they simply do not have an appreciation of the inherent dangers involved in driving. Supervised learner driving is exceptionally safe compared with even experienced solo driving (White, 2005) and maybe this is why learner drivers have yet to appreciate the realistic risks involved with driving. In spite of this, learner drivers still demonstrated an anticipatory score of twenty-three percent which suggests that they have the potential for demonstrating psychophysiological responses to developing hazards. This value could represent a baseline level of emotional hazard appraisal due to associations made through experiences such as being a passenger.

### *6.4.4: Inexperienced drivers' anticipatory SCRs*

Of exceptional interest was the finding that inexperienced drivers who had driven less than 1000 miles in the last twelve months, had an anticipatory score that was almost identical to that of learner drivers. Conversely, inexperienced drivers who had driven more than 1000 miles in the last twelve months demonstrated a score that appeared to demonstrate progress towards the level of experienced drivers. The presentation of these scores in graphical form (see Figure 6.4, p170) exhibits a pattern that strongly suggests a learning curve mediated by driving experience. Intriguingly, an examination of novice driver crash rates reports that crash risk reduces dramatically after 1000 miles of licensed driving (McCartt et al., 2003). Similarly, McKnight and McKnight (2003) report that novice driver crash risk can be seen to considerably reduce after the first 500 miles of solo driving experience. Given that novice drivers are usually not undergoing any education or training during this post-licence period, one must consider what it is that novice drivers are learning? The results of the current study would suggest that they are learning to link environmental cues with feelings and emotion that allow for faster processing and attentional awareness of potential hazards.

In support of this, Sagberg and Bjornskau (2006) found that reaction times to hazard perception reduced significantly with increased driving experience in novice drivers. This could be suggestive of decision making becoming more automated and would theoretically suggest a shift from an 'analytic' appraisal of risk to an 'experiential' appraisal of risk, as defined by Slovic et al. (2002, 2004), and as proposed from the results in Chapter Three. Olsen, Lee and Simons-Morton (2008) tested novice drivers after licensure and six months later on a battery of driving measures like visual scanning and traffic interaction. Similar to the current study's results, they report a learning curve whereby the drivers demonstrated improvement but not to the level achieved by experienced drivers.

### *6.4.5: Somatic Marker Hypothesis (Damasio, 1994)*

With results of the current study exhibiting a learning curve of psychophysiological responses in anticipation of hazards, there is also support for the somatic marker hypothesis (Damasio, 1994). The results, therefore, also extend those of the Iowa Gambling Task (Bechara et al., 1997, 1999). The potential demonstration of somatic markers out-with the gambling task is important given the critique of Dunn et al. (2006). Although it was a laboratory experiment, the present study demonstrates psychophysiological feedback to a day to day activity and highlights the anticipatory nature of such responses. The neurological mechanisms that are the basis of the somatic marker hypothesis are not examined here and an area of future interest may be to test for regions of neural activity during a hazard perception task.

### *6.4.6: Task Difficulty Homeostasis (Fuller, 2005a)*

The literature covered in Chapter Four promoted theory that could advance understanding about the processes involved in the Comparator of Fuller's (2005a) task difficulty homeostasis model (see page 65 for diagram). As results of the current study offer support for the theory covered in that chapter, they therefore also support a greater understanding of what goes on within the Comparator. This will be discussed at greater depth in the following chapter, however, the results suggest that the model of task difficulty homeostasis could be updated to involve a flow of analytical risk appraisal and experiential risk appraisal involving feelings which feeds into an automated or cognitive decision making process. It is likely that this will bring the model further into line with Vaa's (2004) monitor model.

### *6.4.7: Amplitude and area of anticipatory SCRs*

While the current study found that there was a significant difference between experienced drivers and inexperienced and learner drivers in terms of proportionately eliciting an anticipatory SCR, there was no difference found between the groups for the amplitude of these responses or the area under them. While the Iowa Gambling Task studies (see Bechara & Damasio, 2005) reported a difference in area of anticipatory SCRs to advantageous and disadvantageous card choices, the scenario of avoiding a hazard when driving does not vary in emotional valence (except in rare occasions of sensation seeking). It is, therefore, unsurprising that no difference was found in amplitude or area. This finding suggests that the measure of whether there is, or is not, a psychophysiological marker is the most important.

### *6.4.8: Clip by clip anticipatory score*

A problem encountered within the results of the current study is that when comparing driver groups' SCRs by clip, only half of the clips were found to produce a significant difference between the groups. The graph of mean scores (see Figure 6.3) suggests that the pattern on every clip was similar to the overall proportional finding that experienced drivers scored higher than inexperienced and learner drivers. The cause of significant differences only being found for six of the clips could be for a number of reasons. It could be that only certain hazards are able to distinguish between driver groups or it could suggest that the quality of the hazard perception clip is important. Grayson and Sexton (2002) report large variations in hazard perception clip quality when constructing the clips, however, the clips used here are supposed to be of a uniformly high level of quality. Similar to the problems associated with the study in Chapter Five, it could simply be that the study still lacks ecological validity. Participants are still not in control of the vehicle and have no access to peripheral cues in the current study. This is an area of important consideration for any future research.

### *6.4.9: Gender and Personality*

In both the current study and that of Chapter Five, there were no differences in SCR responses by gender, at any experience level. This could be raised as a concern given that novice male drivers are more likely to be crash involved than novice female drivers (Maycock, 2002). A possible explanation for finding no difference between them, in both studies, is that the disparity between male and female novice driver crash rates may not be caused by the factors being investigated. The psychological factors being investigated in the current study are related to the role of inexperience in crash risk. If Damasio (2003) and Slovic et al. (2004) are correct that there is an evolved experiential system of risk appraisal that utilises feelings and emotions then this would be true of all humans, irrespective of gender. The role of gender in novice driver crash risk is most likely linked with age and social factors (Rolls et al., 1991; Gregersen & Bjurulf, 1996) rather than inexperience related factors, hence gender would not, theoretically, influence the results of the current study.

The same theoretical standpoint could be held with regards to personality and SCR response. No sub-scales of the EPQR-S (Eysenck et al., 1985) were significantly correlated with either anticipatory score, event score or the number of SCRs elicited, therefore, whilst not discounting the influence of personality on crash risk, the influence may not have been detectable in the context of the current study.

### *6.4.10: Crashes and Near misses*

If experience allows us to relate emotions and feelings to environmental cues which inform us of danger in the future, logically, a crash or a near miss is a likely scenario for this association to be made. Correlations between drivers' self-reported crashes and near misses with anticipatory score did not demonstrate any significant relationships, however, there was a significant relationship between the reported number of potentially serious near misses and anticipatory score. These results are confusing as it would be strange if potentially serious near misses were to be associated with learning emotional cues whereas actual crashes were not. It is possible that self-report measures of accidents and near misses are simply not accurate enough to be tested in this way. Alternatively, this analysis assumes that emotional appraisal of hazards is only learned from serious events, which is possibly a crude assumption of an evolved system that is probably more refined than this. While the method of analysis here may be too rudimentary, tests of driver groups with distinctly different accident histories may be of interest for future research.

### *6.4.11: An alternative explanation*

The major difficulty in drawing conclusions from the current study is that whilst SCRs signify some form of psychophysiological arousal, their exact meaning and cause can not be determined. Another way in which the results of the current study could be explained is that the SCRs are simply in response to mental workload, in other words, the SCRs represent experienced drivers' advanced cognitive deliberation of the driving task. If experienced drivers were paying more conscious attention to the driving environment however, then they should perform poorly when workload is increased with the addition of other tasks. In a study of driving experience and cognitive workload, Patten, Kircher, Ostlund, Nilsson and Svenson (2006) tested novice drivers, low-mileage drivers and high-mileage drivers on a pre-determined route. The participants had to drive whilst completing a Peripheral Detection Task (PDT), which is a sensitive measure of cognitive workload. Patten et al. (2006) report that the novice and low-mileage drivers use greater workload during normal driving and traffic management tasks and therefore performed badly on the PDT when compared with experienced drivers. They concluded that:

> “This shows how drivers with better training and experience are able to automate their driving more effectively than their less experienced counterparts.”
> (Patten et al., 2006, p893)

From the results of Patten et al. (2006) it would appear that experienced drivers require less cognitive workload compared to novice drivers in normal driving. If this is the case, then the SCRs found in the current study are unlikely to be due to increased cognitive workload. Of course, this still does not necessarily mean that the SCRs precede conscious attention of the developing hazard.

#### *6.4.12: Limitations of the study and suggestions for future research*

A further criticism of the current study is that unlike Helander (1978), it is unable to determine the timing of the SCRs. It is clear that experienced drivers are more likely to produce SCRs during the development of a hazard, but would this precede a behavioural response (i.e. braking) when driving? It would be useful for research with greater resources to consider the use of a simulator or real time driving with measures of accelerator release or braking to determine if the SCRs are likely to be predictive of a behavioural response. Of course, any such study will have the same methodological problem as Helander (1978) with regard to skin conductance response latency. The current study has at least provided the basis for considering such work.

## 6.5: Chapter Six Summary

**The aim of Chapter Six was to test learner, inexperience and experienced drivers for their psychophysiological and cognitive appraisal of encountering hazards when driving.** To build on the results of Chapter Five, dynamic stimuli in the form of professionally made hazard perception clips were used in place of still pictures. Cognitive appraisal of hazards was measured by use of a slider, while skin conductance response (SCR) was used as a measure of psychophysiological arousal.

#### *6.5.1: Anticipatory SCRs*

Two areas were defined during hazards: an anticipatory area during the build of up of a hazard and an event area around the time of the critical moment of the hazard**.**

**Results found that experienced drivers were significantly more likely to produce a SCR within the anticipatory area when compared with the inexperienced and learner drivers. This result remained even when age, gender and exposure were controlled for. However, similar to the results of Chapter Five, there was no difference between the groups for their mean cognitive ratings of the hazards in either the anticipatory area or the event area. This further supports the distinction of two forms of risk appraisal: risk by feelings and risk by analysis (Slovic et al., 2002, 2004).** The implications that these findings may have for official hazard perception testing, like that used within the UK, were discussed.

### *6.5.2: Demonstration of a learning curve*

There was an intriguing result within the inexperienced group. When the group was divided based on the time they had held a driving licence, there was no difference found between their anticipatory SCR scores, however, when they were divided by exposure, there was a significant difference. **Inexperienced drivers who had driven under 1000 miles in the last twelve months had an anticipatory SCR score almost identical to that of the learner drivers. Conversely, inexperienced drivers who had driven more than 1000 miles in the last twelve months had a score that was progressing towards that of the experienced drivers. This provided an illustration of a learning curve whereby psychophysiological arousal to developing hazards is mediated by experience. Interestingly, research has previously found that novice driver crash risk reduces dramatically after 500 and 1000 miles of licensed driving (McKnight & McKnight, 2003; McCartt et al., 2003). The integration of this research with the current study's results is suggestive that learning to emotionally appraise the environment when driving is a crucial process in reducing crash risk.**

### *6.5.3: Somatic markers*

The results therefore provide strong support for the theoretical concepts covered in Chapter Four and build on the results of Chapter Five. Within the context of the somatic marker hypothesis (Damasio, 1994), these results demonstrate examples of somatic markers in response to hazard situations developing. In terms of the theory, these results provide rare support out-with the Iowa Gambling Task (Bechara & Damasio, 2005).

### *6.5.4: Alternative explanation*

An alternative interpretation of the results was considered, with the notion that SCRs may be symbolic of advanced cognitive processes by experienced drivers. However, results of a study into driving experience and cognitive workload found that experienced drivers appear to have more workload capacity than novice drivers due to normal driving being more automated for experienced drivers (Patten et al., 2006). This would suggest that the SCRs recorded in the current study are unlikely to be due to increased workload by experienced drivers.

### *6.5.5: Limitations*

**The main critique of the current study is that whilst cognitive workload is unlikely to account for the SCR results, there is no certainty that the SCRs are symbolic of the emotional processing of hazards either.** Although Crundall et al. (2003) considered SCRs in their study to be 'indicative of sudden increases in hazard awareness' (p169), the nature of skin conductance as a measure means this can not be confirmed. A further criticism is that there is no way to know if the SCRs measured would have been predictive of a behavioural response in real driving, or even if they preceded conscious awareness. **Concerns over the ecological validity of the study were also raised and it was concluded that further research should seek to replicate the study but with the use of an advanced simulator or during real time driving.**

In spite of the criticisms of the study, the research conducted in this thesis has provided insight into the psychological processes involved in learning to drive. As Elvick (2006) states, inexperience is a risk factor in crashes because competence for safe driving is a mental rather than a physical activity. Uncovering the mental processes that underlie novice driver crash risk was the basis for the current research and the results of this study therefore provide a theoretical basis for beginning to understand these processes. Chapter Seven looks to summarise the material and experiments covered within the thesis and suggest how the theory and results may be applied.

# Chapter Seven

## Summary and Conclusion

## Chapter Seven Outline

## 7.1: Introduction

The current thesis has embarked on a journey of which the destination was to improve understanding of the novice driver problem. Chapter One sought to define the problem and explain the wide ranging influences that there are upon novice drivers, especially young novice drivers. Chapter Two looked to establish a driver behaviour model which could assist in the understanding of driver behaviour as a whole. Discussion of driver behaviour models highlighted some key psychological differences between novice and experienced drivers. The Task-Capability Interface (TCI) model (Fuller, 2005a) was considered as being best suited to further investigate the psychological aspects of driving. The study described in Chapter Three found support for the TCI and a previously important result that drivers rated the difficulty of the driving task as they did their feelings of risk (Fuller et al., 2008a). The differentiation of feelings of risk from objective risk estimate was theoretically interesting and discussed further in Chapter Four in relation to Slovic et al. (2002, 2004) and Damasio's (1994) Somatic Marker Hypothesis.

The placement of modern theory against a backdrop of historical skin conductance driving studies suggested an intriguing picture worthy of further investigation. Chapters Five and Six therefore sought to test for differences between novice and experienced drivers for their psychophysiological appraisal of hazards. The results of these studies further demonstrated a differentiation between subjective risk and objective risk estimate. A further important result was that experienced drivers demonstrated significantly more psychophysiological reactions during the development of hazardous driving scenarios than novice drivers. The demonstration of a learning curve mediated by driving experience added support for the theory discussed in Chapter Four.

The aim of this chapter is to summarise the thesis by discussing the theoretical implications of the results, as well as limitations and areas for future research. This will be followed by discussion of results in the wider context of driving research. Finally, implications of the results for policy will be considered.

## 7.2: Theoretical Implications

### *7.2.1: Slovic et al. (2002, 2004)*

Slovic and Peters (2006) state that risk is processed in two ways: risk as analysis and risk as feelings. This is an important differentiation which deviates from traditionally terming risk as subjective and objective. As discussed in Chapter Two, drivers' objective risk is actually their subjective risk estimate of objective risk rather than true objective risk itself. For the purposes of clarity, the current thesis termed this 'objective risk estimate'. Fuller et al. (2008a) reported finding a distinction between drivers' feelings of risk and their 'objective risk estimate', a finding replicated in Chapter Three. Further to this, the studies reported in Chapter Five and Six also found a clear differentiation between drivers' subjective risk and their objective risk estimate.

It is interesting that a discrimination of risk processing was established in all three studies. The study in Chapter Three involved no hazards, while Chapter Five involved the use of pictures and Chapter Six utilised dynamic hazard perception clips. That a differentiation was found in the processing of risk in all three methods suggests that this may be an innate and common discrimination of risk processing. Certainly, this would support the argument outlined by Slovic et al. (2002, 2004).

Slovic et al. (2004) claim that determining risk through feelings is part of an 'experiential' system. This experiential system is seen as an intuitive, automatic system of risk appraisal which has evolved as part of humans' natural assessment of their environment. The experiential system relies on the experience of linking emotions and feelings to cues in the environment. The results of Chapter Five and especially those of Chapter Six provide support for this theoretical standpoint. First, the experiential system (as measured by skin conductance) was shown to be different from the analytic system (as measured by the button box and slider). Second, the experiential system demonstrated learning of hazard awareness mediated by on-the-road experience.

This is important to the task of driving because the role of feelings and emotion in risk appraisal is also discussed in terms of decision making (Peters et al., 2006). Emotions and feelings, otherwise referred to as 'affect', are said to have an important role in decision making processes (Peters et al., 2006). If feelings and emotion have a role to play in risk appraisal and decision making then these must be considered key aspects in the driving process.

### *7.2.2: Somatic Marker Hypothesis (Damasio, 1994, 2003)*

The theoretical position taken by Slovic et al. (2002, 2004) is also found within the description of the Somatic Marker Hypothesis (SMH) (Damasio, 1994). The SMH also states that there is an evolved human system of risk appraisal that utilises feelings and emotion to warn a person of potential danger. This system is linked with decision making as feelings and emotion act to bias decision making towards advantageous outcomes. The 'somatic marker' is a bodily feeling that has been associated with cues in the environment through experience. Somatic markers are said to act like 'alarm bells' (Damasio, 1994).

The results of the studies described in Chapter Five and Chapter Six provide support for the SMH. The psychophysiological responses demonstrated during the development of a hazardous situation could be argued to be examples of somatic markers. Whilst this is an important result for driving behaviour research, it is also an important result for the somatic marker hypothesis. Prior support for the theory has been provided by the Iowa Gambling Task (IGT) (Bechara and Damasio, 2005). As discussed in Chapter Four, while the IGT provides support for the theory and the neurological regions underpinning it, problems associated with the IGT led Dunn et al. (2006) to suggest that other ways of testing the theory were necessary. The current thesis has, therefore, provided a new way of testing the theory related to an everyday activity in which appraisal of the environment to avoid threatening situations is essential. The SMH is well suited to driving behaviour and conceivably this is why the theory is used as the basis for Vaa's (2004) Monitor model.

Although the exact neurological processes, which are described in detail by Damasio (1994, 2003), have been areas of criticism (Maia and McClelland, 2004; Bennett & Hacker, 2003), there is reasonable support for the neural substrates discussed within the model (see Dunn et al., 2006 for a review). This means that as well as the psychophysiological results reported within the IGT studies (e.g. Bechara et al., 1997, 1999), the current thesis and the historical driving studies (e.g. Taylor, 1960; Helander, 1978), there is neurological support for an innate system of risk appraisal.

Of further interest is that the frontal lobe region of the brain, which includes the ventromedial prefrontal cortex utilised within the SMH, has recently been shown to still be maturing in early adulthood until age twenty-five (Gogtay, Giedd, Lusk, Hayashi, Greenstein, Vaituzis et al., 2004; Romine & Reynolds, 2005). On the basis of such work, researchers in New Zealand are working on 'The Frontal Lobe Project' with young novice drivers (Isler, Starkey, Charlton & Shepperd, 2007). A report of this project is due in late 2008. If this area of the brain proves to be germane to young, novice driving behaviour, this would have important implications for the minimum age of licensing.

The current thesis therefore lends support to the Somatic Marker Hypothesis (Damasio, 1994). Conversely, the SMH also supports the results of the studies within this thesis by providing a neurological theory that demonstrates an innate system of risk appraisal and decision making which must be learned through experience. This theory is fascinating when placed alongside driver behaviour research; as has been previously noted by Vaa (2004) and Fuller (2005b).

### *7.2.3: Task-Capability Interface and Task Difficulty Homeostasis (Fuller, 2005a)*

As the name suggests, the TCI is based on the interaction between task demand and a driver's capability. The demand of the driving task must remain below drivers' capability otherwise a loss of control will occur. Task difficulty is defined as being the gap between task demand and capability and it is proposed that drivers drive so as to keep task difficulty within a preferred range. The process of keeping task demand within this preferred area is explained through the Task Difficulty Homeostasis (Fuller, 2005a).

A main source of weakness within the task difficulty homeostasis was identified as the 'comparator' section (see Figure 2.8, Chapter Two, page 65). The comparator processes input from task difficulty and the driver's range of acceptable task difficulty which leads into a decision and behavioural response. It was considered important that the processes involved within the comparator are understood so as to verify the

TCI as a working model. Based on the theory and results discussed within the current thesis a new structure of the task difficulty homeostasis could be proposed (see Figure 7.1).

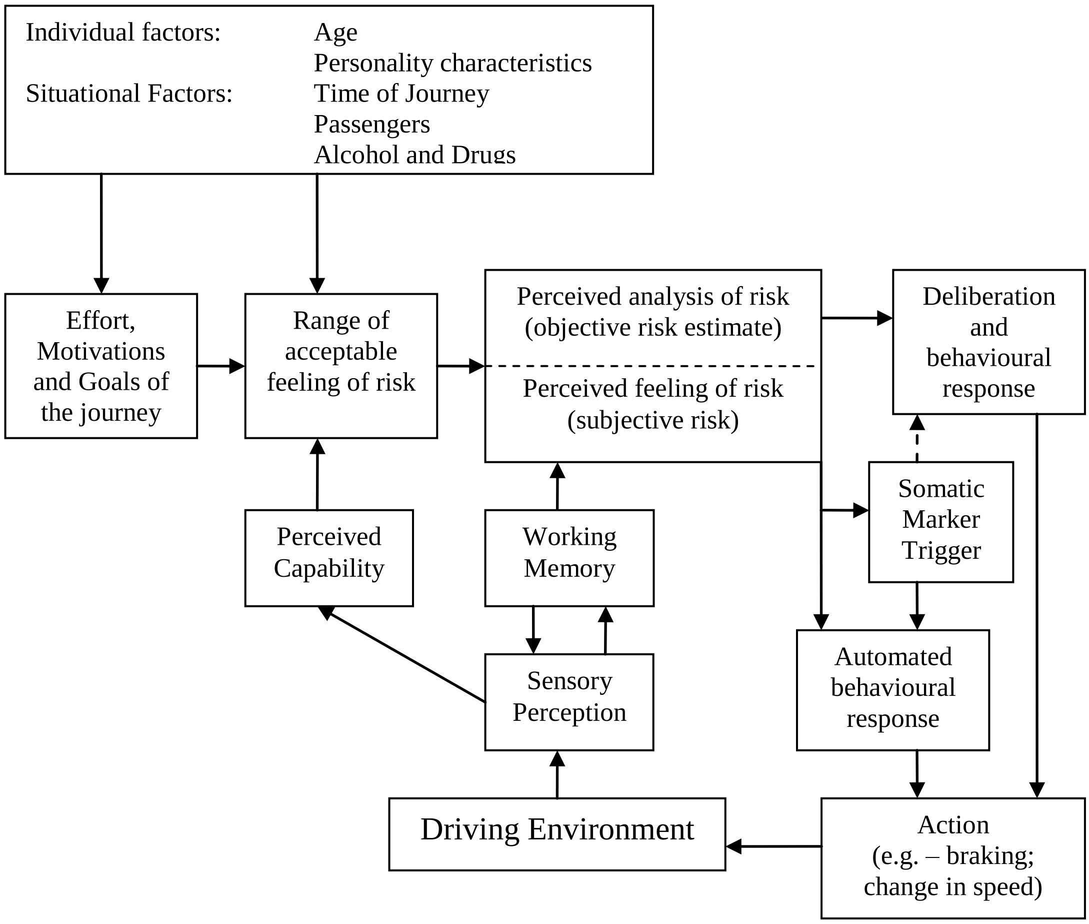



*Figure 7.1: Feelings of Risk Homeostasis*

The first major change is based on the results of Chapter Three. The model suggests that drivers determine the difficulty of the task through their feelings of risk, therefore making it a model of Feelings of Risk Homeostasis rather than Task Difficulty Homeostasis. External factors from the discussion in Chapter One are included as influencing drivers' effort and motivations and their range of acceptable feelings of risk. These factors will, therefore, impact on drivers' perceived analysis of risk and feelings of risk. The risk processing area essentially replaces the comparator. This section of the model is based on the differentiation of risk appraisal found within the studies of the current thesis. The two forms of risk appraisal, although separate when measured, must both be based upon the output of the process between sensory perception and working memory. The two forms of risk are therefore not presented as being totally separate. An example in which both forms of risk may be used at the same time is when a driver wishes to overtake a slower vehicle on a two way road. The driver may make a conscious deliberative judgement that overtaking the slow vehicle is the best option for his/her continued progress, however, the exact judgement of when to perform the manoeuvre is likely to be based upon when it feels safe to do so. Therefore, while the driver is fully conscious of his/her intention and behaviour, what may appear to be a deliberative decision is in fact influenced by risk appraisal through feelings. Of course, experience of this type of situation is important in this process. Experienced drivers' decisions will be more likely to be influenced by somatic markers learned through previous overtaking manoeuvres. These markers may be more important in warning a driver when *not* to attempt the manoeuvre. Inexperienced drivers would therefore be at much greater risk in this scenario without learnt associated feelings to assist their judgement.

The model therefore shows a loop whereby analysis of risk informs deliberation and behavioural response which enforces an action. Without learned associations between the environment and feelings, inexperienced drivers would have to utilise this method of risk appraisal more often, as was suggested by the results of Chapter Three. The results of Chapter Three and Fuller et al. (2008a) would suggest that this method of risk appraisal does not accurately determine the difficulty of the task which may be why inexperienced drivers are often said to be poorly calibrated. Alternatively, feelings of risk feed into an automated behavioural response which enforces an action. It is postulated that this is how experienced driving is performed most of the time. However, this process can be interrupted if cues within the environment trigger an automated somatic marker response. The identification of potential danger picked up through the senses and associated with learned environmental cues would be relayed as a feeling which is likely to result in heightened arousal and an immediate automated response. At the same time however, this identification of danger will bring the situation into full consciousness and therefore within the realm of deliberative judgement which could over ride the automated process.

The final section of the model simply shows that an action will have an influence on the driving environment which is then fed back for processing through sensory perception. Meanwhile, drivers' perceived capability, although relatively stable, will also be influenced by the environment and this will feed back into the driver's range of acceptable feeling of risk.

The model is offered as an update of the Task Difficulty Homeostasis by providing more information regarding how driving is psychologically processed. An area which is not covered in detail here but could develop the model is that of attention and specifically visual scanning. As discussed within the thesis, visual scanning patterns differ by experience level (Underwood et al., 2002) and by expertise (Crundall et al., 2003). Attention and visual scanning are therefore areas in which the model could be enhanced and are likely to be focused on the interaction between 'sensory perception' and 'working memory'.

The Feelings of Risk Homeostasis brings the TCI further into line with Vaa's (2004) Monitor model. Vaa (2004) asserts that sensory perception leads directly into 'somatic marking' which leads into feelings (which are conscious) and/or emotions (which are unconscious) (see Figure 2.5, Chapter Two, page 60). The Feelings of Risk Homeostasis does not differentiate between feelings and emotions which is another area which could be modified. The measures used within the current thesis are not refined enough to suggest a differentiation between measuring a feeling or an emotion. Vaa's (2004) model determines that feelings lead to conscious awareness which opposes the Feelings of Risk Homeostasis which suggests that risk appraisal through feelings is likely to be part of an automated and mainly unconscious process. These differences may simply be due to confused terminology regarding defining emotions and feelings. Nevertheless, clarification and standardised definitions for use within driver behaviour research could be advantageous if this is taken forward as an area for future research.

### 7.3 Limitations of the thesis and suggestions for future research

As well as limitations of the Feelings of Risk Homeostasis, there are wider limitations of the studies within the thesis itself. The major limitation is the use of skin conductance response (SCR) as a measure of feeling and emotion. It is not entirely clear what SCR is specifically measuring and therefore results based on skin conductance must make assumptions as to their meaning. In the current thesis, the assumption is that a SCR demonstrates a feeling of arousal indicative of an increase in hazard awareness. This assumption is supported by Bradley et al. (2001) who found that SCR was suggestive of emotional arousal, although not emotional valence; also Crundall et al. (2003) who considered SCRs to relate to sudden increases in hazard awareness. Nonetheless, the studies reported here could be critiqued similarly to those which demonstrated limitations of the Iowa Gambling Task (Dunn et al., 2006; Maia & McClelland, 2004).

Maia and McClelland (2004) criticised the Iowa Gambling Task as they claimed participants were able to perform the task with conscious awareness, rather than be led by unconscious ‘somatic markers’. The research in this thesis can not claim that drivers did not have conscious awareness of a hazard developing either. It can only claim that experienced drivers elicited more SCRs in response to developing hazards when compared to novice drivers. That the distinction is during the development of the hazard is suggestive of anticipatory processing by experienced drivers, although this may not be led by feelings as the current thesis purports.

As discussed in earlier chapters, the response latency of SCRs makes it difficult to determine if SCRs precede behaviour or behaviour precedes SCRs. Helander (1978) is the only author to have attempted to determine which comes first and concluded that a SCR preceded release of the accelerator and pressure on the brake. This would therefore be a legitimate line for future research. Whilst there is difficulty controlling for the response latency of SCR, there are two ways in which this could be approached. First, a meta-analysis of SCR studies, similar to that of Levinson and Edelberg (1985), could be conducted to establish a mean response latency that can be applied to SCR data. Alternatively, a second approach could take individual measures of response latency in response to precise stimuli (e.g. a loud bang) before performing an experiment. Participants’ SCR timing could therefore be adapted to their individual response latency. There would, however, still be a range of error within either of these measures.

Testing drivers’ psychophysiological responses using more realistic driving stimuli would also be the next logical step. In Chapters Five and Six, a weakness of both studies was reported in relation to the use of still pictures and videos as stimuli.

Although the stimuli used represented driving scenarios they did not require full behavioural responses from the participants. Historical studies used real on-the-road driving (e.g. Taylor, 1964; Helander, 1978) although control of the environment and driver movement must be considered as potentially problematic. While control of driver movement could still prove difficult, the use of a simulator would provide the ideal opportunity to manipulate hazards within the environment while measuring drivers' SCR and behavioural output.

Of course, other methods of measuring a psychophysiological response could also be utilised. As well as skin conductance, psychophysiology can be measured through brain activity like event-related potentials (ERPs) or fMRI (functional magnetic resonance imaging); cardiovascular measures (e.g. heart rate; beats per minute) and changes in pupil diameter (pupillometry). Using ERP or fMRI could advance understanding of the brain regions used to process information when driving. Out-with driving, Critchley, Elliot, Mathias and Dolan (2000) used fMRI and SCR measures with healthy participants on a card task similar to the IGT and found that activation of the ventromedial areas defined within the somatic marker hypothesis were correlated with SCR. This could suggest that a similar finding would be expected if measures of brain activity were taken during a driving task. A similar result is reported by Ernst, Bolla, Mouratidis, Contoreggi, Matochik, Kurian, et al., 2002) using PET (Positron emission tomography) scanning.

Given the evidence provided by the current thesis and other research for an innate risk appraisal system that learns by experience, the main focus of future development may be whether or not essential experiences can be learned through simulated driving. If drivers could learn to associate cues from the environment with feelings using a simulator this could potentially decrease novice drivers' initial crash risk. There would need to be several stages to such research. The first aim would be to replicate the results of the current thesis using a simulator and demonstrate differentiation between experienced and novice drivers' psychophysiological responses to the development of hazards. Second, investigation of learning psychophysiological responses to the driving environment would need to be demonstrated by manipulation of the stimuli encountered during the simulated exercise. This could be done by attempting to associate a neutral cue with a negative driving outcome. Later presentation of the neutral cue on its own would demonstrate if a psychophysiological reaction had been associated. Surprisingly, this suggestion for future research is similar in principle to the classic studies of Pavlov (1927) in which associating previously neutral stimuli with physiological reactions in dogs was demonstrated.

A further stage would be to determine what specific environmental cues, or combination of cues, cause psychophysiological responses in experienced drivers which would enable a database of cues from which to create simulated learning scenarios. If results were to support theory to this stage then the ultimate test would be to provide a group of novice drivers with controlled simulated driver training to learn physiological responses (in addition to their normal driver training) and follow up their crash rates compared with a control group who receive no simulator training.

It remains to be seen, however, whether driving experiences on a simulator can provide the sensory feedback necessary to cross over to real on-the-road driving. It must further be considered that it is currently unknown how much influence learning psychophysiological associations has on drivers' crash risk, especially when the wide range of factors influencing young novice drivers is appreciated.

### 7.4: Results in a wider context

Around 750,000 people qualify for a full UK driving licence each year, of which three-quarters are under twenty-five years old (DfT, 2008). An OECD (2006) summary of young drivers reports that the reasons behind their increased crash risk are exceptionally complex:

> "They involve a myriad of interacting factors, including physiological and emotional development, personality, social norms, the role of youth in society, individuals' socio-economic circumstances, impairments to capabilities, the driving task itself, and the type of driving that young, novice drivers often engage in."
> (OECD, 2006, p12)

Chapter One discussed research which has demonstrated that factors such as parental involvement, alcohol, drugs, personality, sensation seeking and over confidence all have weight in the crash risk of young novice drivers. It is very important to acknowledge the influence of such factors, especially when research narrows in on a particular topic, as it does within the current thesis. With all these other factors being involved in crash risk, it is fair to question just how much impact the results of the current thesis can have in the grand scheme of the novice driver problem.

As noted in Chapter One, influences on novice driver crash risk become summarised as being due to age or experience. Mayhew et al. (2003) analysed new drivers' collision rates in the first few months of driving and report that crash rates are very high after the first month of licensure but then drop dramatically and consistently, by forty-one percent, to the seventh month. While it was not possible to fully separate the effect of age and experience, the authors report it is unlikely that such a dramatic reduction in crash risk is due to seven months of growing older. Similar analysis by McCartt et al. (2003) determined a dramatic reduction within the first five months of solo driving and more specifically after around one thousand miles, as revealed within the discussion of Chapter Six. It must be considered what is happening during this phase of a person's driving career. Groeger (2002) considers driving competence to develop through extensive feedback obtained from frequent experience with a wide variety of driving situations. Although basic vehicle skills can be taught in a matter of hours (Hall & West, 1996), driving competence requires perceptual, attentional and judgement skills which take months and years of experience (Groeger, 2000).

Simons-Morton (2007, p194) states:

> "The rapid decline in crash risk during the first 6 months of licensure is consistent with an effect of learning, suggesting that novices, as their name would suggest, are still learning, although they may have had substantial supervised training and practise prior to licensure. It seems that drivers are not very good, at least not very safe, when first licensed, but get a lot better and safer over time."

How can one explain how a driver gets a lot better or safer over time? Simply saying a driver becomes 'experienced' is not enough; understanding what is being learned during the gaining of experience is an area which has been neglected. As stated above, research demonstrates that drivers' crash risk reduces dramatically within the first few months of licensed driving. Logically, it is unlikely that age can explain this reduction in crash risk and research which has attempted to separate the two effects is suggestive of this (Maycock, 2002; Vlakveld, 2004). Further, the reduction can not be explained by training or education as the vast majority of drivers undergo no further training or education once they have passed their driving test in the UK. Therefore, explaining what a driver is learning or gaining in this early period is critical to understanding the novice driver problem.

The current thesis provides theory and research which supports the notion that what drivers learn during this critical period is to associate events in their environment with sensory feedback through an innate system of risk appraisal. The learning of environmental cues with feelings helps make drivers safe by automating and biasing their attention and behaviour towards advantageous outcomes (i.e. the avoidance of dangerous scenarios). In this respect, the results of the current thesis can be considered extremely important in advancing the understanding of the novice driver problem, even when considered in the wider context of driving behaviour literature.

**7.5: Implications of the research for policy**

> "Reducing the number of young, novice driver crashes and fatalities will require a focussed and co-ordinated approach, involving education, training, licensing, enforcement, communication and the selective use of technology, in combination with other road safety measures. The success of this approach will require public and political acceptance of the gravity of the problem…and the proactive participation of regulators and lawmakers; transport, health, safety and education administrations; the police; parents and young drivers themselves."
> (OECD, 2006, p13)

This quote demonstrates the complexities involved in securing a change in policy. Whilst knowledge of the crash risk of newly qualified drivers is not disputed, what to do about the problem has been of great debate and change to the current system has been resisted, as demonstrated in the context and rationale of this thesis. There is a shift developing, however, whereby European countries are moving toward multiphase licensing systems (Twisk & Stacey, 2007). Chapter One discussed graduated licensing as a potential tool for reducing young novice driver casualties.

Graduated driver licensing (GDL) typically involves a series of stages or restrictions that are aimed at keeping crash risk to a minimum while allowing a driver to gain valuable on-the-road experience. Restrictions can be placed pre-licence (e.g. minimum learner period) or post-licence (e.g. restricted number of passengers or restricted night-time driving). There have been numerous evaluations of GDL systems and many successful reports of casualty reductions (see Chapter One, page 30). In the USA, Florida led the way with the implementation of a GDL system in 1996. Since this time, all US states have put into operation at least one GDL restriction (Williams, 2007). Preusser and Tilson (2007) report that crashes involving sixteen year old drivers across the USA between 2003 and 2005 have fallen by twenty-three percent compared to 1993-95 rates. This is despite an increase in 16 year old population figures (Preusser & Tilson, 2007). Much of the difference is reportedly due to a reduction in night time crashes and crashes when a driver is carrying passengers (Preusser & Tilson, 2007) – two of the most popular GDL restrictions (Mayhew, 2007). The casualty reductions have also been attributed, in some part, to the increased participation of parents. Parents have been made more aware of the risks involved in novice driving due to stricter state restrictions and this also empowers them to apply their own rules (Simons-Morton, 2007)

Nevertheless, there is an admission that some of the perceived effectiveness of GDL restrictions may be simply due to delayed licensure and also due to delaying when a driver can drive unrestricted (Preusser & Tilson, 2007, Mayhew, 2007). Foss (2007) states that while it is clear that GDL works, important questions regarding how and why it works remain. Further, Hedlund and Compton (2005) have noted that no evaluation so far has reported a carryover effect when restricted driving ceases. This means that drivers are still at increased crash risk whenever they are set free to drive unrestricted. The results of the current thesis can be applied to the plight of graduated licensing.

That drivers are at increased crash risk whenever they are free to experience driving with no restrictions is not unsurprising in the context of this thesis. If drivers only learn to associate feelings of risk with environmental cues through experience, then they must experience these situations in the first place. If a driver is restricted in experiencing these situations then they will not be able to learn from them. This is not to devalue the role of graduated licensing however. By restricting drivers from the highest risk situations, drivers can gain general driving experience and competence which is likely to have an influence when encountering new higher risk situations in the future. It must also be considered that if the neural substrates discussed within the somatic marker hypothesis are involved in driving and the frontal lobes are still developing until age 25 (Gogtay et al., 2004), then any delay in licensure and unrestricted driving should be welcomed. The current thesis can therefore help to understand both the effectiveness and weaknesses of graduated licensing. Given the results of GDL evaluations so far, a structured approach to learning to drive must be considered. Implementation of any policy which can save lives should be encouraged.

Despite demonstration of casualty reductions reported by many GDL evaluations, the latest proposal from the Driving Standards Agency and Department of Transport in the UK has all but discounted this approach (DfT, 2008). A recent consultation paper entitled ‘Learning to Drive’ has been published with outline proposals and invites opinion on how the learning to drive process can be improved. The paper explains that although placing regulations and restrictions on drivers was considered, an approach based on education and incentivisation is preferential. Given the historical lack of effectiveness reported in relation to driver education (see Chapter One, page 19), this is a curious approach. On the other hand, the paper also suggests that the Department would like to create a culture of lifelong learning with post-test training. The results of the consultation will be of great interest.

The findings of the current thesis would suggest that there is no easy solution to the novice driver problem. The results imply that drivers need to gain on-the-road experience to ultimately reduce their crash risk, however, gaining on-the-road experience puts drivers at increased risk. Graduated licensing is somewhat supported because giving drivers experience while protecting them from the most dangerous situations is a compromise. That drivers are still at increased crash risk when unrestricted suggests that this is not a complete solution however. Alternatively, improving drivers’ education, as currently proposed in the UK (DfT, 2008), is concerning given the historic failure of equating driver education with casualty reductions. In much the same way as Damasio’s (1994) patient Elliot was able ‘to know but not to feel’, the same may be said of novice drivers in the UK in future.

### 7.6: Conclusion

The ultimate aim of the current thesis was to offer a greater understanding of the psychological process through which a person learns to drive safely. It was hoped that this in turn may advise of appropriate improvements in licensing that could help to prevent novice driver crashes. The current thesis has succeeded in providing a greater understanding of the psychological processes through which a person learns to drive safely and substantiates Fuller's (2005b) suggestion that the role of feelings in driving is 'a new agenda for research'. Implications for policy, meanwhile, would suggest that a graduated style of licensing merits serious consideration but is not a full solution. Future research based on the results of the current thesis should involve the use of simulated driving to explore whether drivers can learn psychophysiological reactions which cross-over to real on-the-road driving scenarios. The future of effective driver training that reduces novice driver crash risk may lie in this arena of research. The journey upon which the thesis travelled to reach this destination is outlined in the Key Point Summary following this conclusion. The Key Point Summary is a collection of the key points (seen in bold) from all the chapter summaries.

In truth, the *real* ultimate aim of this thesis, much like many road safety projects, was to influence policy to save at least one life. It is unlikely that this has been immediately achieved, although it is hoped that the work of the current thesis may have advanced research towards influencing policy in the future. As noted in the context and rationale of this thesis, the DfT (2002) admitted that a simple change in licensing structure would be expected to yield significant savings of lives and serious injuries. Since the DfT's (2004) rejection of this, and all other changes, it must be difficult for those who have lost a loved one to comprehend the possibility that their loss could have been prevented. It is therefore appropriate to conclude with a sense of this unnecessary loss through the words of Elizabeth Davidson, mother of the late Dr Margaret Davidson:

> "I know I was lucky to have a daughter like Margaret but then I knew that when she was alive."

(See page 2 for Elizabeth Davidson's full letter)

# Key point summary

**A collation of bolded text from the chapter summaries**

**The worldwide fatality trend of young drivers eclipses both culture and driver training methods suggesting a human element in the learning to drive process that is currently not understood and more importantly, is being ignored.**

**Research (e.g. Maycock et al., 1991) suggests that the effect of inexperience on drivers' initial crash risk is twice as important as age. Whilst age should always be considered as an important contributory factor, the larger role of inexperience suggests that our understanding of the psychological learning process is currently poor.**

**Change to the licensing structure in the UK is necessary and heavily supported, although what to change to is of great debate. There is a need for scientific study that can help to guide the most appropriate course of action.**

**It would appear that simply increasing novice/young drivers' skill and/or knowledge level is not related to reducing their crash risk. If it is not the skills of how to drive or the knowledge of how to drive safely that are deficient, the question therefore remains, what are novice/young drivers' lacking?**

**Research has identified important influences that all increase young/novice drivers' crash risk. These factors must be appreciated as the wider context of research into the current topic. Nonetheless, that increased crash risk is inherent in novices of all ages and not simply young novices suggests that there is still more that needs to be understood.**

**Graduated licensing has shown early promise and yielded several impressive casualty savings. Evaluations suggest that some of these savings are due to the restrictions on passenger and night time driving (Begg & Stephenson, 2003). However, there is recent suggestion that much of the gain is due to the delay of full licensing and that drivers still have a high crash risk when they graduate. This needs to be better understood and a greater understanding of the psychological process of how a person learns to drive may help.**

**The early skin conductance studies (Hulbert, 1957, Michaels, 1960; Taylor, 1964) provided the first evidence that there are psychophysiological reactions when driving. Whilst the early driver behaviour models based on this research failed to adequately incorporate this notion, the physiological evidence that drivers are appraising risk in some form whilst driving is still a key indication of the psychological processes involved when driving.**

**Despite the insight given by the early skin conductance studies, comprehending how subjective risk is processed and how this may influence drivers' behaviour is still to be understood. Risk compensation literature suggests that perceptual and sensory feedback may be an important influence.**

**The difference between novice and experienced drivers with regard to their hazard perception skills is another clue to understanding the psychological process involved in determining risk. It suggests that hazard perception is a skill learnt through the experience of driving. Further evidence of this being a learned process is the notion that inexperienced drivers are poorly 'calibrated', which conversely suggests that experienced drivers are 'calibrated'. This poses the question: how does a novice driver become calibrated?**

**Through evaluation of previous driver behaviour modelling and modern neurological theory, Vaa (2004) suggests that feelings and emotions are involved in the assessment of risk and influence driver behaviour. The essence of the theory behind the Monitor model (Vaa, 2004) is also discussed within the literature supporting Fuller's (2005a) Task-Capability Interface (TCI).**

**The comparator section of the TCI model, which lies between feedback and decision and behavioural response, is the model's main area of weakness. Investigating how a driver processes feedback from the environment and how this influences their behavioural response is therefore a key area that is not yet understood. Until we can comprehend this process, the model remains theoretical only and our appreciation of the psychological processes underpinning novice drivers can not be addressed.**

Chapter Three

**In testing the concepts of the Task-Capability Interface (Fuller, 2005a), Fuller et al. (2008a) gained participants' responses of task difficulty, feelings of risk and objective risk estimate to video clips of driving sequences shown at different speeds. They reported the surprising result that participants' ratings of feelings of risk tracked their ratings of task difficulty almost exactly.**

**The aim of Chapter Three was, therefore, to replicate Fuller et al.'s (2008a) study using new stimuli. In addressing one of the main areas of critique, participants of different driving experience were sought.**

**Theoretically, the results of this study suggest that feeling risk may be an important part of the information processing which would take place in what Fuller (2005a,b) terms the 'comparator'. The difference in objective risk estimate by experience level suggests that novice drivers may be relying on a cost-benefit analysis of risk rather than their feelings of risk, although results suggest that novice drivers can sense risk in the same way as experienced drivers. If novice drivers utilise cost-benefit analysis rather than feelings of risk then they will be poorly calibrated to the difficulty of the task.**

Chapter Four

**Slovic et al. (2004) suggest that within the area of risk appraisal, there are two forms of processing: analytical and experiential. The analytical system is essentially a cold cost-benefit analysis, whereas the experiential system relies on learned associations between experienced events and emotions. In relation to the results of Chapter Three, Slovic et al.'s (2004) theory could explain the reason why subjective risk (experiential system) and objective risk estimates (analytic system) were rated differently by participants. Further, as the experiential system requires experience to learn associations between events and emotions, this can explain why a difference was found between inexperienced and experienced drivers in ratings of objective risk estimate. Without having learned associations between events and emotions, inexperienced drivers would have no choice but to rely on their analytic appraisal of risk.**

**If the experiential system is an evolved human system of risk appraisal, then all humans must have the innate ability to appraise risk, however, it is only by experience and association that risky events will be associated with emotional cues. Inexperienced drivers therefore do not lack the ability to sense risk, but simply have not yet learned to associate risky cues in the driving environment to emotional warning signals.**

**Somatic markers are emotions and feelings that have been connected through learning to predicted future outcomes of certain scenarios. When these scenarios are encountered again, somatic markers are elicited and bias decision making towards an advantageous response. The Somatic Marker Hypothesis (Damasio, 1994) provides neurological support for the role of emotions in risk appraisal and decision making.**

**Much of the empirical support for the Somatic Marker Hypothesis comes from studies involving the use of the Iowa Gambling Task (IGT) (Bechara et al., 1994, 1996, 1997, 1999, 2000; Bechara & Damasio, 2005). The IGT studies provide support for the brain regions involved in the somatic marker hypothesis (i.e. ventromedial prefrontal cortex and amygdala), the learning of somatic markers in healthy participants and the role of emotion in decision making, as measured by skin conductance response.**

**The results of Helander (1978), Michaels (1960) and Taylor (1964) suggest that there is physiological support for the relationship between perceived task difficulty and perceived feelings of risk. These results could suggest that when driving, feelings of risk and task difficulty are one and the same thing, a position supported by Vaa (2004).**

**Testing for the presence or absence of Somatic Markers in drivers could be a timely test of the hypothesis.**

Chapter Five

**The integration of current theory and historical literature is suggestive of the role of emotional risk appraisal when driving.**

**Chapter Five therefore aimed to compare inexperienced and experienced drivers for their hazard rating and Skin Conductance Responses (SCRs) to fifteen pictures depicting safe, developing hazard and hazard scenarios.**

**The key result in Chapter Five was that both driver groups cognitively rated developing hazards almost identically but that the experienced driver group produced significantly more SCRs to developing hazard pictures compared with the inexperienced driver group. This suggested supporting the results of Chapter Three and Crundall et al. (2003) that there are two ways in which drivers appraise risk.**

**As there was a difference between inexperienced and experienced drivers' SCR scores to the developing hazard pictures but not the hazard pictures, it would appear that it is within the build up to a hazard that experienced drivers may benefit from an emotional appraisal of the situation. Given that inexperienced drivers do not appear to have this appraisal, lends support to the idea that this is part of a learning system, as possibly demonstrated in the Iowa Gambling Task (Bechara & Damasio, 2005). The development of a hazardous situation when driving is the kind of scenario in which the role of somatic markers would be of maximal use (Damasio, 1994, 2003).**

Chapter Six

**The aim of Chapter Six was to test learner, inexperience and experienced drivers for their psychophysiological and cognitive appraisal of encountering hazards when driving.**

**Results found that experienced drivers were significantly more likely to produce a SCR within the anticipatory area when compared with the inexperienced and learner drivers. This result remained even when age, gender and exposure were**

**controlled for. However, similar to the results of Chapter Five, there was no difference between the groups for their mean cognitive ratings of the hazards in either the anticipatory area or the event area. This further supports the distinction of two forms of risk appraisal: risk by feelings and risk by analysis (Slovic et al., 2002, 2004).**

**Inexperienced drivers who had driven under 1000 miles in the last twelve months had an anticipatory SCR score almost identical to that of the learner drivers. Conversely, inexperienced drivers who had driven more than 1000 miles in the last twelve months had a score that was progressing towards that of the experienced drivers. This provided an illustration of a learning curve whereby psychophysiological arousal to developing hazards is mediated by experience. Interestingly, research has previously found that novice driver crash risk reduces dramatically after 500 and 1000 miles of licensed driving (McKnight & McKnight, 2003; McCartt et al., 2003). The integration of this research with the current study's results is suggestive that learning to emotionally appraise the environment when driving is a crucial process in reducing crash risk.**

**The main critique of the current study is that whilst cognitive workload is unlikely to account for the SCR results, there is no certainty that the SCRs are symbolic of the emotional processing of hazards either.**

**Concerns over the ecological validity of the study were raised and it was concluded that further research should seek to replicate the study but with the use of an advanced simulator or during real time driving.**

Chapter Seven

**The study in Chapter Three involved no hazards, while Chapter Five involved the use of pictures and Chapter Six utilised dynamic hazard perception clips. That a differentiation was found in the processing of risk in all three methods suggests that this may be an innate and common discrimination of risk processing. Certainly, this would support the argument outlined by Slovic et al. (2002, 2004).**

**The theoretical position that is taken by Slovic et al. (2002, 2004) is also found within the description of the Somatic Marker Hypothesis (SMH) (Damasio, 1994). The SMH also states that there is an evolved human system of risk appraisal that utilises feelings and emotion to warn a person of potential danger. This system is linked with decision making as feelings and emotion act to bias decision making towards advantageous outcomes.**

**The results of the studies described in Chapter Five and Chapter Six provide support for the SMH. The psychophysiological responses demonstrated during the development of a hazardous situation could be argued to be examples of somatic markers. Whilst this is an important result for driving behaviour research, it is also an important result for the somatic marker hypothesis.**

**A main source of weakness within the task difficulty homeostasis (Fuller, 2005a) was identified as the 'comparator' section. Based on the theory and results discussed within the current thesis a new structure of the task difficulty homeostasis could be proposed. The model of Feelings of Risk Homeostasis is offered as an update of the Task Difficulty Homeostasis by providing more information regarding how driving is psychologically processed.**

**The major limitation of the thesis is the use of skin conductance response (SCR) as a measure of feeling and emotion. It is not entirely clear what SCR is specifically measuring and therefore results based on skin conductance must make assumptions as to their meaning. In the current thesis, the assumption is that a SCR demonstrates a feeling of arousal indicative of an increase in hazard awareness.**

**Given the evidence provided by the current thesis and other research for an innate risk appraisal system that learns by experience, the main focus of future development may be whether or not essential experiences can be learned through simulated driving.**

**The learning of environmental cues with feelings help make drivers safe by automating and biasing their attention and behaviour towards advantageous outcomes (i.e. the avoidance of dangerous scenarios). In this respect, the results of the current thesis can be considered extremely important in advancing the understanding of the novice driver problem, even when considered in the wider context of driving behaviour literature.**

**The findings of the current thesis would suggest that there is no easy solution to the novice driver problem. The results imply that drivers need to gain on-the-road experience to ultimately reduce their crash risk, however, gaining on-the-road experience puts drivers at increased risk. Graduated licensing is somewhat supported because giving drivers experience while protecting them from the most dangerous situations is a compromise. That drivers are still at increased crash risk when unrestricted suggests that this is not a complete solution however.**

**The ultimate aim of the current thesis was to offer a greater understanding of the psychological process through which a person learns to drive safely. The current thesis has succeeded in providing a greater understanding of the psychological processes through which a person learns to drive safely and substantiates Fuller's (2005b) suggestion that the role of feelings in driving is 'a new agenda for research'.**

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## List of Appendices

# Appendix
# 2A

List of driver behaviour models

**Theoretical Models Applied to Driver Behaviour by Decade [adapted and updated from Vaa (2001a) and Summala (2005)]**

| Decade of publication | Number of models published |
|---|---|
| 1938 | 1 |
| 1960-1969 | 2 |
| 1970-1979 | 2 |
| 1980-1989 | 11 |
| 1990-1999 | 1 |
| 2000-2007 | 3 |

**1938**
Field of safe travel - A theoretical field-analysis of automobile driving
(Gibson & Crooks, 1938)

**1960-1969**
Driving as a self-paced task governed by tension/anxiety - Drivers' galvanic skin responses and the risk of accidents
(Taylor, 1964)

Proxemics – The Hidden Dimension
(Hall, 1966)

**1970-1979**
Zero-Risk Model - A model for the role of motivational factors in drivers' decision making
(Näätänen & Summala, 1974)

The Model of Subjective and Objective Safety - Das Model der subjektiven und objektiven Sicherheit
(Klebelsberg, 1977)

**1980-1989**
Theory of Reasoned Action - Understanding attitudes and predicting behaviour
(Ajzen & Fishbein, 1980)

Risk Homeostasis Theory (RHT) - The Theory of Risk Homeostasis: Implications for Safety and Health
(Wilde, 1982)

Human Performance Models/Levels - Skills, rules, and knowledge: signals, signs and symbols, and other distinctions in human performance models
(Rasmussen, 1983)

The Threat-Avoidance Model - A conceptualisation of driving behaviour as threat Avoidance
(Fuller, 1984)

Theory of Planned Behaviour - From intentions to actions: A theory of planned Behaviour
(Ajzen, 1985)

The perceptual and cognitive filter model - The role of perceptual and cognitive filters in observed behaviour
(Rumar 1985)

The feedback model - Human Behaviour Feedback and Traffic Safety
(Evans, 1985)

The Hierarchical Risk Model - A hierarchical risk model for traffic participants
(van der Molen & Bötticher 1988)

Motivational Approach to Modelling: The role of pleasure. Risk and the absence of pleasure
(Rothengatter 1988).

Stress Model
(Hancock & Warm, 1989)

Production-rule models/Rule-based models - Explanatory pitfalls and rule-based models
(Michon, 1989)

**1990-1999**
Inner Models - Inner models as basis for traffic behaviour
(Keskinen, Hatakka & Katila, 1992)

**2000-2007**
The Task-Capability Interface Model
(Fuller, 2000)

A Theoretical Model of Responding to Risk on the Road.
(Grayson, Maycock, Groeger, Hammond & Field, 2003)

The Monitor Model
(Vaa, 2004)

# Appendix 3A

Participant consent form with written instructions

## Before you begin please read and sign the following disclaimer:

**What is this about and what will my answers be used for?**
This study and the attached questionnaire are part of research towards completion of a PhD thesis. The results are for this purpose only. You will not have to identify yourself and there is no way any response can be tracked to any individual participant. There are no public authorities involved with this research.

You are under no obligation to participate or complete this study and have the right to leave at any point.

There are no right or wrong answers. The study is **not** about road safety so please be honest with your answers. Responses of your real attitudes and feelings towards driving will be beneficial to the research.

Thank you.

### Disclaimer:

I understand the above statement and voluntarily offer to take part in the study giving honest responses to the best of my knowledge.

**Participants signature ___________________________ Date _________**

**Thank you. Lets Begin:**

You are requested to complete the following two parts:

Part 1: Watch Driving Sequences and Respond (15-20mins)
*Please follow the on-screen instructions from the computer in front of you. Enter your responses in this response booklet when prompted.*

Part 2: You and Your Driving Questionnaire (5-10 mins)
*Once you have competed Part 1, please complete the 'You and Your Driving Questionnaire'. When you have finished, please hand the questionnaire and the response booklet to the experimenter.*

**Part 1 On-screen Instructions**

- You will be presented with a series of driving clips from a drivers eye view.  Whilst watching the clip, concentrate on the road and imagine that you are the driver of the car.
- At the end of each clip you will be prompted to answer four questions in the response booklet.
- Once you have completed the questions, press the space bar to continue with the next clip.

**Press space bar to begin the first clip…**

# Appendix
# 3B

Pictures of driving clips used in Experiment 1

**Residential Road**

**Straight Country Road**

**Bendy Country Road**

**Dual Carriageway**

# Appendix 3C

You and Your Driving questionnaire

# You and Your Driving Questionnaire

# Section 1

Here are the four driving scenarios you have viewed in part 1.
Please write the **fastest** speed you would drive on each section of road.

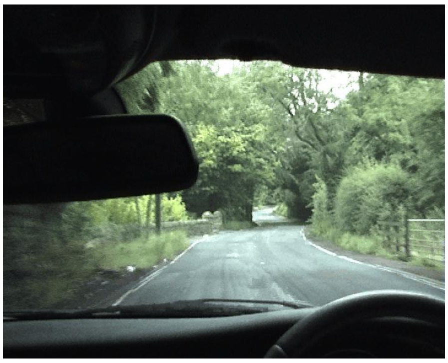
Road A

__________ mph

Road B

__________ mph

Road C



__________ mph

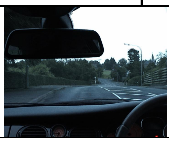
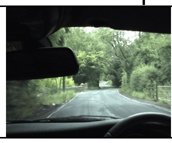
Road D

__________ mph

Why would you <u>not</u> drive faster than the speeds you have just stated?

Below is a list of possible reasons why you would <u>not</u> drive faster.

Please tick if the reason would influence you <u>not</u> to drive faster than the speed you have stated for each individual road.

| **Write in what your fastest speed was from the previous page:** | mph | mph | mph | mph |
|---|---|---|---|---|
| If I drove any faster on this road…<br><br>(Tick all that apply. If none, leave blank) |  |  |  |  |
| Road: | A | B | C | D |
| *EXAMPLE: I might lose control* | | | | |
| | | | | |
| my speed would not be socially acceptable | | | | |
| it would feel too stressful | | | | |
| the car would be difficult to drive | | | | |
| driving on bends would be difficult | | | | |
| I would be over the speed limit | | | | |
| | | | | |
| I would be more likely to harm other road users | | | | |
| it would feel too risky | | | | |
| I would feel less in control | | | | |
| the engine would not feel comfortable | | | | |
| I would be more likely to have an accident | | | | |
| | | | | |
| my passengers would want me to slow down | | | | |
| it would not feel enjoyable | | | | |
| I would not be able to take in all the information about the road, traffic & hazards | | | | |
| the road surface would make the ride uncomfortable | | | | |
| I would be more likely to be stopped by the police or flashed by a speed camera | | | | |
| | | | | |
| *Any other reasons? Please write here:* | And tick which roads your other reasons would apply to: | | | |
| | | | | |
| | | | | |
| | | | | |

# Section 2

Age ________years _________ months

Gender (*please tick*) Male ☐ Female ☐

Please tick all of the following that apply to you?

I am currently learning to drive ☐

I have a full UK car driving licence ☐

I have a driving licence from another country ☐

I have a provisional motorcycle licence ☐

I have a full motorcycle licence ☐

If applicable, how long have you held your full licence? _____years _____months

For how long were you / have you been a learner driver? _____years _____months

How much learning experience did you gain before passing your test / or have you had?
Official tuition _____ Hours
Private practice _____ Hours

How many times have you taken the UK driving test? _____ times

Have you taken the following official tests?

| | | | | |
|---|---|---|---|---|
| Theory test | Yes | ☐ | No | ☐ |
| Hazard Perception test | Yes | ☐ | No | ☐ |
| Pass Plus? | Yes | ☐ | No | ☐ |

Approximately how many miles have you driven in the past 12 months?
_________ miles

Do you have regular access to a car? Yes ☐ No ☐

Who owns the vehicle you drive most? (*please tick one*)

| | | | |
|---|---|---|---|
| Myself | ☐ | My employer | ☐ |
| My partner | ☐ | Other | ☐ |
| My parents | ☐ | | |

What is the engine size of the car you drive most often?

| | | | |
|---|---|---|---|
| 1.0 litre or less | ☐ | 1.7-1.8 | ☐ |
| 1.1 - 1.2 litres | ☐ | 1.9-2.0 | ☐ |
| 1.3 – 1.4 litres | ☐ | over 2.0 | ☐ |
| 1.5 – 1.6 litres | ☐ | Don't know | ☐ |

What is the make and model of your car?
Make _______________ (e.g. - Ford)    Model_______________ (e.g. - Focus)

Are there any modifications to the vehicle? Yes ☐ No ☐

Which of the following applies to your car use with regards to work? (*please tick one*)

Professional driver ☐

Use a car during work and for commuting ☐

Use a car for commuting only ☐

Don't use a car for work at all ☐

How many times have you been flashed by a speed camera in the past three years?
_____ times

How many times have you been stopped for speeding in the past three years?
_____ times

How many penalty points do you have on your licence?
_____ points

Have you ever had a crash or near-miss because you were going too fast?

Yes ☐ No ☐

How many accidents have you been involved in as a driver in the last 3 years?
Please write the numbers in the boxes (if none, enter 0).

| | Active crashes (i.e. you hit another road user, or an obstacle) | Passive crashes (i.e. you were hit by another road user) |
|---|---|---|
| Damage only | | |
| Minor injury | | |
| Serious or fatal injury | | |

*And finally…*

Please rate your response towards the following statements:

| | Not at all | | | | | | | | | | Very much |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| I would like to risk my life as a racing driver | | | | | | | | | | | |
| I sometimes like to frighten myself a little while driving | | | | | | | | | | | |
| I get a real thrill out of driving fast | | | | | | | | | | | |
| I enjoy listening to loud, exciting music while driving | | | | | | | | | | | |
| I like to raise my adrenaline levels while driving | | | | | | | | | | | |
| I would enjoy driving a sports car on a road with no speed limit | | | | | | | | | | | |
| I enjoy the sensation of accelerating rapidly | | | | | | | | | | | |
| I enjoy cornering at high speed | | | | | | | | | | | |
| In general I enjoy driving | | | | | | | | | | | |

**Your participation is appreciated.**

*THANK YOU*

Any comments about driving or this questionnaire/study?

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

# Appendix 3D

You and Your Driving questionnaire with participants' means and frequencies

# **You and Your Driving Questionnaire**

# <u>Section 1</u>

Here are the four driving scenarios you have viewed in part 1.
Please write the **fastest** speed you would drive on each section of road.

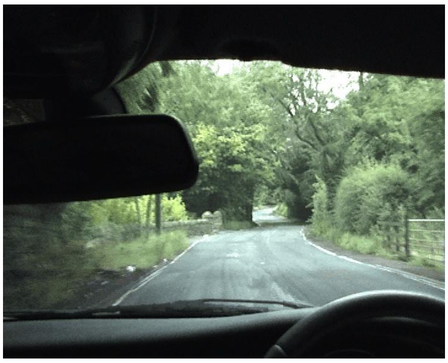
Road A

| **Residential** | *Mean* | *sd* | *N* |
|---|---|---|---|
| *Overall* | 37.0 | 8.5 | 151 |
| *Learner* | 35.3 | 9.1 | 39 |
| *Inexperienced* | 37.7 | 6.6 | 52 |
| *Experienced* | 37.5 | 9.6 | 60 |

Road B

| **Country Sraight** | *Mean* | *sd* | *N* |
|---|---|---|---|
| *Overall* | 51.8 | 12.4 | 151 |
| *Learner* | 47.4 | 13.1 | 39 |
| *Inexperienced* | 52.6 | 12.3 | 52 |
| *Experienced* | 53.8 | 11.6 | 60 |

Road C



| **Country Bendy** | *Mean* | *sd* | *N* |
|---|---|---|---|
| *Overall* | 40.4 | 10.0 | 151 |
| *Learner* | 30.9 | 10.9 | 39 |
| *Inexperienced* | 39.6 | 8.3 | 52 |
| *Experienced* | 42.1 | 10.7 | 60 |

Road D

| **Dual Carriageway** | *Mean* | *sd* | *N* |
|---|---|---|---|
| *Overall* | 68.9 | 12.3 | 151 |
| *Learner* | 64.9 | 11.4 | 39 |
| *Inexperienced* | 66.1 | 10.9 | 52 |
| *Experienced* | 73.8 | 68.9 | 60 |

Why would you <u>not</u> drive faster than the speeds you have just stated?

Please tick if the reason would influence you <u>not</u> to drive faster than the speed you have stated for each individual road.

| **Write in what your fastest speed was from the previous page:** | mph | mph | mph | mph |
|---|---|---|---|---|
| If I drove any faster on this road… (Tick all that apply. If none, leave blank) |  |  |  |  |
| Road: | A | B | C | D |
| | Scale 0-1 | Scale 0-1 | Scale 0-1 | Scale 0-1 |
| | | | | |
| my speed would not be socially acceptable | .69 (sd=.464) | .19 (sd=.393) | .31 (sd=.465) | .28 (sd=.448) |
| it would feel too stressful | .20 (sd=.402) | .34 (sd=.476) | .51 (sd=.501) | .20 (sd=.402) |
| the car would be difficult to drive | .14 (sd=.349) | .33 (sd=.471) | .53 (sd=.501) | .19 (sd=..397) |
| driving on bends would be difficult | .32 (sd=.466) | .24 (sd=.427) | .82 (sd=.385) | .26 (sd=.437) |
| I would be over the speed limit | .69 (sd=.455) | .33 (sd=.471) | .27 (sd=.444) | .50 (sd=.502) |
| | | | | |
| I would be more likely to harm other road users | .71 (sd=.455) | .48 (sd=.501) | .63 (sd=.484) | .33 (sd=.471) |
| it would feel too risky | .42 (sd=.496) | .58 (sd=.495) | .76 (sd=.429) | .36 (sd=.482) |
| I would feel less in control | .32 (sd=.466) | .61 (sd=.490) | .78 (sd=.416) | .47 (sd=.501) |
| the engine would not feel comfortable | .04 (sd=.197) | .08 (sd=.267) | .07 (sd=.250) | .15 (sd=.363) |
| I would be more likely to have an accident | .56 (sd=.498) | .67 (sd=.471) | .81 (sd=.391) | .55 (sd=.499) |
| | | | | |
| my passengers would want me to slow down | .26 (sd=.437) | .37 (sd=.485) | .43 (sd=.496) | .32 (sd=.466) |
| it would not feel enjoyable | .24 (sd=.430) | .34 (sd=.476) | .49 (sd=.501) | .28 (sd=.448) |
| I would not be able to take in all the information about the road, traffic & hazards | .65 (sd=.478) | .38 (sd=.486) | .49 (sd=.502) | .40 (sd=.492) |
| the road surface would make the ride uncomfortable | .05 (sd=.226) | .37 (sd=.485) | .47 (sd=.501) | .09 (sd=.293) |
| I would be more likely to be stopped by the police or flashed by a speed camera | .72 (sd=.451) | .24 (sd=.431) | .25 (sd=.433) | .69 (sd=.464) |
| *N** | 149 | 143 | 150 | 149 |

** If no reason was given, participants were excluded from the analysis (for each road type) as it could not be determined whether no reasons applied or the participant did not answer.*

## **Additional Reasons**

| *Reason* | *Applicable to which road type(s)* |
|---|---|
| A danger to pedestrians | Residential only |
| Blind dips | Country Straight only |
| Cutting corners | Country Bendy only |
| Other drivers on other side of the road causing danger | Country Straight and Country Bendy |
| If I did not know the road well | All roads |
| Going over hills at speed is not good for the car | Country Straight only |
| Housing and possibly kids | Residential only |
| Pedestrians | Residential & Country Bendy |
| Never in a hurry | All roads |
| Would be likely to have to slow down for an upcoming junction | Residential only |
| Harming pedestrians | Residential only |
| Don’t trust other drivers | Country Bendy & Residential |
| Hidden driveways | Country Bendy |
| Lots of exits of other roads and close to residential area | Straight Country |
| Pedestrian risk | Residential |
| Obscured road view | Straight and Bendy Country |
| Lines on the road are not very clear | Straight and Bendy Country |
| Might harm pedestrians | Residential |
| Cannot see into road properly | Straight and Bendy Country & Residential |

# Section 2

| | | | | |
|---|---|---|---|---|
| Age | **24.5 years (range = 17.9 - 62; sd = 8.05)** | | | |
| Gender | Male | **44.7%** | Female | **55.3%** |

Licence Held:

| | |
|---|---|
| Full Licence | **70%** |
| Full Licence & Motorcycle Licence | **2%** |
| Full Licence & Provisional Motorcycle Licence | **2%** |
| Learner | **26%** |

| | |
|---|---|
| If applicable, how long have you held your full licence? | **Mean 5.95 years (sd=6.7; range 1-40) N=112** |
| For how long were you / have you been a learner driver? | **Mean 13.5 months (sd=15.7; range 1-108) N=132** |

How much learning experience did you gain before passing your test / or have you had?

| | |
|---|---|
| Official tuition | **29.8 Hours (sd=31.9; range 0-300) N=141** |
| Private practice | **23.1 Hours (sd=44.7; range 0-370) N=133** |

| | |
|---|---|
| How many times have you taken the UK driving test? | **1.44 times (sd=1.2; range 0-6) N=150** |

Have you taken the following official tests?

| | | | | | |
|---|---|---|---|---|---|
| Theory test | Yes | **70%** | No | **30%** | **N=151** |
| Hazard Perception test | Yes | **49%** | No | **51%** | **N=151** |
| Pass Plus? | Yes | **6%** | No | **94%** | **N=149** |

Approximately how many miles have you driven in the past 12 months?
**4319 miles (sd=5638; range=2-30’000) N=133**

| | | | | | |
|---|---|---|---|---|---|
| Do you have regular access to a car? | Yes | **75%** | No | **25%** | **N=152** |

Who owns the vehicle you drive most?
**N=147**

| | |
|---|---|
| Myself | **48%** |
| My partner | **5%** |
| My parents | **38%** |
| My employer | **3%** |
| Other | **6%** |

What is the engine size of the car you drive most? **N=142**

| | | | |
|---|---|---|---|
| 1.0 litre or less | **6%** | 1.7-1.8 litres | **6%** |
| 1.1-1.2 litres | **25%** | 1.9-2.0 litres | **9%** |
| 1.3-1.4 litres | **22%** | over 2.0 litres | **4%** |
| 1.5-1.6 litres | **16%** | Don't know | **12%** |

What is the make and model of your car?
**N=142**

| | | | | | |
|---|---|---|---|---|---|
| Ford | **15%** | Renault | **15%** | Vauxhall | **13%** |
| Volkswagen | **10%** | Citroen | **7%** | Nissan | **7%** |
| Mazda | **5%** | Peugeot | **4%** | Other | **24%** |

**N=139**

| | | | | | |
|---|---|---|---|---|---|
| Small car | **55%** | Medium family | **24%** | Large family | **11%** |
| People carrier | **4%** | Sports | **4%** | 4x4 SUV | **2%** |
| Van | **1%** | | | | |

Are there any modifications to the vehicle? Yes **10%** No **90%** **N=146**

Which of the following applies to your car use with regards to work? **N=145**

| | |
|---|---|
| Professional driver | **0%** |
| Use a car during work and for commuting | **19%** |
| Use a car for commuting only | **33%** |
| Don't use a car for work at all | **48%** |

How many times have you been flashed by a speed camera in the past three years?
**0.19 times (sd=.675, range 0-5) N=149**

How many times have you been stopped for speeding in the past three years?
**0.06 times (sd=.239, range 0-1) N=149**

How many penalty points do you have on your licence?
**0.24 points (sd=..890, range 0-6) N=149**

Have you ever had a crash or near-miss because you were going too fast?
Yes **32%** No **68%** **N=148**

How many accidents have you been involved in as a driver in the last 3 years?

| | Active crashes (i.e. you hit another road user, or an obstacle) | Passive crashes (i.e. you were hit by another road user) |
|---|---|---|
| Mean | **0.32 (sd=.752, range=0-5) N=145** | **0.13 (sd=.339, range=0-1) N=145** |

*And Finally…*

Please rate your response towards the following statements:

| **N=150** | Not at all | | | | | | | | | | Very much |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| I would like to risk my life as a racing driver | **1.80 (sd=3.02, range=0-10)** | | | | | | | | | | |
| I sometimes like to frighten myself a little while driving | **1.63 (sd=2.61, range=0-10)** | | | | | | | | | | |
| I get a real thrill out of driving fast | **3.41 (sd=2.93, range=0-10)** | | | | | | | | | | |
| I enjoy listening to loud, exciting music while driving | **4.56 (sd=3.06, range=0-10)** | | | | | | | | | | |
| I like to raise my adrenaline levels while driving | **2.41 (sd=2.56, range=0-10)** | | | | | | | | | | |
| I would enjoy driving a sports car on a road with no speed limit | **5.22 (sd=3.66, range=0-10)** | | | | | | | | | | |
| I enjoy the sensation of accelerating rapidly | **4.15 (sd=3.25, range=0-10)** | | | | | | | | | | |
| I enjoy cornering at high speed | **2.43 (sd=2.85, range=0-10)** | | | | | | | | | | |
| In general I enjoy driving | **7.33 (sd=2.57, range=1-10)** | | | | | | | | | | |

# Your participation is appreciated.

*THANK YOU*

**Any comments about driving or this questionnaire/study?**
**(Full Quotes)**

Female, 21, Learner for 3.5 years
I consider myself a careful driver and this experiment has emphasised the fact that I would not feel comfortable driving at high speeds. It was good to access driving at high speeds and to feel the risk without actually driving at those sorts of speeds.

Female 18.5, Full licence for 5 months
Seeing clips does not stimulate the same feelings you would have as a driver but more what you would feel as a passenger so results may not be very accurate.

Female, 19, Full licence for 17 months
I can get myself so worked up and frustrated about other road users driving slow and as a result I probably drive less safely in those situations.

Female, 18, Full licence for 12 months
I feel, for part 1, some of the scenarios I was not saying what I would usually say if it was a road I knew. My confidence whilst driving is much higher when I know where I am going and what journey I am going to take. In the event that I did know the road, I would be much more cautious and careful. Not sure if that is relevant! ☺

Female, 29, Full licence and provisional motorcycle for 12 years
When watching clips it may have been better to include sound (this may have been difficult though in the way you produce the clips) but sound may have helped to determine speed.

Female, 33, Full licence for 16 years
Very interesting! I'm sure most of us think we are better drivers than we actually are.

Male, 23, Full licence for 2.5 years
Doing this kind of questionnaire for the first time. Although a little stressed it was good.

Female, 19, Full Licence for 2 years
It made me think I'm a bad driver!

Male, 19, Full Licence for 1 year
I think this study would be a good way to see how people of different ages and gender have different attitudes towards driving

Female, 40, Licence for 14 years
Driving below or around speed limit can be as hazardous as speeding. Some slower drivers almost stop when turning corners which can be dangerous for following drivers.

Male, 22, Full Licence for 4 years
A few of the video clips were pretty similar

Male, 22, Full Licence for 5 years
Participant generally thinks 'In town slow down' due to moral obligation. Out of town on quiet roads they may drive faster for a little fun but never to a dangerous level. Or never in anger or out of control.

Male, 18, Learner for 12 months
Give participants to those with little/no real driving experience rather than basing questions on experience.

Male, 19, Full licence for 18 months
I am not a speed freak, but I enjoy small scares when I am driving on my own. I put my passengers and those around me safety first.

Male 28, Full licence for 10 years, Motorcycle licence also
I do not have any points but on the date of doing study was the first day I was driving after coming back from a driving ban for speeding.

Female, 19, Full licence for 20 months
Take my experience with 38000kms (23000miles) into account otherwise if I would have had only half or less I wouldn't feel so safe in a car! Especially at my age! Also, there are many roads with no speed limit in Germany and I had a fast car, therefore I love driving fast.

# Appendix
# 3E

Ethical approval from Glasgow Caledonian University

PSYECOG1APP007

Christine

EC1

## GLASGOW CALEDONIAN UNIVERSITY

## Applications for Ethical Approval for Research Involving Human Participants

| **1. Reason for Submission to Committee (tick as many as appropriate)** | θ ✓ |
|---|---|
| a) minor method or procedure | θ |
| b) minor extended method or procedure | θ |
| c) major invasive research method or procedure involved | θ |
| d) submission to School Committee | θ |
| e) to place an appeal before the University Committee subsequent to School refusal | θ |
| f) failure to reach agreement at School level | θ |
| g) School seeks advice and/or guidance | θ |

**2. School:** LIFE SCIENCES

**3. Category of Researcher**

| | | | | | |
|---|---|---|---|---|---|
| Staff | θ ✓ | Temporary | θ ✓ | Permanent | θ |
| Postgraduate | θ | | | | |
| Post-Doctoral | θ | | | | |
| Contract | θ | | | | |
| Other | θ | | | | |
| | θ | | | | |

**4. If contract staff please give date of termination of contract:**

ROLLING CONTRACT SINCE OCT '04.

**5. Researcher's Name:** NEALE KINNEAR

**Dean of School:** KEVIN GARTLAND

**Director of Studies:**

**6. Title of Study:**

THE ASSOCIATION OF RISK AND TASK DEMAND IN DRIVING.

**7. Outline the aims and objectives of the study:**

(PLEASE SEE ATTACHED)

**8. Research Participants:**

i) Approximate numbers: 200, 100 MALE
100 FEMALE

ii) Inclusion criteria: CURRENT DRIVING LICENSE OR PROVISIONAL

iii) Recruitment method: OPPORTUNIST SAMPLING.

**9 (a). Methods/Procedures to be Used – non-invasive procedures**
*(for definition see guidelines paragraph 2.3.2(a))*

i) Non-invasive Procedure: WATCHING VIDEO CLIPS OF DRIVING SCENARIOS AND QUESTIONNAIRE RESPONSES.

ii) Non-invasive Procedure:

iii) Non-invasive Procedure:

iv) Non-invasive Procedure:

**9 (b). Name of Approved Supervisor (if the researcher is a student)**

**10 (a). Methods/Procedures to be Used – Minor invasive research method**
*(for definition see guidelines paragraph 2.3.2 (b))*

i) Minor Invasive Method:

ii) Minor Invasive Method:

**10 (b). Name of Approved Supervisor (if the researcher is a student)**

**11. Implications of any of the above non-invasive/ minor invasive procedure(s):**
(Outline any stress or discomfort to research participants which may be involved in any of the above minor/extended minor procedures which have not been approved)

NO STRESS OR DISCOMFORT ANTICIPATED

**12. Major Invasive research methods and procedure(s):** *(for definition see guidelines paragraph 2.3.2(c)*
(Please describe each procedure and state number of times it is to be performed on each subject and over what time period)

**13. Potential hazards of major invasive research methods and procedures, and precautions taken to meet them:**

**14. Please state the name of a qualified and suitably experienced person who will be available during the conduct of the major invasive research methods and procedures.**

**15. Will the participants be paid?** Yes θ No θ
(for research involving major invasive procedures only)

**If yes, please state amount:** £

**16. Start Date:** April '06 **Estimated Completion Date:** July '06

**17. Location(s) in which study/project will be undertaken:**

GCU

**18. Ethical principles incorporated into the study:**

**(i) Explanation of the aims and benefits of the study for research participants:**

(i) Written explanation (please enclose copy for major procedures) — Yes θ✓ No θ

(ii) Oral explanation — Yes θ✓ No θ

(iii) If the procedure involves justifiable deception will explanation be offered following participation? * — Yes θ No θ

(iv) Consent form (please enclose a copy for major procedures) — Yes θ✓ No θ

(v) Oral consent — Yes θ✓ No θ

*For example of justifiable deception please see guidelines paragraph xxx

**(ii) Safeguarding the rights of subject in respect of participation:**

(i) Subject offered opportunity to decline to take part — Yes θ✓ No θ

(ii) Subject offered opportunity to withdraw at any stage — Yes θ✓ No θ

(iii) Expert advice available if required — Yes θ✓ No θ

(iv) Participants informed there may be no benefit to them — Yes θ✓ No θ

**(iii) Safeguarding the rights of subject in respect of participation:**

(i) Subject guaranteed confidentiality — Yes θ✓ No θ

(ii) Subject guaranteed anonymity — Yes θ✓ No θ

(iii) Provisions of the Data Protection Act met — Yes θ✓ No θ

(iv) Safe data storage secured — Yes θ✓ No θ

**19. Has this application been considered by a School Ethics Committee?**

Yes θ No θ✓

**20. Protection for the researcher:**

Will the researcher be at any risk of sustaining either physical or psychological harm as a result of the research? Yes θ No θ✓

If yes, please specify and give details of precautions which will be taken to protect the researcher:

**21. Academic scrutiny of the research proposal:**

Will the research proposal be submitted to the Higher Degrees Committee? Yes θ No θ✓

If no, will the research proposal be subject to peer review within the School? Yes θ No θ✓

**22. Declaration:**

I declare that the proposed investigation described in this application will be carried out as detailed and that if any changes to the procedures are planned, written permission will be sought from the School Ethics Committee/Glasgow Caledonian University Ethics Committee. *(Delete as appropriate).*

~~Dean of School/~~Supervisor: [signature] Date: 06/04/06

**23. School Approval:**

This study was considered by the School Ethics Committee on (date): 21 April 2006

**Signed:** [signature]

**Position:** Chair SLS EC | PESC

# Appendix 3F

Additional analysis of Enjoyment

*I. Enjoyment by experience level*

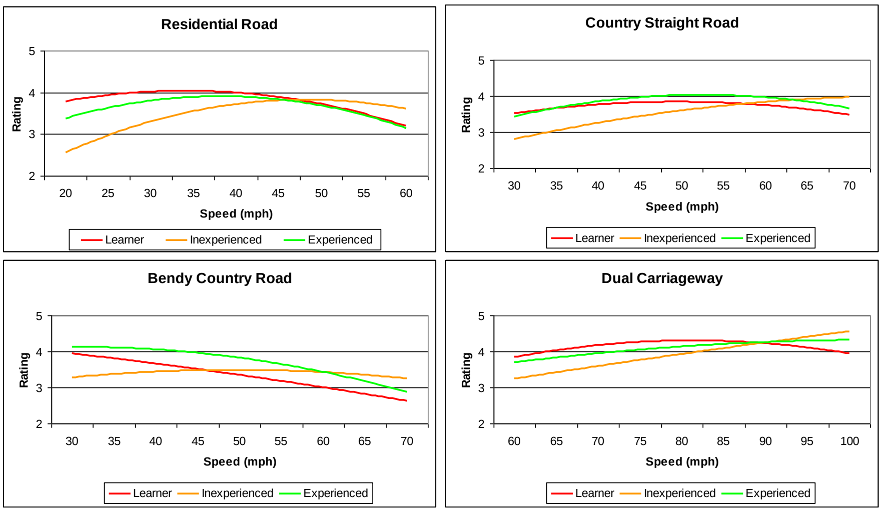



*Figure 3F.1: Comparison of mean ratings Enjoyment across speed by experience group on all road types*

Graphical comparison of Enjoyment mean scores by experience level can be seen in Figure 3F.1. The mean scores suggest that whilst the range of scores across speed is similar, the relationship between enjoyment and speed differs slightly by experience level on all road types. Intriguingly, the means scores of learner and experienced driver groups appear to follow a similar pattern. On the residential and bendy country roads, enjoyment appears to peak at a lower speed for learner and experienced drivers when compared to the inexperienced group. For the open settings of the straight country road and the dual carriageway, the enjoyment levels for inexperienced drivers rose with speed up to the maximum speed tested. This pattern was not present for learner drivers or experienced drivers on the country road, although experienced drivers demonstrated a similar pattern on the dual carriageway. Table 3F.1 shows the speed level at which mean enjoyment scores peak for each experience group. The inexperienced driver group demonstrate a peak level of enjoyment at higher speeds than the other groups on all road types; although peak speed on the dual carriageway is unable to be determined from these results. It may be a concern that the inexperienced groups' enjoyment scores peak on the residential road at 55mph.

*Table 3F.1 – Speed level at which mean enjoyment scores peak by driver experience group*

| | Speed of Peak Enjoyment (mph) | | | |
|---|---|---|---|---|
| | *Residential* | *Bendy Country* | *Straight Country* | *Dual Carriageway* |
| Learner | 30 | 25 | 40-50 | 85 |
| Inexperienced | 55 | 55-60 | 70* | 100* |
| Experienced | 40 | 45 | 50 | 95-100** |

* - Maximum speed measured in current study. Peak enjoyment level could be higher than this.

** - Maximum speed measured in the current study although the same mean rating for the final two measures may signify a peak plateau

Repeated measures Multivariate Analysis of Variance (MANOVA) was performed to test for differences in Enjoyment ratings at all speed levels by experience. The assumption of "sphericity" was examined, but this assumption was not met hence in reporting results, the Greenhouse-Geisser statistic is used. There was a significant difference between the experience groups ratings of Enjoyment on the residential road but results were marginally insignificant on all other road types (Residential: $F$ (4, 307)=3.55, $p$=.007; Straight Country: $F$ (3.5, 261)=1.93, $p$=.114; Bendy Country: $F$ (3, 236)=2.47, $p$=.059; Dual Carriageway: $F$ (3.5, 265)=2.375, $p$=.06). Post Hoc Tukey analysis determined that significant differences for the residential road were found between the inexperienced group and both the learner group ($p$=.004) and experienced group ($p$=.037) at 20 mph; and between the inexperienced group and the learner group at 25mph and 30mph (both $p$=.009).

*II. Enjoyment in relation to speed by experience level*

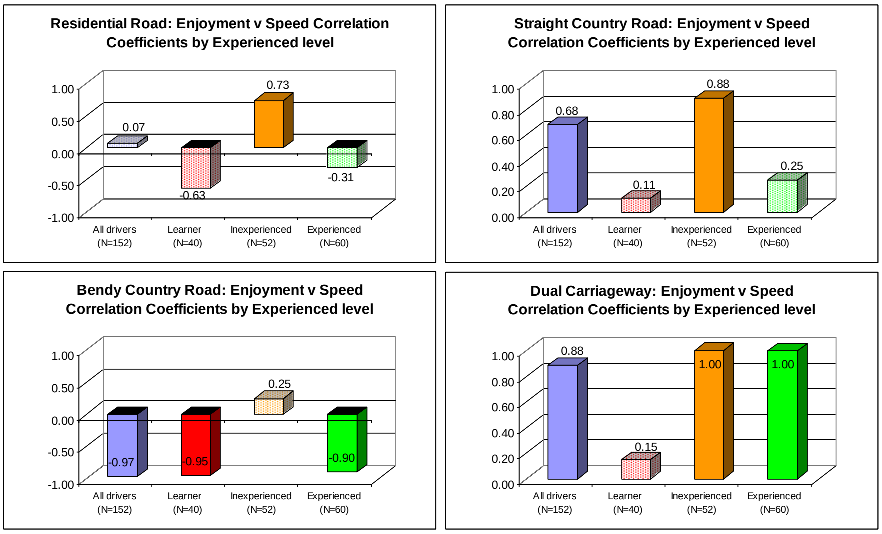



*Figure 3F.2: Comparison of correlation coefficients between Enjoyment and speed by experience group on all road types. Full colours are significant at the p<.05 level. Shaded colours are not significant.*

Mean enjoyment ratings were calculated for each of the nine speed levels on each road type. Overall mean scores and mean scores for the experience groups were then correlated with speed. Spearmans rho correlations demonstrate intriguing differences between the experience groups and by road type, which can be seen in Figure 3F.2. On the residential road there is no significant correlation overall or for the learner group or the experienced group; although both groups demonstrate a negative relationship. Conversely, the inexperienced group demonstrate a strong significant positive relationship between enjoyment and speed (rho=0.73, p=.02). A similar distinction between experience groups is found for the straight country road, where only the inexperienced group demonstrate a significant positive relationship (rho=0.88, p<.01).

The inverse is true for the bendy country road. No significant relationship if found for the inexperienced group, however, both the learner (rho=-0.95, p<.01) and experienced group (rho=-0.90, p<.01) demonstrate significant negative relationships between enjoyment and speed; such that as speed is increasing, their enjoyment levels decrease.

There is a difference pattern of results for the dual carriageway whereby both inexperienced and experienced drivers ratings of enjoyment are perfectly correlated with speed (both rho=1.00, p<.01). There is no significant correlation for the learner driver group on the dual carriageway.

Whilst this method of analysis is a little crude, it highlights an intriguing difference between the experience groups on all four road types; worthy of deeper examination.

*III. Enjoyment in relation to task difficulty and risk by experience level*

*Learner Drivers*

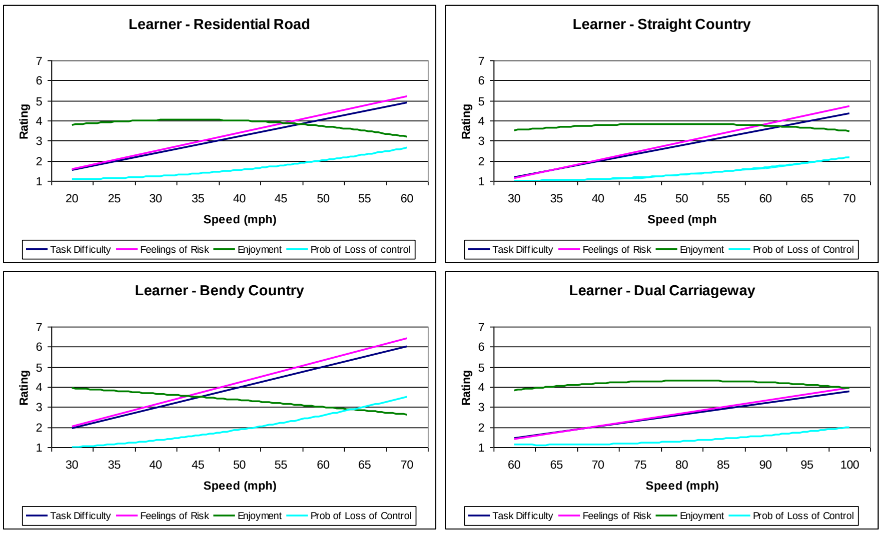



*Figure 3F.3: Means plot of Learners ratings of Task Difficulty, Feelings of Risk, Enjoyment and Probability of Loss of Control across speed for the four road types.*

A comparison of learner drivers' mean ratings for all factors across speed can be seen in Figure 3F.3. The most notable trend is possibly that feelings of risk and task difficulty intersect enjoyment levels at around the same rating level on each road type (rating 3-4). Aside from the dual carriageway where the information is not available, after the point of intersection, task difficulty and feelings of risk continue to rise whilst enjoyment levels decline. Meanwhile probability of loss of control only intersects enjoyment on the bendy country road at high speed.

Spearmans rho correlations of enjoyment with all other factors are tabulated at the end of this appendix for each experience group. Learner drivers' (N=40) ratings of enjoyment and task difficulty are unrelated at low speeds on all road types; however, once task difficulty ratings exceed a level of around 3, there are significant negative relationships between the two factors. The negative relationships remain significant until the highest speed measured on each road type (Residential: 50mph rho=-0.34, $p<.05$; 55mph rho=-0.38, $p<.05$; 60mph rho=-0.32, $p<.05$; Straight Country: 55mph rho=-0.36, $p<.05$; 60mph rho=-0.46, $p<.01$; 65mph rho=-0.43, $p<.01$; 70mph, rho=-0.52, $p<.01$; Bendy Country: 45mph rho=-0.68, $p<.01$; 50mph rho=-0.65, $p<.01$; 55mph rho=-0.79, $p<.01$; 60mph rho=-0.65, $p<.01$; 65mph rho=-0.54, $p<.01$; 70mph rho=-0.64, $p<.01$; Dual Carriageway: 80mph rho=-0.38, $p<.05$; 85mph rho=-0.33, p<.05; 90mph rho=-0.60, p<.01; 95mph rho=-0.52, p<.01; 100mph rho= -0.59, p<.01).

Given the relationship between task difficulty and feelings of risk, enjoyment unsurprisingly has a similar relationship with feelings of risk as it does with task difficulty. Again at low speeds, there are no significant relationships but after a certain threshold, there are significant negative relationships on each road type (Residential: 50mph rho=-0.35, p<.05; 55mph rho=-0.35, p<.05; Straight Country: 55mph rho=-0.37, p<.05; 60mph rho=-0.59, p<.01; 65mph rho=-0.49, p<.01; 70mph, rho=-0.56, p<.01; Bendy Country: 45mph rho=-0.59, p<.01; 50mph rho=-0.70, p<.01; 55mph rho=-0.73, p<.01; 60mph rho=-0.53, p<.01; 65mph rho=-0.48, p<.01; 70mph rho=-0.54, p<.01; Dual Carriageway: 80mph rho=-0.33, p<.05; 90mph rho=-0.57, p<.01; 95mph rho=-0.46, p<.01; 100mph rho= -0.56, p<.01).

The learner groups relationship between the probability of loss of control and enjoyment was less clear with few significant results (Straight Country: 60mph rho=-0.32, p<.05; 65mph rho=-0.33, p<.05; Bendy Country: 55mph rho=-0.36, p<.05; Dual Carriageway: 100mph -0.42, p<.05).

*Inexperienced Drivers*

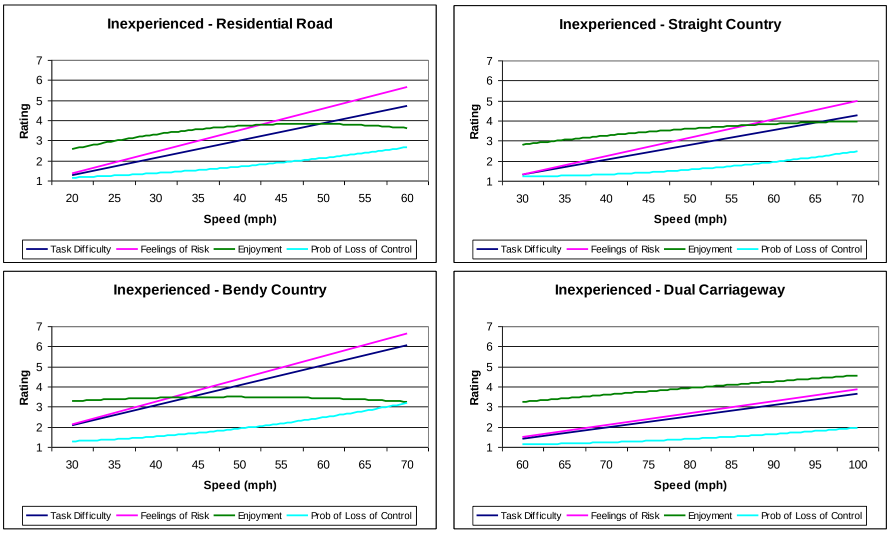



*Figure 3F.4: Means plot of Inexperienced drivers ratings of Task Difficulty, Feelings of Risk, Enjoyment and Probability of Loss of Control across speed for the four road types.*

A comparison of inexperienced drivers' mean ratings for all factors across speed can be seen in Figure 3F.4. It appears from the graphs that inexperienced drivers tend to gradually increase ratings of enjoyment as speed increases although, other than on the dual carriageway, this later reaches a plateau followed by a minor decline. Similar to the learner driver group, however, ratings of feelings of risk and task difficulty intersect enjoyment at a comparable level (rating 3-4) on each road type except the dual carriageway. Unlike the learner group, however, inexperienced drivers ratings of enjoyment as speed increases on the dual carriageway suggests the faster the better, even at 100mph.

Correlation tables of enjoyment and all other factors across all road types for inexperienced drivers (N=52) can be seen at the end of this appendix. The correlation tables demonstrate the increase of enjoyment ratings by the inexperienced group when related to other factors. Whereas the learner driver group had no significant positive relationships between enjoyment and any other factor, the inexperienced group demonstrates significant positive relationships with all factors. Enjoyment and task difficulty show significant relationships on the residential road (35mph: rho=0.54, $p<.01$; 40mph: rho=0.46; $p<.01$; 45mph: rho=0.33, $p<.05$), the straight country road (30mph rho=0.37, $p<.05$; 35mph rho=0.42, $p<.01$; 40mph rho=0.47, $p<.01$; 45mph rho=0.35, $p<.05$; 50mph rho=0.30, $p<.05$), the bendy country road (30mph: rho=0.30, $p<.05$) and the dual carriageway (65mph: rho=0.37, $p<.05$).

Similar relationships are found between enjoyment and feelings of risk demonstrating significant positive relationships on the residential road (35mph: rho=0.39, $p<.01$), the straight country road (30mph rho=0.30, $p<.05$; 35mph rho=0.31, $p<.05$; 40mph rho=0.52, $p<.01$; 45mph rho=0.38, $p<.05$; 50mph rho=0.33, $p<.05$; 55mph rho=0.35, $p<.05$) and the dual carriageway (65mph rho=0.30, $p<.05$; 70mph rho=0.29, $p<.05$; 75mph rho=0.29, $p<.05$).

Enjoyment and probability of loss of control also demonstrate significant positive relationships on the residential (25mph rho=0.33, $p<.05$; 30mph rho=0.33; $p<.05$; 35mph rho=0.42, $p<.01$) and straight country road (30mph rho=0.44, $p<.01$; 35mph rho=0.34; $p<.05$; 40mph rho=0.44, $p<.01$; 45mph rho=0.40, $p<.01$).

At higher speeds there were significant negative relationships between enjoyment and task difficulty on the bendy country road (65mph rho=-0.36, p<.05; 70mph rho=-0.45, p<.01) and the straight country road (65mph rho=-0.28, p<.05; 70mph rho=-0.43, p<.01). A similar relationship is reported for enjoyment and feelings of risk for the bendy country road (55mph rho=-0.29, p<.05; 60mph rho=-0.44; p<.01; 65mph rho=-0.38, p<.05; 70mph rho=-0.42, p<.01) and the straight country road (70mph rho=-0.40, p<.01).

Enjoyment and the probability of loss of control demonstrate negative correlations for the bendy country road (60mph rho=-0.32; p<.05; 65mph rho=-0.37, p<.05; 70mph rho=-0.33, p<.05) and the dual carriageway (95mph rho=-0.34, p<.05).

*Experienced Drivers*

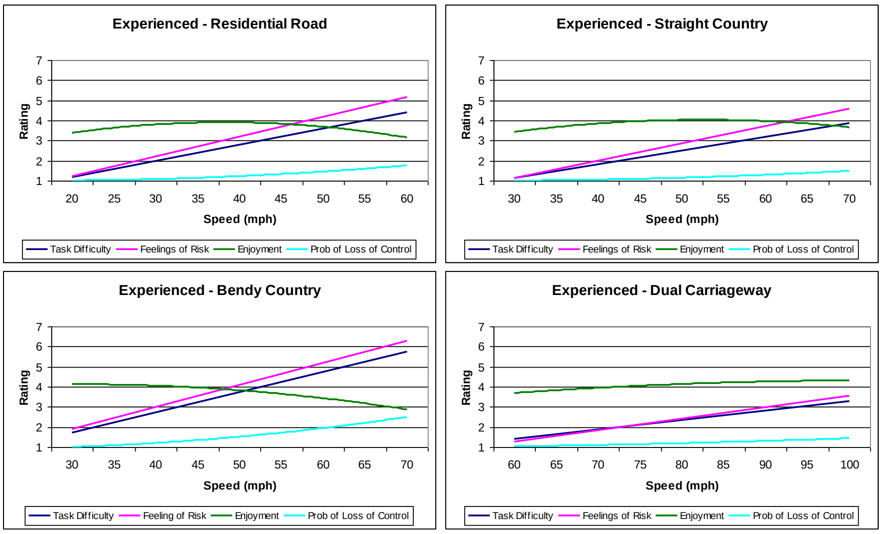



*Figure 3F.5: Means plot of Experienced driver ratings of Task Difficulty, Feelings of Risk, Enjoyment and Probability of Loss of Control across speed for the four road types.*

A comparison of experienced drivers' mean ratings for all factors across speed can be seen in Figure 3F.5. Similarly to learner drivers, feelings of risk and task difficulty intersect enjoyment levels at around the same rating level on each road type (rating 3-4); except the dual carriageway where the point of intersection is unknown. Also similar is that after the point of intersection, task difficulty and feelings of risk continue to rise whilst enjoyment levels decline. Probability of loss of control doesn't intersect enjoyment on any of the road types. On the residential and straight country roads, there is a clear peak enjoyment period whereby before or after this period, enjoyment declines. On the bendy country road, the peak is possibly already established at the lowest speed tested; meanwhile, a peak on the dual carriageway is undetectable as enjoyment rises with speed until the maximum speed tested.

Correlation tables of enjoyment and all other factors across all road types for experienced drivers (N=60) can be seen at the end of this appendix. Similar to the learner driver group, and unlike inexperienced drivers, there are no positive correlations between enjoyment and task difficulty or feelings of risk for the experienced driver group. No significant correlations are found at lower speeds for these factors although there are significant negative correlations between enjoyment and task difficulty on all road types (Residential: 50mph rho=-0.46, p<.01; 55mph rho=-0.59, p<.01; 60mph rho=-0.67, p=.01; Bendy Country: 40mph rho=-0.36, p<.01; 50mph rho=-0.34, p<.05; 55mph rho=-0.51, p<.01; 60mph rho=-0.62, p=.01; 65mph rho=-0.67, p=.01; 70mph rho=-0.68, p=.01; Straight Country: 60mph rho=-0.29, p=.05; 65mph rho=-0.27, p=.05; 70mph rho=-0.46, p=.01; Dual Carriageway: 90mph rho=-0.39, p=.01; 95mph rho=-0.39, p=.01; 100mph rho=-0.42, p=.01). A similar pattern of relationships is found between enjoyment and feelings of risk (Residential: 50mph rho=-0.36, p<.01; 55mph rho=-0.52, p<.01; 60mph rho=-0.59, p=.01; Bendy Country: 40mph rho=-0.37, p<.01; 45mph rho=-0.36, p<.01; 50mph rho=-0.34, p<.05; 55mph rho=-0.42, p<.01; 60mph rho=-0.56, p=.01; 65mph rho=-0.63, p=.01; 70mph rho=-0.63, p=.01; Straight Country: 55mph rho=-0.26, p<.05 60mph rho=-0.36, p=.01; 65mph rho=-0.21, p=.05; 70mph rho=-0.50, p=.01; Dual Carriageway: 100mph rho=-0.32, p=.05).

Correlations between enjoyment and probability of loss of control demonstrate no significant relationships for the straight country road. Unlike the relationships with the other factors, there are some positive relationships between enjoyment and the probability of loss of control (Residential: 25mph rho=0.29, p<.05; 30mph, p<.05; Dual Carriageway: 60mph rho=0.35, p<.05; 65mph rho=0.30, p<.05). At higher speeds there are also significant negative relationships for the residential road (50mph rho=-0.27, p<.05; 60mph rho=-0.33); the bendy country road (45mph rho=-0.32, p<.05; 50mph rho=-0.48, p<.05; 55mph rho=-0.43, p<.01; 60mph rho=-0.42, p=.01; 65mph rho=-0.41, p=.01; 70mph rho=-0.41, p=.01); and the dual carriageway (100mph rho=-0.14, p<.05).

Tables of Enjoyment and Task Difficulty, Feelings of Risk and Probability of Loss of Control Correlation Coefficients by Experience Group

Learners only (N=40) Enjoyment v Task Difficulty

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| **20** | 0.07 | | | |
| **25** | 0.19 | | | |
| **30** | -0.07 | -0.07 | -0.09 | |
| **35** | 0.08 | -0.16 | -0.24 | |
| **40** | 0.03 | -0.29 | -0.12 | |
| **45** | -0.10 | ***-0.68*** | -0.19 | |
| **50** | **-0.34** | ***-0.65*** | -0.20 | |
| **55** | **-0.38** | ***-0.79*** | **-0.36** | |
| **60** | **-0.32** | ***-0.65*** | ***-0.46*** | 0.07 |
| **65** | | ***-0.54*** | **-0.43** | -0.09 |
| **70** | | ***-0.64*** | ***-0.52*** | -0.11 |
| **75** | | | | -0.16 |
| **80** | | | | **-0.38** |
| **85** | | | | **-0.33** |
| **90** | | | | ***-0.60*** |
| **95** | | | | ***-0.52*** |
| **100** | | | | ***-0.59*** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Learners only (N=40) Enjoyment v Feelings of Risk

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| 20 | -0.13 | | | |
| 25 | 0.17 | | | |
| 30 | 0.01 | 0.09 | -0.07 | |
| 35 | 0.16 | 0.04 | -0.10 | |
| 40 | -0.05 | -0.26 | -0.15 | |
| 45 | -0.15 | ***-0.59*** | -0.18 | |
| 50 | **-0.35** | ***-0.70*** | -0.22 | |
| 55 | **-0.35** | ***-0.73*** | **-0.37** | |
| 60 | -0.26 | ***-0.53*** | ***-0.59*** | -0.03 |
| 65 | | ***-0.48*** | ***-0.49*** | 0.05 |
| 70 | | ***-0.54*** | ***-0.56*** | -0.04 |
| 75 | | | | -0.06 |
| 80 | | | | **-0.33** |
| 85 | | | | -0.24 |
| 90 | | | | ***-0.57*** |
| 95 | | | | ***-0.46*** |
| 100 | | | | ***-0.56*** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Learner drivers only (N=40) Enjoyment v Probability of Loss of Control

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| **20** | -0.06 | | | |
| **25** | 0.19 | | | |
| **30** | 0.00 | 0.18 | -0.01 | |
| **35** | 0.20 | 0.06 | 0.17 | |
| **40** | 0.04 | -0.19 | 0.12 | |
| **45** | 0.06 | -0.24 | 0.07 | |
| **50** | -0.11 | -0.21 | 0.00 | |
| **55** | -0.14 | **-0.36** | -0.18 | |
| **60** | -0.25 | -0.18 | **-0.32** | 0.03 |
| **65** | | -0.18 | **-0.33** | -0.02 |
| **70** | | -0.19 | -0.30 | -0.05 |
| **75** | | | | -0.15 |
| **80** | | | | -0.22 |
| **85** | | | | -0.23 |
| **90** | | | | -0.29 |
| **95** | | | | -0.32 |
| **100** | | | | **-0.42** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Inexperienced drivers only (N=52) Enjoyment v Task Difficulty

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| **20** | 0.26 | | | |
| **25** | 0.19 | | | |
| **30** | 0.25 | **0.30** | **0.37** | |
| **35** | ***0.54*** | 0.18 | ***0.42*** | |
| **40** | ***0.46*** | 0.15 | ***0.47*** | |
| **45** | **0.33** | 0.09 | **0.35** | |
| **50** | 0.03 | -0.13 | **0.30** | |
| **55** | -0.06 | -0.20 | 0.24 | |
| **60** | -0.24 | -0.15 | -0.03 | 0.24 |
| **65** | | **-0.36** | **-0.28** | **0.37** |
| **70** | | ***-0.45*** | ***-0.43*** | 0.27 |
| **75** | | | | 0.18 |
| **80** | | | | 0.14 |
| **85** | | | | -0.06 |
| **90** | | | | -0.04 |
| **95** | | | | -0.13 |
| **100** | | | | -0.16 |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Inexperienced drivers only (N=52) Enjoyment v Feelings of Risk

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| 20 | 0.09 | | | |
| 25 | 0.20 | | | |
| 30 | 0.27 | 0.08 | **0.30** | |
| 35 | ***0.39*** | 0.20 | **0.31** | |
| 40 | 0.26 | 0.18 | ***0.52*** | |
| 45 | 0.13 | 0.03 | ***0.38*** | |
| 50 | -0.02 | -0.15 | **0.33** | |
| 55 | -0.10 | **-0.29** | **0.35** | |
| 60 | -0.28 | ***-0.44*** | 0.14 | 0.25 |
| 65 | | **-0.38** | -0.19 | **0.30** |
| 70 | | ***-0.42*** | ***-0.40*** | **0.29** |
| 75 | | | | **0.29** |
| 80 | | | | 0.23 |
| 85 | | | | 0.02 |
| 90 | | | | -0.14 |
| 95 | | | | -0.12 |
| 100 | | | | -0.20 |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Inexperienced drivers only (N=52) Enjoyment v Probability of Loss of Control

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| **20** | 0.08 | | | |
| **25** | **0.33** | | | |
| **30** | **0.33** | 0.12 | ***0.44*** | |
| **35** | ***0.42*** | 0.16 | **0.34** | |
| **40** | 0.26 | 0.02 | ***0.44*** | |
| **45** | 0.12 | 0.10 | ***0.40*** | |
| **50** | 0.03 | -0.20 | 0.24 | |
| **55** | 0.02 | -0.27 | 0.26 | |
| **60** | -0.26 | **-0.32** | 0.14 | 0.13 |
| **65** | | **-0.37** | -0.03 | 0.20 |
| **70** | | **-0.33** | -0.13 | 0.16 |
| **75** | | | | 0.16 |
| **80** | | | | 0.18 |
| **85** | | | | -0.05 |
| **90** | | | | -0.23 |
| **95** | | | | **-0.34** |
| **100** | | | | -0.24 |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Experienced drivers only (N=60) Enjoyment v Task Difficulty

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| **20** | 0.06 | | | |
| **25** | 0.07 | | | |
| **30** | 0.06 | -0.16 | 0.01 | |
| **35** | -0.08 | -0.04 | -0.05 | |
| **40** | 0.02 | ***-0.36*** | 0.12 | |
| **45** | -0.08 | -0.21 | -0.07 | |
| **50** | ***-0.46*** | **-0.34** | -0.05 | |
| **55** | ***-0.59*** | ***-0.51*** | -0.07 | |
| **60** | ***-0.67*** | ***-0.62*** | **-0.29** | -0.05 |
| **65** | | ***-0.67*** | **-0.27** | 0.01 |
| **70** | | ***-0.68*** | ***-0.46*** | 0.09 |
| **75** | | | | 0.01 |
| **80** | | | | -0.18 |
| **85** | | | | -0.06 |
| **90** | | | | ***-0.39*** |
| **95** | | | | ***-0.39*** |
| **100** | | | | ***-0.42*** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Experienced drivers only (N=60) Enjoyment v Feelings of Risk

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| 20 | 0.13 | | | |
| 25 | 0.14 | | | |
| 30 | 0.15 | -0.07 | 0.02 | |
| 35 | -0.04 | -0.10 | 0.08 | |
| 40 | 0.11 | ***-0.37*** | 0.15 | |
| 45 | -0.07 | ***-0.36*** | -0.10 | |
| 50 | ***-0.36*** | **-0.34** | -0.11 | |
| 55 | ***-0.52*** | ***-0.42*** | **-0.26** | |
| 60 | ***-0.59*** | ***-0.56*** | ***-0.36*** | 0.09 |
| 65 | | ***-0.63*** | **-0.21** | 0.08 |
| 70 | | ***-0.63*** | ***-0.50*** | 0.14 |
| 75 | | | | 0.13 |
| 80 | | | | -0.07 |
| 85 | | | | -0.09 |
| 90 | | | | -0.19 |
| 95 | | | | -0.24 |
| 100 | | | | **-0.32** |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

Experienced drivers only (N=60) Enjoyment v Probability of Loss of Control

| Road Type/Speed (mph) | **Residential** | **Bendy Country** | **Straight Country** | **Dual Carriageway** |
|---|---|---|---|---|
| **20** | 0.18 | | | |
| **25** | **0.29** | | | |
| **30** | **0.31** | -0.01 | -0.04 | |
| **35** | 0.12 | -0.07 | -0.08 | |
| **40** | 0.18 | -0.11 | 0.00 | |
| **45** | -0.01 | **-0.32** | 0.02 | |
| **50** | **-0.27** | ***-0.48*** | 0.07 | |
| **55** | -0.22 | ***-0.43*** | -0.03 | |
| **60** | ***-0.33*** | ***-0.42*** | -0.14 | **0.35** |
| **65** | | ***-0.41*** | 0.02 | **0.30** |
| **70** | | ***-0.41*** | -0.11 | 0.22 |
| **75** | | | | 0.20 |
| **80** | | | | 0.15 |
| **85** | | | | 0.07 |
| **90** | | | | 0.00 |
| **95** | | | | -0.14 |
| **100** | | | | -0.14 |

**Bold denotes significant at p<.05**
***Bold and Italics denotes significant at p<.01***

# Appendix 5A

Examples of pictures used in Study 2

**Safe**

**Developing Hazard**

**Hazard**

# Appendix 5B

Participant consent form and information sheet

**Participant Information Sheet**

Thank you for volunteering to take part in this study. We will ask you to look at various pictures of road scenes taken from a driver's viewpoint and ask you to rate each scene according to how hazardous you think that particular situation is. The scenes could be of any situation which could be encountered or indeed may have been encountered by you on a public road. This is an exploratory study and there are no right or wrong answers.

While you are doing this, we will take measurements using 'galvanic skin response' equipment. This involves two small electrodes being placed on two of your fingers. These will measure the conductivity of your skin by sending a tiny electrical current between the two electrodes. This procedure in entirely safe and you will not feel any sensation at all from this procedure. We will also measure your respiration using a material band which we will ask you to fasten around your chest.

We would also like to ask you to complete a short questionnaire about you and your driving.

You will be asked to sign a consent form which shows that you have read and understood this sheet and that you agree to participate in the study.

You may:

- Stop your participation at any point during the study without giving a reason
- Refuse to answer any question without giving a reason

The data we keep (driving history, demographics, ratings and bodily responses to pictures) will be indexed by a number and not contain your name or contact details. These data will be kept for a standard 5 years after publication of the study results after which they will be destroyed.

You will receive more detailed instructions about performing the task once we have seated you in front of the computer display. You will also receive more information on the study and its purpose once the testing session is over. However, please feel free to ask any questions about the study that you may still have before signing the consent form.

**Consent Form**

Perception of Driving Conditions Study

Researchers: Neale Kinnear, Dr. Steve Kelly, Prof. James Thomson, Lindsay Horton, Prof. Steve Stradling

Transport Research Institute, Napier University
Psychology Department, University of Strathclyde

Please read the following points and sign below if you agree with them:

- I have read and understood the accompanying information sheet which details that the study involves watching and rating pictures of road scenes and having bodily responses measured using galvanic skin response and respiration rate equipment.
- I understand that I will be asked to give information about my driving history and experience.
- I have been given an opportunity to ask further questions and am satisfied that these have been fully answered.
- I give my consent to taking part in the study and for the resulting data to be used in scientific publications.
- I am aware that I may withdraw my participation at any time or refuse to answer a question without giving a reason for doing so.

Name:

Signed …………………………………………… Date …………………

# Appendix
# 5C

Ethical Approval from Strathclyde University

University of Strathclyde

The following study was granted ethical approval by the Psychology Department's Ethics Committee:

**Emotional learning and prediction of potentially hazardous situations in driving** (DEC2005/50)

Chief Investigator: Steve Kelly
Other Strathclyde Investigators: James Thomson
Named collaborators: Neale Kinnear, Steve Stradling (Napier University)

Approved by Alison Sanford (Convener)
Date: 14th December, 2005.

**Department of Psychology**
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40 George Street
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Scotland

t: +44 (0)141 552 4400
(direct line) +44 (0)141 548 + ext
f: +44 (0)141 548 4001

# Appendix
# 5D

Peak to peak skin conductance analysis

In addition to the presence or absence of SCRs, the size of the psychophysiological response, where generated, may also provide useful information about driver differences. Where an SCR was evoked, peak to peak measurements were compared across groups and stimulus categories (mean values are shown in Figure 5D.1). One outlier (defined as more than 2 standard deviations from the mean) was replaced with the recalculated group mean for the Inexperienced: Hazard condition. Numerically, experienced and inexperienced drivers show similar increases in SCR to Safe and Developing Hazard clips, with inexperienced drivers showing a noticeably larger increase to Hazardous images than experienced drivers.

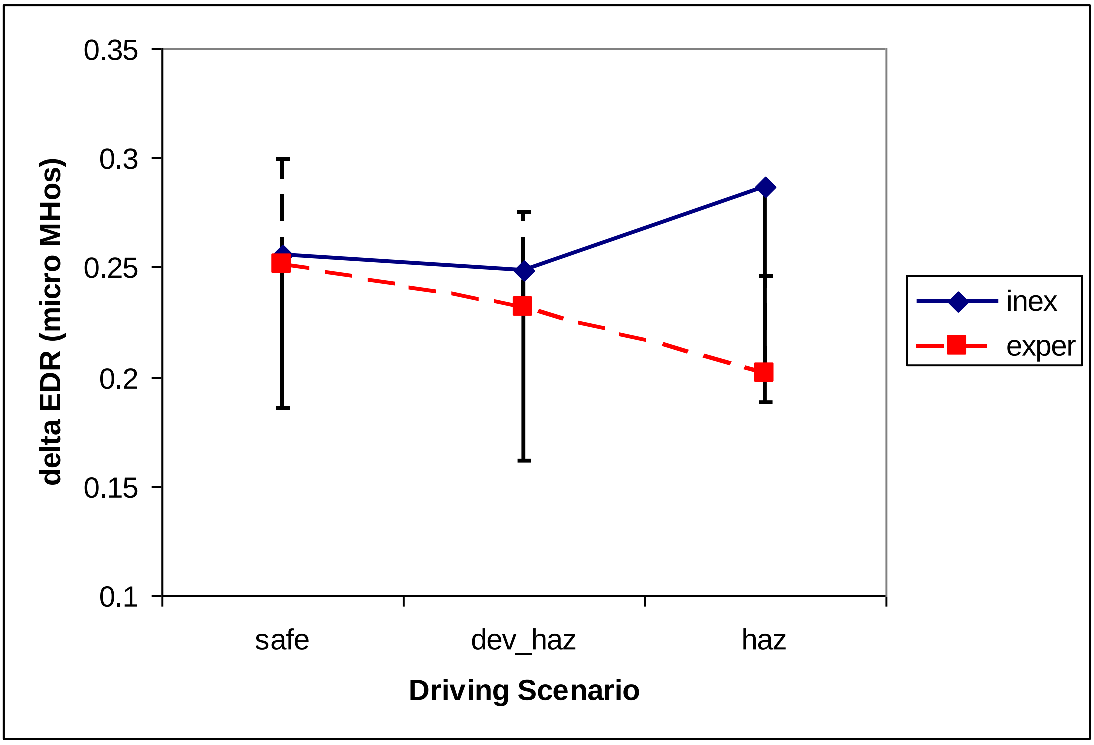


*Figure 5D.1: Mean peak to peak measurements (with standard error bars) for electrodermal responses to safe, developing hazard and hazardous scenarios in $\mu S$.*

As responses were not obtained for each participant in every stimulus category condition, only comparisons across the between-subjects factor are appropriate. T-tests were performed and demonstrate no significant difference between experienced and inexperienced drivers for safe, developing hazard or hazard scenes ($t(22) = .059$; $t(20) = -.199$; $t(21) = .811$, respectively, $p > .10$).

# Appendix 6A

Contract with Driving Standards Agency (DSA)

**THIS LICENCE AGREEMENT** is made on 20th June 2006 between:

(1) THE SECRETARY OF STATE FOR TRANSPORT represented by THE DRIVING STANDARDS AGENCY of Stanley House, 56 Talbot Street, Nottingham, NG1 5GU (DSA); and

(2) Neale Kinnear, Transport Research Institute, Napier University, Sighthill Campus, Edinburgh, EH11 4BN

and,

Dr Steve Kelly, Department of Psychology, University of Strathclyde, Graham Hills Building, 40 George Street, Glasgow, G1 11QE

**IT IS HEREBY AGREED** as follows:

**1. Preliminary**

1.1 The DSA is the Government agency, which has responsibility for the implementation of the UK driving theory test. The theory test question bank developed for the DSA is subject to Crown copyright.

1.2 The Crown is the proprietor of and entitled to certain trademark and copyright material.

1.3 Under the terms of Royal Letters Patent, the Controller of Her Majesty's Stationery Office (HMSO) is responsible for the licensing of rights in Crown copyright material.

**2. Use of the Licensed Material**

2.1 The Licensee must not use the Material in any way that is likely to mislead others, or present your version of the Material as being the Official Source; for example by replicating the Official Source's style and appearance.

2.2 The purchased DSA Hazard Perception Test video clips are licensed to the Licensee for re-use only. The DSA Hazard Perception Test video clips must not be passed on to a third party.

2.3 The Licensed Material includes and is limited to the re-use of 16 (sixteen) Hazard Perception Simulated Video Clips.

Neale Kinnear and Dr Steve Kelly confirm the following:

- No Commercial gain will made from the resulting product.
- The resulting product / work will not be copied, sold, published electronically or passed off in any way as being available for sale.
- The following acknowledgement will be stated on the resulting product and wherever Crown copyright material is used: "Crown copyright material has been reproduced with the permission of the Driving Standards Agency which does not accept any responsibility for the accuracy of the reproduction".
- Users are not charged by Neale Kinnear & Dr Steve Kelly for access to the Crown copyright material.
- It is understood that DSA do not in any way approve or recommend the work or resulting product.
- DSA will be given sight of any research results before they are issued.

SIGNED BY .............................................. DATE 22 June 2006

Name in block capitals PAUL BUTLER

Job Title Policy and Research Director

for and on behalf of
The Secretary of State for Transport

SIGNED BY .............................................. DATE 20 JUNE '06

Name in block capitals NEALE KINNEAR

Job Title PHD RESEARCH STUDENT

for and on behalf of
*Transport Research Institute, Napier University & Dr Steve Kelly, Strathclyde University with approval*

# Appendix 6B

Hazard Perception clip information

| Clip No. | Hazard Description | Hazard Length (secs) | Total Time of Clip (secs) |
|---|---|---|---|
| 1 | Man comes out of house, crosses road ahead and enters passenger side of car. **Car then pulls out** | **11.08** | **50.4** |
| 2 | **Cyclist** pulls out of junction ahead into cars path, then swerves to overtake indicating car. | **7.84** | **67.12** |
| 3 | **Pedestrian runs onto the road** without looking whilst waving a bus down | **10.76** | **55.16** |
| 5 | **Child on a bicycle** crosses the road causing a **motorbike** in front to slow down. | **5.68** | **46.76** |
| 6 | **Car pulls out** from a slip road onto **dual carriageway** in front of you. | **12.36** | **67.16** |
| 7 | **School children cross the road** at a zebra crossing near a school. | **9.16** | **58.76** |
| 10 | **Man steps onto road with box from behind a van** and crosses in front of you. | **4.8** | **56.96** |
| 11 | **White van** approaches and pulls out of junction on a country road. | **8.24** | **57.92** |
| 12 | **Motorbike pulls out** into the middle of road to pass parked car. | **10.36** | **59.24** |
| 13 | **Car in front brakes** for a **cyclist**, and then overtakes them. | **14.2** | **59.32** |
| 15 | **2 motorbikes** pull out of junction onto the road ahead. | **6.36** | **59.36** |
| 16 | **Lorry performs a U-turn** on dual carriageway. | **11.92** | **59.12** |

# Appendix 6C

You and Your Driving questionnaire – version II

# **You and Your Driving Questionnaire**

Age ________years _________ months

Gender (*please tick*) Male ☐ Female ☐

Do you have a UK driving licence (please tick)?

YES ☐

↓

How long have you held your licence?

_______years _______months

↓

How many times have you taken the UK driving test? _____ times

↓

Approximately, how long were you a learner driver before passing your test?

_______years _______months

↓

Approximately, how much driving experience did you have as a learner driver?

Official tuition: _______hours

Private practise: _______hours

NO ☐

↓

Approximately, how long have you been a learner driver?

_______years _______months

↓

Approximately, how much learning experience have you had?

Official tuition: _______hours

Private practise: _______hours

↓

How many times have you taken the UK driving test? _____ times

Have you ever taken the following official tests?

| | | | | |
|---|---|---|---|---|
| Theory test | Yes | ☐ | No | ☐ |
| Hazard Perception test | Yes | ☐ | No | ☐ |
| Pass Plus? | Yes | ☐ | No | ☐ |

Approximately, how many miles have you driven in the past 12 months? _____ miles
Approximately, how many miles have you driven in the past 3 years? _____ miles

Do you ride a motorcycle?
- Yes, I have a full motorcycle licence? ☐
- Yes, I have a provisional motorcycle licence? ☐
- No. ☐

Do you have regular access to a car? Yes ☐ No ☐

Who owns the vehicle you drive most? (*please tick one*)

| | | | |
|---|---|---|---|
| Myself | ☐ | My employer | ☐ |
| My partner | ☐ | Other | ☐ |
| My parents | ☐ | | |

What is the engine size of the car you drive most often?

- 1.0 litre or less ☐
- 1.1 - 1.2 litres ☐
- 1.3 – 1.4 litres ☐
- 1.5 – 1.6 litres ☐
- 1.7 – 1.8 litres ☐
- 1.9 – 2.0 litres ☐
- Over 2.0 litres ☐
- Don’t know ☐

What is the make and model of the car you drive most?
Make ________________ (e.g. - Ford) Model________________ (e.g. - Focus)

Are there any modifications to the vehicle? Yes ☐ No ☐

Which of the following applies to your car use with regards to work? (*please tick one*)

Professional driver ☐

Use a car during work and for commuting ☐

Use a car for commuting only ☐

Don't use a car for work at all ☐

How many times have you been flashed by a speed camera in the past three years?
_____ times

How many times have you been stopped for speeding in the past three years?
_____ times

How many penalty points do you have on your licence?
_____ points

Have you ever had a crash or near-miss because you were going too fast?

Yes ☐ No ☐

How many motor vehicle accidents have you been involved in, **in your lifetime**?
Please write the numbers in the boxes (if none, enter 0).

| | **As a passenger** | **As a driver** |
|---|---|---|
| Damage only | | |
| Minor injury | | |
| Serious or fatal injury | | |

How many accidents have you been involved in **as a driver in the last 3 years**?
Please write the numbers in the boxes (if none, enter 0).

| | Active crashes (i.e. you hit another road user, or an obstacle) | Passive crashes (i.e. you were hit by another road user) |
|---|---|---|
| Damage only | | |
| Minor injury | | |
| Serious or fatal injury | | |

How many times have you been involved in a near miss **as a driver?** ________

How many of these would you consider to have been potentially serious? ________

How many times have you been involved in a near miss **as a passenger?** ________

How many of these would you consider to have been potentially serious? ________

*And finally…*
Please rate your response towards the following statements:

| | Not at all | | | | | | | | | | Very much |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| I would like to risk my life as a racing driver | | | | | | | | | | | |
| I sometimes like to frighten myself a little while driving | | | | | | | | | | | |
| I get a real thrill out of driving fast | | | | | | | | | | | |
| I enjoy listening to loud, exciting music while driving | | | | | | | | | | | |
| I like to raise my adrenaline levels while driving | | | | | | | | | | | |
| I would enjoy driving a sports car on a road with no speed limit | | | | | | | | | | | |
| I enjoy the sensation of accelerating rapidly | | | | | | | | | | | |
| I enjoy cornering at high speed | | | | | | | | | | | |
| In general I enjoy driving | | | | | | | | | | | |

**Your participation is appreciated.**

*THANK YOU*

Any comments about driving or this questionnaire/study?

______________________________________________

______________________________________________

# Appendix 6D

You and Your Driving questionnaire – version II with participants' means and frequencies

Mean scores and frequencies given here are for all participants excluding learners. Learner mean scores are given in red text.

# You and Your Driving Questionnaire

| | | | | |
|---|---|---|---|---|
| Age | **23.4 years (range: 17.75 – 33.8; sd = 3.78)** | | | |
| Gender | Male | **48.7%** | Female | **51.3%** |

Do you have a UK driving licence?

YES **N=39**

↓

How long have you held your licence?
**Mean: 3.91 years (range: 1 month–14 years; sd = 3.95)**

↓

How many times have you taken the UK driving test?
**Mean: 1.97 (range: 1 – 8; sd = 1.4)**

↓

Approximately, how long were you a learner driver before passing your test?
**11.6 months (range: 3 – 30 months; sd = 7.4)**

↓

Approximately, how much driving experience did you have as a learner driver?

| | | |
|---|---|---|
| Official tuition: | **42.8 hours** | **(range: 2 - 260 hours; sd = 42.6)** |
| Private practise: | **26.9 hours** | **(range: 0 - 240 hours; sd = 47.5)** |

NO **N=11**

↓

Approximately, how long have you been a learner driver?
**Mean: 19.1 months (range: 3 – 49 months; sd = 16.6)**

↓

Approximately, how much learning experience have you had?

| | |
|---|---|
| Official tuition: | **17.9 hours (range: 0-40; sd = 12.2)** |
| Private practise: | **15.64 hours (range: 0-100; sd = 28.9)** |

↓

How many times have you taken the UK driving test? **0.18 times (range: 0-2; sd = 0.6)**

Have you ever taken the following official tests? **N=39**

| | | | | |
|---|---|---|---|---|
| Theory test | Yes | **92.3%** | No | **7.7%** |
| Hazard Perception test | Yes | **61.5%** | No | **38.5%** |
| Pass Plus? | Yes | **12.8%** | No | **87.2%** |

Approximately, how many miles have you driven in the past 12 months? **4364 miles (range = 10 – 50'000; sd = 8650)**

Approximately, how many miles have you driven in the past 3 years? **10316 miles (range = 20 – 87'000; sd = 16'900)**

| | | |
|---|---|---|
| Do you ride a motorcycle? | Yes, I have a full motorcycle licence? | **0%** |
| | Yes, I have a provisional motorcycle licence? | **0%** |
| | No. | **100%** |

Do you have regular access to a car? **N=39** Yes **100%** No **0%**

Who owns the vehicle you drive most?
**N=37**

| | | | |
|---|---|---|---|
| Myself | **46%** | My employer | **3%** |
| My partner | **5%** | Other | **0%** |
| My parents | **46%** | | |

What is the engine size of the car you drive most often?
**N=37**

| | |
|---|---|
| 1.0 litre or less | **5%** |
| 1.1 - 1.2 litres | **32%** |
| 1.3 – 1.4 litres | **27%** |
| 1.5 – 1.6 litres | **16%** |
| 1.7 – 1.8 litres | **0%** |
| 1.9 – 2.0 litres | **11%** |
| Over 2.0 litres | **3%** |
| Don't know | **6%** |

What is the make and model of the car you drive most?
**N=36**

| | | | | | |
|---|---|---|---|---|---|
| Ford | **17%** | Renault | **19%** | Vauxhall | **11%** |
| Volkswagen | **17%** | Citroen | **6%** | Nissan | **3%** |
| Fiat | **8%** | Peugeot | **11%** | Other | **8%** |

**N=36**

| | | | | | |
|---|---|---|---|---|---|
| Small car | **56%** | Medium family | **33%** | Large family | **8%** |
| People carrier | **3%** | Sports | **0%** | 4x4 SUV | **0%** |
| Van | **0%** | | | | |

Are there any modifications to the vehicle? **N=39** Yes **2.7%** No **97.3%**

Which of the following applies to your car use with regards to work?
**N=39**

| | |
|---|---|
| Professional driver | **0%** |
| Use a car during work and for commuting | **18%** |
| Use a car for commuting only | **31%** |
| Don't use a car for work at all | **51%** |

How many times have you been flashed by a speed camera in the past three years?
**0.21 times (sd=.52, range 0-2) N=39**

How many times have you been stopped for speeding in the past three years?
**0.15 times (sd=.54, range 0-3) N=39**

How many penalty points do you have on your licence?
**0.54 points (sd=1.8, range 0-9) N=39**

Have you ever had a crash or near-miss because you were going too fast?
**N=39**
Yes **31%** No **69%**

How many motor vehicle accidents have you been involved in, **in your lifetime**?
Please write the numbers in the boxes (if none, enter 0).

| | **As a passenger** | **As a driver** |
|---|---|---|
| **Mean** | **0.69**<br>Sd = .77<br>Range = 0-3 | **0.64**<br>Sd = 1.16<br>Range = 0-5 |

How many accidents have you been involved in **as a driver in the last 3 years**?
Please write the numbers in the boxes (if none, enter 0).

| | Active crashes (i.e. you hit another road user, or an obstacle) | Passive crashes (i.e. you were hit by another road user) |
|---|---|---|
| **Mean** | **0.46**<br>Sd = .94<br>Range = 0-5 | **0.26**<br>Sd = .55<br>Range = 0-2 |

How many times have you been involved in a <u>near miss</u> **as a driver? 2.26 times (sd = 3.5; range = 0-20)**

How many of these would you consider to have been potentially serious? **1.03 times (sd = 1.44; range = 0-5)**

How many times have you been involved in a <u>near miss</u> **as a passenger? 1.92 times (sd = 2.15; range = 0-10)**

How many of these would you consider to have been potentially serious? **0.97 times (sd = 1.25; range = 0-5)**

*And finally…*
Please rate your response towards the following statements:

| **N=39** | Not at all | | | | | | | | | Very much |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| I would like to risk my life as a racing driver | **2.18 (sd=2.82, range=0-10)** | | | | | | | | | | |
| I sometimes like to frighten myself a little while driving | **1.54 (sd=2.16, range=0-8)** | | | | | | | | | | |
| I get a real thrill out of driving fast | **3.77 (sd=2.98, range=0-10)** | | | | | | | | | | |
| I enjoy listening to loud, exciting music while driving | **6.00 (sd=2.78, range=0-10)** | | | | | | | | | | |
| I like to raise my adrenaline levels while driving | **2.97 (sd=2.68, range=0-10)** | | | | | | | | | | |
| I would enjoy driving a sports car on a road with no speed limit | **5.49 (sd=3.47, range=0-10)** | | | | | | | | | | |
| I enjoy the sensation of accelerating rapidly | **5.72 (sd=2.87, range=0-10)** | | | | | | | | | | |
| I enjoy cornering at high speed | **2.56 (sd=2.66, range=0-10)** | | | | | | | | | | |
| In general I enjoy driving | **7.90 (sd=1.65, range=5-10)** | | | | | | | | | | |

**Your participation is appreciated.**

*THANK YOU*

# Appendix
# 6E

Eysenck Personality Questionnaire Revised – Short version
(EPQR-S) (Eysenck, Eysenck and Barrett, 1985)

*Short-scale EPQ-R*

Age . . . . . . . .                                                                                                            Sex . . . . . . . .

| | | | |
|---|---|---|---|
| 1. | Does your mood often go up and down? | YES | NO |
| 2. | Do you take much notice of what people think? | YES | NO |
| 3. | Are you a talkative person? | YES | NO |
| 4. | If you say you will do something, do you always keep your promise no matter how inconvenient it might be? | YES | NO |
| 5. | Do you ever feel 'just miserable' for no reason? | YES | NO |
| 6. | Would being in debt worry you? | YES | NO |
| 7. | Are you rather lively? | YES | NO |
| 8. | Were you ever greedy by helping yourself to more than your share of anything? | YES | NO |
| 9. | Are you an irritable person? | YES | NO |
| 10. | Would you take drugs which may have strange or dangerous effects? | YES | NO |
| 11. | Do you enjoy meeting new people? | YES | NO |
| 12. | Have you ever blamed someone for doing something you knew was really your fault? | YES | NO |
| 13. | Are your feelings easily hurt? | YES | NO |
| 14. | Do you prefer to go your own way rather than act by the rules? | YES | NO |
| 15. | Can you usually let yourself go and enjoy yourself at a lively party? | YES | NO |
| 16. | Are *all* your habits good and desirable ones? | YES | NO |
| 17. | Do you often feel 'fed-up'? | YES | NO |
| 18. | Do good manners and cleanliness matter much to you? | YES | NO |
| 19. | Do you usually take the initiative in making new friends? | YES | NO |
| 20. | Have you ever taken anything (even a pin or button) that belonged to someone else? | YES | NO |
| 21. | Would you call yourself a nervous person? | YES | NO |
| 22. | Do you think marriage is old-fashioned and should be done away with? | YES | NO |
| 23. | Can you easily get some life into a rather dull party? | YES | NO |
| 24. | Have you ever broken or lost something belonging to someone else? | YES | NO |
| 25. | Are you a worrier? | YES | NO |
| 26. | Do you enjoy co-operating with others? | YES | NO |
| 27. | Do you tend to keep in the background on social occasions? | YES | NO |
| 28. | Does it worry you if you know there are mistakes in your work? | YES | NO |
| 29. | Have you ever said anything bad or nasty about anyone? | YES | NO |
| 30. | Would you call yourself tense or 'highly-strung'? | YES | NO |
| 31. | Do you think people spend too much time safeguarding their future with savings and insurances? | YES | NO |
| 32. | Do you like mixing with people? | YES | NO |
| 33. | As a child were you ever cheeky to your parents? | YES | NO |
| 34. | Do you worry too long after an embarrassing experience? | YES | NO |
| 35. | Do you try not to be rude to people? | YES | NO |
| 36. | Do you like plenty of bustle and excitement around you? | YES | NO |
| 37. | Have you ever cheated at a game? | YES | NO |
| 38. | Do you suffer from 'nerves'? | YES | NO |
| 39. | Would you like other people to be afraid of you? | YES | NO |
| 40. | Have you ever taken advantage of someone? | YES | NO |
| 41. | Are you mostly quiet when you are with other people? | YES | NO |
| 42. | Do you often feel lonely? | YES | NO |
| 43. | Is it better to follow society's rules than go your own way? | YES | NO |
| 44. | Do other people think of you as being very lively? | YES | NO |
| 45. | Do you always practice what you preach? | YES | NO |
| 46. | Are you often troubled about feelings of guilt? | YES | NO |
| 47. | Do you sometimes put off until tomorrow what you ought to do today? | YES | NO |
| 48. | Can you get a party going? | YES | NO |

# Appendix 6F

Participant consent form and information sheet

## Participant Information Sheet

Thank you for volunteering to take part in this study. We will ask you to watch various film clips of road scenes taken from a driver's perspective and ask you to rate the clip according to how hazardous you think it is. The scenes could be of any situation which could be encountered or indeed may have been encountered by you on a public road. This is an exploratory study and there are no right or wrong answers.

While you are doing this, we will take measurements using 'galvanic skin response' equipment. This involves two small electrodes being placed on two of your fingers. These will measure the conductivity of your skin by sending a tiny electrical current between the two electrodes. This procedure in entirely safe and you will not feel any sensation at all from this procedure. We will also measure your respiration using a material band which we will ask you to fasten around your chest.

We would also like to ask you to complete a short questionnaire about you and your driving.

You will be asked to sign a consent form which shows that you have read and understood this sheet and that you agree to participate in the study.

You may:

- Stop your participation at any point during the study without giving a reason
- Refuse to answer any question without giving a reason

The data we keep (driving history, demographics, ratings and bodily responses to pictures) will be indexed by a number and not contain your name or contact details. These data will be kept for a standard 5 years after publication of the study results after which they will be destroyed.

You will receive more detailed instructions about performing the task once we have seated you in front of the computer display. You will also receive more information on the study and its purpose once the testing session is over. However, please feel free to ask any questions about the study that you may still have before signing the consent form.

**Consent Form**

Perception of Driving Conditions Study

Researchers: Neale Kinnear, Dr. Steve Kelly, Prof. James Thomson, Lindsay Horton, Prof. Steve Stradling

Transport Research Institute, Napier University
Psychology Department, University of Strathclyde

Please read the following points and sign below if you agree with them:

- I have read and understood the accompanying information sheet which details that the study involves watching video clips of road scenes and having bodily responses measured using galvanic skin response and respiration rate equipment.
- I understand that I will be asked to give information about my driving history and experience.
- I have been given an opportunity to ask further questions and am satisfied that these have been fully answered.
- I give my consent to taking part in the study and for the resulting data to be used in scientific publications.
- I am aware that I may withdraw my participation at any time or refuse to answer a question without giving a reason for doing so.

Name:

Signed …………………………………………… Date …………………

# Appendix 6G

SPSS output: Post hoc analysis of anticipatory score per clip by experience group

## Post-hoc Tukey analysis of participant groups' anticipatory score per clip

**Multiple Comparisons**

| Clip | Participant Group | Participant Group Comparison | Mean Difference | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| 1 | Learner | Inexperienced | 0.01 | 0.20 | 1.00 | -0.47 | 0.48 |
| | | Experienced | -0.20 | 0.20 | 0.57 | -0.68 | 0.28 |
| | Inexperienced | Learner | -0.01 | 0.20 | 1.00 | -0.48 | 0.47 |
| | | Experienced | -0.21 | 0.17 | 0.46 | -0.62 | 0.21 |
| | Experienced | Learner | 0.20 | 0.20 | 0.57 | -0.28 | 0.68 |
| | | Inexperienced | 0.21 | 0.17 | 0.46 | -0.21 | 0.62 |
| 2 | Learner | Inexperienced | -0.19 | 0.19 | 0.58 | -0.64 | 0.27 |
| | | Experienced | -0.42 | 0.19 | 0.07 | -0.88 | 0.03 |
| | Inexperienced | Learner | 0.19 | 0.19 | 0.58 | -0.27 | 0.64 |
| | | Experienced | -0.24 | 0.16 | 0.32 | -0.63 | 0.16 |
| | Experienced | Learner | 0.42 | 0.19 | 0.07 | -0.03 | 0.88 |
| | | Inexperienced | 0.24 | 0.16 | 0.32 | -0.16 | 0.63 |
| 3 | Learner | Inexperienced | -0.29 | 0.18 | 0.24 | -0.72 | 0.14 |
| | | Experienced | -0.67 | 0.19 | **0.00** | -1.12 | -0.21 |
| | Inexperienced | Learner | 0.29 | 0.18 | 0.24 | -0.14 | 0.72 |
| | | Experienced | -0.38 | 0.16 | 0.06 | -0.77 | 0.01 |
| | Experienced | Learner | 0.67 | 0.19 | **0.00** | 0.21 | 1.12 |
| | | Inexperienced | 0.38 | 0.16 | 0.06 | -0.01 | 0.77 |
| 5 | Learner | Inexperienced | -0.06 | 0.14 | 0.90 | -0.40 | 0.28 |
| | | Experienced | -0.47 | 0.14 | **0.00** | -0.80 | -0.14 |
| | Inexperienced | Learner | 0.06 | 0.14 | 0.90 | -0.28 | 0.40 |
| | | Experienced | -0.41 | 0.12 | **0.01** | -0.71 | -0.11 |
| | Experienced | Learner | 0.47 | 0.14 | **0.00** | 0.14 | 0.80 |
| | | Inexperienced | 0.41 | 0.12 | **0.01** | 0.11 | 0.71 |
| 6 | Learner | Inexperienced | -0.18 | 0.18 | 0.60 | -0.62 | 0.27 |
| | | Experienced | -0.58 | 0.17 | **0.01** | -1.01 | -0.16 |
| | Inexperienced | Learner | 0.18 | 0.18 | 0.60 | -0.27 | 0.62 |
| | | Experienced | -0.41 | 0.16 | **0.04** | -0.80 | -0.01 |
| | Experienced | Learner | 0.58 | 0.17 | **0.01** | 0.16 | 1.01 |
| | | Inexperienced | 0.41 | 0.16 | **0.04** | 0.01 | 0.80 |
| 7 | Learner | Inexperienced | 0.08 | 0.19 | 0.90 | -0.38 | 0.54 |
| | | Experienced | -0.43 | 0.19 | 0.07 | -0.89 | 0.03 |
| | Inexperienced | Learner | -0.08 | 0.19 | 0.90 | -0.54 | 0.38 |
| | | Experienced | -0.51 | 0.16 | **0.01** | -0.90 | -0.13 |
| | Experienced | Learner | 0.43 | 0.19 | 0.07 | -0.03 | 0.89 |
| | | Inexperienced | 0.51 | 0.16 | **0.01** | 0.13 | 0.90 |
| 10 | Learner | Inexperienced | 0.06 | 0.17 | 0.94 | -0.35 | 0.46 |
| | | Experienced | -0.26 | 0.17 | 0.29 | -0.66 | 0.15 |
| | Inexperienced | Learner | -0.06 | 0.17 | 0.94 | -0.46 | 0.35 |
| | | Experienced | -0.31 | 0.15 | 0.11 | -0.68 | 0.06 |
| | Experienced | Learner | 0.26 | 0.17 | 0.29 | -0.15 | 0.66 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Inexperienced | 0.31 | 0.15 | 0.11 | -0.06 | 0.68 |
| 11 | Learner | Inexperienced | -0.13 | 0.20 | 0.79 | -0.60 | 0.35 |
| | | Experienced | -0.37 | 0.19 | 0.13 | -0.84 | 0.09 |
| | Inexperienced | Learner | 0.13 | 0.20 | 0.79 | -0.35 | 0.60 |
| | | Experienced | -0.25 | 0.17 | 0.34 | -0.67 | 0.18 |
| | Experienced | Learner | 0.37 | 0.19 | 0.13 | -0.09 | 0.84 |
| | | Inexperienced | 0.25 | 0.17 | 0.34 | -0.18 | 0.67 |
| 12 | Learner | Inexperienced | -0.30 | 0.18 | 0.22 | -0.73 | 0.13 |
| | | Experienced | -0.62 | 0.18 | **0.00** | -1.06 | -0.19 |
| | Inexperienced | Learner | 0.30 | 0.18 | 0.22 | -0.13 | 0.73 |
| | | Experienced | -0.32 | 0.15 | 0.10 | -0.69 | 0.05 |
| | Experienced | Learner | 0.62 | 0.18 | **0.00** | 0.19 | 1.06 |
| | | Inexperienced | 0.32 | 0.15 | 0.10 | -0.05 | 0.69 |
| 13 | Learner | Inexperienced | 0.06 | 0.20 | 0.95 | -0.43 | 0.55 |
| | | Experienced | -0.25 | 0.20 | 0.43 | -0.74 | 0.24 |
| | Inexperienced | Learner | -0.06 | 0.20 | 0.95 | -0.55 | 0.43 |
| | | Experienced | -0.31 | 0.16 | 0.15 | -0.71 | 0.09 |
| | Experienced | Learner | 0.25 | 0.20 | 0.43 | -0.24 | 0.74 |
| | | Inexperienced | 0.31 | 0.16 | 0.15 | -0.09 | 0.71 |
| 15 | Learner | Inexperienced | -0.02 | 0.19 | 0.99 | -0.47 | 0.43 |
| | | Experienced | -0.35 | 0.19 | 0.16 | -0.81 | 0.11 |
| | Inexperienced | Learner | 0.02 | 0.19 | 0.99 | -0.43 | 0.47 |
| | | Experienced | -0.33 | 0.17 | 0.13 | -0.74 | 0.08 |
| | Experienced | Learner | 0.35 | 0.19 | 0.16 | -0.11 | 0.81 |
| | | Inexperienced | 0.33 | 0.17 | 0.13 | -0.08 | 0.74 |
| 16 | Learner | Inexperienced | 0.09 | 0.18 | 0.88 | -0.35 | 0.52 |
| | | Experienced | -0.37 | 0.18 | 0.10 | -0.80 | 0.05 |
| | Inexperienced | Learner | -0.09 | 0.18 | 0.88 | -0.52 | 0.35 |
| | | Experienced | -0.46 | 0.16 | **0.02** | -0.85 | -0.07 |
| | Experienced | Learner | 0.37 | 0.18 | 0.10 | -0.05 | 0.80 |
| | | Inexperienced | 0.46 | 0.16 | **0.02** | 0.07 | 0.85 |
| **Bold denotes significant at the .05 level** | | | | | | | |

# Appendix
# 6H

SPSS output: Anticipatory SCR peak to peak analysis

| Descriptives - Anticipatory Peak to Peak Comparison by Experience Group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Clip | | N | Mean | Std. Dev. | Std. Error | 95% Confidence Interval for Mean | | Min. | Max. |
| | | | | | | Lower Bound | Upper Bound | | |
| **1** | Learner | 10 | 0.09 | 0.20 | 0.06 | -0.05 | 0.23 | 0 | 0.61 |
| | Inexperienced | 17 | 0.16 | 0.34 | 0.08 | -0.01 | 0.34 | 0 | 1.23 |
| | Experienced | 16 | 0.19 | 0.34 | 0.09 | 0.01 | 0.37 | 0 | 1.30 |
| | Total | 43 | 0.16 | 0.31 | 0.05 | 0.06 | 0.25 | 0 | 1.30 |
| **2** | Learner | 10 | 0.22 | 0.34 | 0.11 | -0.02 | 0.47 | 0 | 0.83 |
| | Inexperienced | 17 | 0.57 | 0.79 | 0.19 | 0.16 | 0.98 | 0 | 2.81 |
| | Experienced | 17 | 0.75 | 0.83 | 0.20 | 0.33 | 1.18 | 0 | 3.42 |
| | Total | 44 | 0.56 | 0.74 | 0.11 | 0.33 | 0.79 | 0 | 3.42 |
| **3** | Learner | 10 | 0.01 | 0.02 | 0.01 | -0.01 | 0.02 | 0 | 0.07 |
| | Inexperienced | 18 | 0.36 | 0.61 | 0.14 | 0.06 | 0.67 | 0 | 1.91 |
| | Experienced | 13 | 0.27 | 0.36 | 0.10 | 0.05 | 0.49 | 0 | 1.28 |
| | Total | 41 | 0.25 | 0.47 | 0.07 | 0.10 | 0.40 | 0 | 1.91 |
| **5** | Learner | 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0.00 |
| | Inexperienced | 16 | 0.01 | 0.02 | 0.01 | -0.01 | 0.02 | 0 | 0.09 |
| | Experienced | 17 | 0.28 | 0.48 | 0.12 | 0.03 | 0.52 | 0 | 1.63 |
| | Total | 44 | 0.11 | 0.32 | 0.05 | 0.01 | 0.21 | 0 | 1.63 |
| **6** | Learner | 11 | 0.04 | 0.12 | 0.04 | -0.04 | 0.13 | 0 | 0.41 |
| | Inexperienced | 14 | 0.28 | 0.71 | 0.19 | -0.13 | 0.69 | 0 | 2.66 |
| | Experienced | 17 | 0.60 | 1.02 | 0.25 | 0.08 | 1.12 | 0 | 3.62 |
| | Total | 42 | 0.35 | 0.79 | 0.12 | 0.10 | 0.59 | 0 | 3.62 |
| **7** | Learner | 9 | 0.06 | 0.10 | 0.03 | -0.02 | 0.13 | 0 | 0.24 |
| | Inexperienced | 16 | 0.12 | 0.33 | 0.08 | -0.05 | 0.30 | 0 | 1.31 |
| | Experienced | 17 | 0.24 | 0.23 | 0.06 | 0.13 | 0.36 | 0 | 0.70 |
| | Total | 42 | 0.16 | 0.26 | 0.04 | 0.08 | 0.24 | 0 | 1.31 |
| **10** | Learner | 11 | 0.01 | 0.03 | 0.01 | -0.01 | 0.03 | 0 | 0.08 |
| | Inexperienced | 16 | 0.04 | 0.10 | 0.03 | -0.02 | 0.09 | 0 | 0.34 |
| | Experienced | 16 | 0.10 | 0.15 | 0.04 | 0.02 | 0.18 | 0 | 0.52 |
| | Total | 43 | 0.05 | 0.12 | 0.02 | 0.02 | 0.09 | 0 | 0.52 |
| **11** | Learner | 11 | 0.05 | 0.09 | 0.03 | -0.01 | 0.11 | 0 | 0.21 |
| | Inexperienced | 15 | 0.11 | 0.20 | 0.05 | 0.00 | 0.22 | 0 | 0.62 |
| | Experienced | 17 | 0.26 | 0.36 | 0.09 | 0.07 | 0.44 | 0 | 1.31 |
| | Total | 43 | 0.15 | 0.27 | 0.04 | 0.07 | 0.23 | 0 | 1.31 |
| **12** | Learner | 10 | 0.02 | 0.03 | 0.01 | -0.01 | 0.04 | 0 | 0.08 |
| | Inexperienced | 18 | 0.38 | 0.70 | 0.16 | 0.04 | 0.73 | 0 | 2.11 |
| | Experienced | 17 | 0.37 | 0.51 | 0.12 | 0.11 | 0.63 | 0 | 2.08 |
| | Total | 45 | 0.30 | 0.55 | 0.08 | 0.13 | 0.46 | 0 | 2.11 |
| **13** | Learner | 8 | 0.03 | 0.07 | 0.02 | -0.02 | 0.09 | 0 | 0.19 |
| | Inexperienced | 16 | 0.03 | 0.08 | 0.02 | -0.01 | 0.07 | 0 | 0.29 |
| | Experienced | 16 | 0.41 | 0.77 | 0.19 | 0.00 | 0.82 | 0 | 2.99 |
| | Total | 40 | 0.18 | 0.51 | 0.08 | 0.02 | 0.35 | 0 | 2.99 |
| **15** | Learner | 11 | 0.09 | 0.18 | 0.05 | -0.03 | 0.20 | 0 | 0.53 |
| | Inexperienced | 17 | 0.29 | 0.56 | 0.14 | 0.01 | 0.58 | 0 | 1.87 |
| | Experienced | 16 | 0.30 | 0.38 | 0.09 | 0.10 | 0.50 | 0 | 1.42 |
| | Total | 44 | 0.24 | 0.43 | 0.06 | 0.11 | 0.37 | 0 | 1.87 |
| **16** | Learner | 11 | 0.03 | 0.06 | 0.02 | -0.01 | 0.07 | 0 | 0.14 |
| | Inexperienced | 16 | 0.14 | 0.34 | 0.08 | -0.04 | 0.32 | 0 | 1.12 |
| | Experienced | 17 | 0.36 | 0.57 | 0.14 | 0.07 | 0.65 | 0 | 1.98 |
| | Total | 44 | 0.20 | 0.43 | 0.06 | 0.07 | 0.33 | 0 | 1.98 |

| ANOVA - Anticipatory Peak to Peak Comparison by Experience Group | | | | | | |
|---|---|---|---|---|---|---|
| | | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| **1** | Between Groups | 0.06 | 2 | 0.03 | 0.31 | 0.73 |
| | Within Groups | 3.95 | 40 | 0.10 | | |
| | Total | 4.01 | 42 | | | |
| **2** | Between Groups | 1.74 | 2 | 0.87 | 1.62 | 0.21 |
| | Within Groups | 22.06 | 41 | 0.54 | | |
| | Total | 23.81 | 43 | | | |
| **3** | Between Groups | 0.83 | 2 | 0.42 | 1.98 | 0.15 |
| | Within Groups | 8.00 | 38 | 0.21 | | |
| | Total | 8.84 | 40 | | | |
| **5** | Between Groups | 0.78 | 2 | 0.39 | 4.39 | 0.02 |
| | Within Groups | 3.64 | 41 | 0.09 | | |
| | Total | 4.42 | 43 | | | |
| **6** | Between Groups | 2.17 | 2 | 1.09 | 1.81 | 0.18 |
| | Within Groups | 23.38 | 39 | 0.60 | | |
| | Total | 25.55 | 41 | | | |
| **7** | Between Groups | 0.24 | 2 | 0.12 | 1.84 | 0.17 |
| | Within Groups | 2.55 | 39 | 0.07 | | |
| | Total | 2.79 | 41 | | | |
| **10** | Between Groups | 0.05 | 2 | 0.03 | 2.00 | 0.15 |
| | Within Groups | 0.51 | 40 | 0.01 | | |
| | Total | 0.56 | 42 | | | |
| **11** | Between Groups | 0.33 | 2 | 0.17 | 2.50 | 0.10 |
| | Within Groups | 2.67 | 40 | 0.07 | | |
| | Total | 3.00 | 42 | | | |
| **12** | Between Groups | 1.02 | 2 | 0.51 | 1.74 | 0.19 |
| | Within Groups | 12.33 | 42 | 0.29 | | |
| | Total | 13.36 | 44 | | | |
| **13** | Between Groups | 1.34 | 2 | 0.67 | 2.77 | 0.08 |
| | Within Groups | 8.97 | 37 | 0.24 | | |
| | Total | 10.31 | 39 | | | |
| **15** | Between Groups | 0.37 | 2 | 0.18 | 1.00 | 0.38 |
| | Within Groups | 7.51 | 41 | 0.18 | | |
| | Total | 7.88 | 43 | | | |
| **16** | Between Groups | 0.80 | 2 | 0.40 | 2.35 | 0.11 |
| | Within Groups | 6.98 | 41 | 0.17 | | |
| | Total | 7.78 | 43 | | | |

# Appendix 6I

SPSS output: Anticipatory SCR area analysis

| Descriptives - Anticipatory Area under SCR Comparison by Experience Group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | Mean | Std. Dev. | Std. Error | 95% Confidence Interval for Mean | | Min. | Max. |
| | | | | | | Lower Bound | Upper Bound | | |
| **1** | Learner | 10 | 0.12 | 0.23 | 0.07 | -0.05 | 0.28 | 0 | 0.70 |
| | Inexperienced | 17 | 0.26 | 0.58 | 0.14 | -0.04 | 0.56 | 0 | 2.20 |
| | Experienced | 16 | 0.32 | 0.53 | 0.13 | 0.04 | 0.60 | 0 | 1.68 |
| | Total | 43 | 0.25 | 0.50 | 0.08 | 0.10 | 0.40 | 0 | 2.20 |
| **2** | Learner | 10 | 0.39 | 0.59 | 0.19 | -0.03 | 0.81 | 0 | 1.55 |
| | Inexperienced | 17 | 1.00 | 1.62 | 0.39 | 0.16 | 1.83 | 0 | 6.22 |
| | Experienced | 17 | 1.35 | 1.30 | 0.32 | 0.68 | 2.02 | 0 | 4.02 |
| | Total | 44 | 1.00 | 1.35 | 0.20 | 0.58 | 1.41 | 0 | 6.22 |
| **3** | Learner | 10 | 0.01 | 0.02 | 0.01 | -0.01 | 0.02 | 0 | 0.07 |
| | Inexperienced | 18 | 0.43 | 0.66 | 0.16 | 0.10 | 0.75 | 0 | 1.92 |
| | Experienced | 13 | 0.37 | 0.40 | 0.11 | 0.12 | 0.61 | 0 | 1.46 |
| | Total | 41 | 0.31 | 0.51 | 0.08 | 0.14 | 0.47 | 0 | 1.92 |
| **5** | Learner | 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0.00 |
| | Inexperienced | 16 | 0.01 | 0.02 | 0.01 | -0.01 | 0.02 | 0 | 0.08 |
| | Experienced | 17 | 0.23 | 0.67 | 0.16 | -0.12 | 0.57 | 0 | 2.81 |
| | Total | 44 | 0.09 | 0.42 | 0.06 | -0.04 | 0.22 | 0 | 2.81 |
| **6** | Learner | 11 | 0.09 | 0.24 | 0.07 | -0.07 | 0.25 | 0 | 0.79 |
| | Inexperienced | 14 | 0.43 | 1.22 | 0.33 | -0.27 | 1.13 | 0 | 4.58 |
| | Experienced | 17 | 0.94 | 1.44 | 0.35 | 0.19 | 1.68 | 0 | 4.82 |
| | Total | 42 | 0.54 | 1.19 | 0.18 | 0.17 | 0.92 | 0 | 4.82 |
| **7** | Learner | 9 | 0.09 | 0.13 | 0.04 | -0.01 | 0.19 | 0 | 0.30 |
| | Inexperienced | 16 | 0.19 | 0.59 | 0.15 | -0.13 | 0.50 | 0 | 2.34 |
| | Experienced | 17 | 0.38 | 0.47 | 0.11 | 0.14 | 0.62 | 0 | 1.54 |
| | Total | 42 | 0.24 | 0.48 | 0.07 | 0.09 | 0.39 | 0 | 2.34 |
| **10** | Learner | 11 | 0.05 | 0.14 | 0.04 | -0.05 | 0.14 | 0 | 0.48 |
| | Inexperienced | 16 | 0.01 | 0.05 | 0.01 | -0.01 | 0.04 | 0 | 0.18 |
| | Experienced | 16 | 0.08 | 0.12 | 0.03 | 0.02 | 0.14 | 0 | 0.35 |
| | Total | 43 | 0.05 | 0.11 | 0.02 | 0.01 | 0.08 | 0 | 0.48 |
| **11** | Learner | 11 | 0.08 | 0.15 | 0.05 | -0.02 | 0.18 | 0 | 0.40 |
| | Inexperienced | 15 | 0.16 | 0.32 | 0.08 | -0.02 | 0.34 | 0 | 1.02 |
| | Experienced | 17 | 0.31 | 0.49 | 0.12 | 0.05 | 0.56 | 0 | 1.87 |
| | Total | 43 | 0.20 | 0.38 | 0.06 | 0.08 | 0.31 | 0 | 1.87 |
| **12** | Learner | 10 | 0.02 | 0.05 | 0.02 | -0.01 | 0.06 | 0 | 0.12 |
| | Inexperienced | 18 | 0.62 | 1.15 | 0.27 | 0.04 | 1.19 | 0 | 3.34 |
| | Experienced | 17 | 0.60 | 0.95 | 0.23 | 0.11 | 1.09 | 0 | 3.82 |
| | Total | 45 | 0.48 | 0.95 | 0.14 | 0.19 | 0.76 | 0 | 3.82 |
| **13** | Learner | 8 | 0.05 | 0.12 | 0.04 | -0.05 | 0.16 | 0 | 0.35 |
| | Inexperienced | 16 | 0.07 | 0.18 | 0.04 | -0.02 | 0.17 | 0 | 0.54 |
| | Experienced | 16 | 0.52 | 0.83 | 0.21 | 0.07 | 0.96 | 0 | 2.93 |
| | Total | 40 | 0.25 | 0.58 | 0.09 | 0.06 | 0.43 | 0 | 2.93 |
| **15** | Learner | 11 | 0.13 | 0.24 | 0.07 | -0.04 | 0.29 | 0 | 0.72 |
| | Inexperienced | 17 | 0.27 | 0.52 | 0.13 | 0.00 | 0.54 | 0 | 1.83 |
| | Experienced | 16 | 0.32 | 0.46 | 0.11 | 0.08 | 0.57 | 0 | 1.39 |
| | Total | 44 | 0.25 | 0.44 | 0.07 | 0.12 | 0.39 | 0 | 1.83 |
| **16** | Learner | 11 | 0.06 | 0.11 | 0.03 | -0.01 | 0.14 | 0 | 0.30 |
| | Inexperienced | 16 | 0.15 | 0.41 | 0.10 | -0.07 | 0.37 | 0 | 1.57 |
| | Experienced | 17 | 0.42 | 0.65 | 0.16 | 0.09 | 0.75 | 0 | 2.49 |
| | Total | 44 | 0.23 | 0.49 | 0.07 | 0.08 | 0.38 | 0 | 2.49 |

| ANOVA - Anticipatory Area under SCR Comparison by Experience Group | | | | | | |
|---|---|---|---|---|---|---|
| | | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
| **1** | Between Groups | 0.26 | 2 | 0.13 | 0.51 | 0.60 |
| | Within Groups | 10.05 | 40 | 0.25 | | |
| | Total | 10.31 | 42 | | | |
| **2** | Between Groups | 5.80 | 2 | 2.90 | 1.64 | 0.21 |
| | Within Groups | 72.51 | 41 | 1.77 | | |
| | Total | 78.31 | 43 | | | |
| **3** | Between Groups | 1.20 | 2 | 0.60 | 2.44 | 0.10 |
| | Within Groups | 9.38 | 38 | 0.25 | | |
| | Total | 10.59 | 40 | | | |
| **5** | Between Groups | 0.53 | 2 | 0.27 | 1.51 | 0.23 |
| | Within Groups | 7.22 | 41 | 0.18 | | |
| | Total | 7.75 | 43 | | | |
| **6** | Between Groups | 5.08 | 2 | 2.54 | 1.86 | 0.17 |
| | Within Groups | 53.10 | 39 | 1.36 | | |
| | Total | 58.18 | 41 | | | |
| **7** | Between Groups | 0.58 | 2 | 0.29 | 1.28 | 0.29 |
| | Within Groups | 8.76 | 39 | 0.22 | | |
| | Total | 9.33 | 41 | | | |
| **10** | Between Groups | 0.03 | 2 | 0.02 | 1.52 | 0.23 |
| | Within Groups | 0.45 | 40 | 0.01 | | |
| | Total | 0.49 | 42 | | | |
| **11** | Between Groups | 0.37 | 2 | 0.19 | 1.33 | 0.28 |
| | Within Groups | 5.57 | 40 | 0.14 | | |
| | Total | 5.94 | 42 | | | |
| **12** | Between Groups | 2.66 | 2 | 1.33 | 1.50 | 0.23 |
| | Within Groups | 37.17 | 42 | 0.88 | | |
| | Total | 39.83 | 44 | | | |
| **13** | Between Groups | 1.95 | 2 | 0.98 | 3.27 | 0.06 |
| | Within Groups | 11.03 | 37 | 0.30 | | |
| | Total | 12.99 | 39 | | | |
| **15** | Between Groups | 0.26 | 2 | 0.13 | 0.65 | 0.53 |
| | Within Groups | 8.15 | 41 | 0.20 | | |
| | Total | 8.41 | 43 | | | |
| **16** | Between Groups | 1.02 | 2 | 0.51 | 2.25 | 0.12 |
| | Within Groups | 9.31 | 41 | 0.23 | | |
| | Total | 10.34 | 43 | | | |

# Appendix 6J

SPSS output: Analysis of mean and peak to peak slider response by experience group per clip

**Analysis output of mean slider response in the anticipatory area by experience group (Learner, Inexperienced and Experienced) for each clip.**

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Clip 1 Anticipatory Slider Mean | Between Groups | 14.52 | 2 | 7.26 | 1.42 | 0.25 |
| | Within Groups | 234.59 | 46 | 5.10 | | |
| | Total | 249.10 | 48 | | | |
| Clip 2 Anticipatory Slider Mean | Between Groups | 1.49 | 2 | 0.74 | 0.16 | 0.85 |
| | Within Groups | 210.93 | 46 | 4.59 | | |
| | Total | 212.42 | 48 | | | |
| Clip 3 Anticipatory Slider Mean | Between Groups | 7.98 | 2 | 3.99 | 0.90 | 0.41 |
| | Within Groups | 203.65 | 46 | 4.43 | | |
| | Total | 211.63 | 48 | | | |
| Clip 5 Anticipatory Slider Mean | Between Groups | 9.52 | 2 | 4.76 | 0.79 | 0.46 |
| | Within Groups | 275.68 | 46 | 5.99 | | |
| | Total | 285.20 | 48 | | | |
| Clip 6 Anticipatory Slider Mean | Between Groups | 1.44 | 2 | 0.72 | 0.20 | 0.82 |
| | Within Groups | 167.94 | 46 | 3.65 | | |
| | Total | 169.39 | 48 | | | |
| Clip 7 Anticipatory Slider Mean | Between Groups | 3.15 | 2 | 1.57 | 0.31 | 0.74 |
| | Within Groups | 234.37 | 46 | 5.09 | | |
| | Total | 237.51 | 48 | | | |
| Clip 10 Anticipatory Slider Mean | Between Groups | 26.11 | 2 | 13.05 | 2.34 | 0.11 |
| | Within Groups | 251.20 | 45 | 5.58 | | |
| | Total | 277.30 | 47 | | | |
| Clip 11 Anticipatory Slider Mean | Between Groups | 0.62 | 2 | 0.31 | 0.07 | 0.93 |
| | Within Groups | 199.29 | 47 | 4.24 | | |
| | Total | 199.91 | 49 | | | |
| Clip 12 Anticipatory Slider Mean | Between Groups | 4.54 | 2 | 2.27 | 0.42 | 0.66 |
| | Within Groups | 251.82 | 47 | 5.36 | | |
| | Total | 256.36 | 49 | | | |
| Clip 13 Anticipatory Slider Mean | Between Groups | 4.54 | 2 | 2.27 | 0.69 | 0.51 |
| | Within Groups | 152.28 | 46 | 3.31 | | |
| | Total | 156.83 | 48 | | | |
| Clip 15 Anticipatory Slider Mean | Between Groups | 0.58 | 2 | 0.29 | 0.07 | 0.93 |
| | Within Groups | 196.67 | 46 | 4.28 | | |
| | Total | 197.25 | 48 | | | |
| Clip 16 Anticipatory Slider Mean | Between Groups | 4.78 | 2 | 2.39 | 0.58 | 0.56 |
| | Within Groups | 189.37 | 46 | 4.12 | | |
| | Total | 194.15 | 48 | | | |

**Analysis output of mean slider response in the event area by experience group (Learner, Inexperienced and Experienced) for each clip.**

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Clip 1 Hazard Slider Mean | Between Groups | 21.54 | 2 | 10.77 | 1.53 | 0.23 |
| | Within Groups | 324.01 | 46 | 7.04 | | |
| | Total | 345.55 | 48 | | | |
| Clip 2 Hazard Slider Mean | Between Groups | 37.45 | 2 | 18.73 | 3.01 | 0.06 |
| | Within Groups | 286.42 | 46 | 6.23 | | |
| | Total | 323.88 | 48 | | | |
| Clip 3 Hazard Slider Mean | Between Groups | 9.58 | 2 | 4.79 | 0.92 | 0.41 |
| | Within Groups | 239.49 | 46 | 5.21 | | |
| | Total | 249.07 | 48 | | | |
| Clip 5 Hazard Slider Mean | Between Groups | 0.15 | 2 | 0.07 | 0.01 | 0.99 |
| | Within Groups | 315.63 | 46 | 6.86 | | |
| | Total | 315.78 | 48 | | | |
| Clip 6 Hazard Slider Mean | Between Groups | 23.02 | 2 | 11.51 | 1.80 | 0.18 |
| | Within Groups | 293.77 | 46 | 6.39 | | |
| | Total | 316.79 | 48 | | | |
| Clip 7 Hazard Slider Mean | Between Groups | 9.47 | 2 | 4.74 | 0.73 | 0.49 |
| | Within Groups | 296.78 | 46 | 6.45 | | |
| | Total | 306.25 | 48 | | | |
| Clip 10 Hazard Slider Mean | Between Groups | 13.26 | 2 | 6.63 | 0.94 | 0.40 |
| | Within Groups | 317.24 | 45 | 7.05 | | |
| | Total | 330.50 | 47 | | | |
| Clip 11 Hazard Slider Mean | Between Groups | 10.26 | 2 | 5.13 | 0.98 | 0.38 |
| | Within Groups | 246.32 | 47 | 5.24 | | |
| | Total | 256.57 | 49 | | | |
| Clip 12 Hazard Slider Mean | Between Groups | 17.93 | 2 | 8.97 | 1.29 | 0.28 |
| | Within Groups | 326.31 | 47 | 6.94 | | |
| | Total | 344.25 | 49 | | | |
| Clip 13 Hazard Slider Mean | Between Groups | 15.59 | 2 | 7.80 | 1.33 | 0.27 |
| | Within Groups | 269.94 | 46 | 5.87 | | |
| | Total | 285.53 | 48 | | | |
| Clip 15 Hazard Slider Mean | Between Groups | 29.06 | 2 | 14.53 | 2.36 | 0.11 |
| | Within Groups | 283.60 | 46 | 6.17 | | |
| | Total | 312.66 | 48 | | | |
| Clip 16 Hazard Slider Mean | Between Groups | 5.88 | 2 | 2.94 | 0.56 | 0.58 |
| | Within Groups | 242.48 | 46 | 5.27 | | |
| | Total | 248.36 | 48 | | | |

**Analysis output of peak to peak slider response in the anticipatory area by experience group (Learner, Inexperienced and Experienced) for each clip.**

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Clip 1 Anticipatory Slider Peak to Peak | Between Groups | 1.25 | 2 | 0.62 | 0.22 | 0.80 |
| | Within Groups | 131.05 | 46 | 2.85 | | |
| | Total | 132.30 | 48 | | | |
| Clip 2 Anticipatory Slider Peak to Peak | Between Groups | 47.32 | 2 | 23.66 | 4.74 | **0.01** |
| | Within Groups | 229.39 | 46 | 4.99 | | |
| | Total | 276.70 | 48 | | | |
| Clip 3 Anticipatory Peak to Peak | Between Groups | 16.10 | 2 | 8.05 | 1.85 | 0.17 |
| | Within Groups | 199.90 | 46 | 4.35 | | |
| | Total | 216.00 | 48 | | | |
| Clip 5 Anticipatory Peak to Peak | Between Groups | 8.17 | 2 | 4.09 | 1.41 | 0.25 |
| | Within Groups | 133.43 | 46 | 2.90 | | |
| | Total | 141.60 | 48 | | | |
| Clip 6 Anticipatory Peak to Peak | Between Groups | 1.78 | 2 | 0.89 | 0.16 | 0.85 |
| | Within Groups | 257.02 | 46 | 5.59 | | |
| | Total | 258.80 | 48 | | | |
| Clip 7 Anticipatory Peak to Peak | Between Groups | 34.56 | 2 | 17.28 | 4.69 | **0.01** |
| | Within Groups | 169.54 | 46 | 3.69 | | |
| | Total | 204.10 | 48 | | | |
| Clip 10 Anticipatory Peak to Peak | Between Groups | 2.90 | 2 | 1.45 | 0.40 | 0.68 |
| | Within Groups | 165.16 | 45 | 3.67 | | |
| | Total | 168.06 | 47 | | | |
| Clip 11 Anticipatory Peak to Peak | Between Groups | 16.10 | 2 | 8.05 | 2.23 | 0.12 |
| | Within Groups | 169.64 | 47 | 3.61 | | |
| | Total | 185.74 | 49 | | | |
| Clip 12 Anticipatory Peak to Peak | Between Groups | 12.58 | 2 | 6.29 | 1.01 | 0.37 |
| | Within Groups | 292.48 | 47 | 6.22 | | |
| | Total | 305.06 | 49 | | | |
| Clip 13 Anticipatory Peak to Peak | Between Groups | 24.96 | 2 | 12.48 | 2.52 | 0.09 |
| | Within Groups | 227.38 | 46 | 4.94 | | |
| | Total | 252.34 | 48 | | | |
| Clip 15 Anticipatory Peak to Peak | Between Groups | 25.27 | 2 | 12.63 | 2.78 | 0.07 |
| | Within Groups | 208.88 | 46 | 4.54 | | |
| | Total | 234.15 | 48 | | | |
| Clip 16 Anticipatory Peak to Peak | Between Groups | 4.82 | 2 | 2.41 | 0.76 | 0.47 |
| | Within Groups | 145.24 | 46 | 3.16 | | |
| | Total | 150.07 | 48 | | | |

Post-hoc Tukey analysis

**Multiple Comparisons**

Tukey HSD

| Clip | Participant Group | Participant Group Comparison | Mean Difference | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| 1 | Learner | Inexperienced | -0.41 | 0.63 | 0.79 | -1.94 | 1.11 |
| | | Experienced | -0.25 | 0.65 | 0.92 | -1.83 | 1.33 |
| | Inexperienced | Learner | 0.41 | 0.63 | 0.79 | -1.11 | 1.94 |
| | | Experienced | 0.17 | 0.55 | 0.95 | -1.17 | 1.50 |
| | Experienced | Learner | 0.25 | 0.65 | 0.92 | -1.33 | 1.83 |
| | | Inexperienced | -0.17 | 0.55 | 0.95 | -1.50 | 1.17 |
| 2 | Learner | Inexperienced | -2.49 | 0.83 | **0.01** | -4.50 | -0.47 |
| | | Experienced | -1.14 | 0.86 | 0.39 | -3.23 | 0.95 |
| | Inexperienced | Learner | 2.49 | 0.83 | **0.01** | 0.47 | 4.50 |
| | | Experienced | 1.35 | 0.73 | 0.17 | -0.42 | 3.11 |
| | Experienced | Learner | 1.14 | 0.86 | 0.39 | -0.95 | 3.23 |
| | | Inexperienced | -1.35 | 0.73 | 0.17 | -3.11 | 0.42 |
| 3 | Learner | Inexperienced | -0.26 | 0.78 | 0.94 | -2.14 | 1.61 |
| | | Experienced | 1.01 | 0.81 | 0.43 | -0.94 | 2.97 |
| | Inexperienced | Learner | 0.26 | 0.78 | 0.94 | -1.61 | 2.14 |
| | | Experienced | 1.28 | 0.68 | 0.16 | -0.37 | 2.92 |
| | Experienced | Learner | -1.01 | 0.81 | 0.43 | -2.97 | 0.94 |
| | | Inexperienced | -1.28 | 0.68 | 0.16 | -2.92 | 0.37 |
| 5 | Learner | Inexperienced | -0.43 | 0.63 | 0.78 | -1.96 | 1.11 |
| | | Experienced | -1.07 | 0.66 | 0.25 | -2.66 | 0.53 |
| | Inexperienced | Learner | 0.43 | 0.63 | 0.78 | -1.11 | 1.96 |
| | | Experienced | -0.64 | 0.56 | 0.49 | -1.99 | 0.71 |
| | Experienced | Learner | 1.07 | 0.66 | 0.25 | -0.53 | 2.66 |
| | | Inexperienced | 0.64 | 0.56 | 0.49 | -0.71 | 1.99 |
| 6 | Learner | Inexperienced | -0.39 | 0.88 | 0.90 | -2.52 | 1.74 |
| | | Experienced | -0.01 | 0.91 | 1.00 | -2.23 | 2.20 |
| | Inexperienced | Learner | 0.39 | 0.88 | 0.90 | -1.74 | 2.52 |
| | | Experienced | 0.38 | 0.77 | 0.87 | -1.49 | 2.25 |
| | Experienced | Learner | 0.01 | 0.91 | 1.00 | -2.20 | 2.23 |
| | | Inexperienced | -0.38 | 0.77 | 0.87 | -2.25 | 1.49 |
| 7 | Learner | Inexperienced | -1.96 | 0.71 | **0.02** | -3.69 | -0.23 |
| | | Experienced | -0.50 | 0.74 | 0.78 | -2.30 | 1.30 |
| | Inexperienced | Learner | 1.96 | 0.71 | **0.02** | 0.23 | 3.69 |
| | | Experienced | 1.46 | 0.63 | 0.06 | -0.06 | 2.98 |
| | Experienced | Learner | 0.50 | 0.74 | 0.78 | -1.30 | 2.30 |
| | | Inexperienced | -1.46 | 0.63 | 0.06 | -2.98 | 0.06 |
| 10 | Learner | Inexperienced | -0.27 | 0.71 | 0.93 | -2.00 | 1.46 |
| | | Experienced | 0.30 | 0.75 | 0.92 | -1.52 | 2.12 |
| | Inexperienced | Learner | 0.27 | 0.71 | 0.93 | -1.46 | 2.00 |
| | | Experienced | 0.56 | 0.64 | 0.65 | -0.98 | 2.11 |
| | Experienced | Learner | -0.30 | 0.75 | 0.92 | -2.12 | 1.52 |
| | | Inexperienced | -0.56 | 0.64 | 0.65 | -2.11 | 0.98 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | Learner | Inexperienced | -0.45 | 0.71 | 0.80 | -2.17 | 1.26 |
| | | Experienced | 0.83 | 0.73 | 0.49 | -0.93 | 2.59 |
| | Inexperienced | Learner | 0.45 | 0.71 | 0.80 | -1.26 | 2.17 |
| | | Experienced | 1.28 | 0.61 | 0.10 | -0.19 | 2.76 |
| | Experienced | Learner | -0.83 | 0.73 | 0.49 | -2.59 | 0.93 |
| | | Inexperienced | -1.28 | 0.61 | 0.10 | -2.76 | 0.19 |
| 12 | Learner | Inexperienced | -0.28 | 0.93 | 0.95 | -2.52 | 1.97 |
| | | Experienced | 0.84 | 0.95 | 0.66 | -1.47 | 3.15 |
| | Inexperienced | Learner | 0.28 | 0.93 | 0.95 | -1.97 | 2.52 |
| | | Experienced | 1.12 | 0.80 | 0.35 | -0.82 | 3.06 |
| | Experienced | Learner | -0.84 | 0.95 | 0.66 | -3.15 | 1.47 |
| | | Inexperienced | -1.12 | 0.80 | 0.35 | -3.06 | 0.82 |
| 13 | Learner | Inexperienced | -1.47 | 0.83 | 0.19 | -3.48 | 0.53 |
| | | Experienced | -0.05 | 0.86 | 1.00 | -2.13 | 2.03 |
| | Inexperienced | Learner | 1.47 | 0.83 | 0.19 | -0.53 | 3.48 |
| | | Experienced | 1.42 | 0.73 | 0.13 | -0.34 | 3.18 |
| | Experienced | Learner | 0.05 | 0.86 | 1.00 | -2.03 | 2.13 |
| | | Inexperienced | -1.42 | 0.73 | 0.13 | -3.18 | 0.34 |
| 15 | Learner | Inexperienced | -1.45 | 0.79 | 0.17 | -3.37 | 0.47 |
| | | Experienced | 0.00 | 0.82 | 1.00 | -2.00 | 1.99 |
| | Inexperienced | Learner | 1.45 | 0.79 | 0.17 | -0.47 | 3.37 |
| | | Experienced | 1.45 | 0.70 | 0.10 | -0.23 | 3.13 |
| | Experienced | Learner | 0.00 | 0.82 | 1.00 | -1.99 | 2.00 |
| | | Inexperienced | -1.45 | 0.70 | 0.10 | -3.13 | 0.23 |
| 16 | Learner | Inexperienced | 0.32 | 0.66 | 0.88 | -1.28 | 1.92 |
| | | Experienced | 0.82 | 0.69 | 0.47 | -0.85 | 2.48 |
| | Inexperienced | Learner | -0.32 | 0.66 | 0.88 | -1.92 | 1.28 |
| | | Experienced | 0.50 | 0.58 | 0.67 | -0.91 | 1.90 |
| | Experienced | Learner | -0.82 | 0.69 | 0.47 | -2.48 | 0.85 |
| | | Inexperienced | -0.50 | 0.58 | 0.67 | -1.90 | 0.91 |
| **Bold denotes significant at the .05 level** | | | | | | | |

**Analysis output of peak to peak slider response in the event area by experience group (Learner, Inexperienced and Experienced) for each clip.**

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Clip 1 Hazard Slider Peak to Peak | Between Groups | 2.81 | 2 | 1.40 | 0.72 | 0.49 |
| | Within Groups | 89.77 | 46 | 1.95 | | |
| | Total | 92.58 | 48 | | | |
| Clip 2 Hazard Slider Peak to Peak | Between Groups | 1.81 | 2 | 0.91 | 0.55 | 0.58 |
| | Within Groups | 75.90 | 46 | 1.65 | | |
| | Total | 77.72 | 48 | | | |
| Clip 3 Hazard Peak to Peak | Between Groups | 1.21 | 2 | 0.60 | 0.12 | 0.89 |
| | Within Groups | 235.36 | 46 | 5.12 | | |
| | Total | 236.57 | 48 | | | |
| Clip 5 Hazard Peak to Peak | Between Groups | 9.24 | 2 | 4.62 | 2.22 | 0.12 |
| | Within Groups | 95.57 | 46 | 2.08 | | |
| | Total | 104.81 | 48 | | | |
| Clip 6 Hazard Peak to Peak | Between Groups | 22.58 | 2 | 11.29 | 3.30 | 0.06 |
| | Within Groups | 157.16 | 46 | 3.42 | | |
| | Total | 179.74 | 48 | | | |
| Clip 7 Hazard Peak to Peak | Between Groups | 4.48 | 2 | 2.24 | 1.10 | 0.34 |
| | Within Groups | 93.98 | 46 | 2.04 | | |
| | Total | 98.46 | 48 | | | |
| Clip 10 Hazard Peak to Peak | Between Groups | 22.14 | 2 | 11.07 | 6.82 | **0.00** |
| | Within Groups | 73.00 | 45 | 1.62 | | |
| | Total | 95.15 | 47 | | | |
| Clip 11 Hazard Peak to Peak | Between Groups | 3.88 | 2 | 1.94 | 1.08 | 0.35 |
| | Within Groups | 84.47 | 47 | 1.80 | | |
| | Total | 88.34 | 49 | | | |
| Clip 12 Hazard Peak to Peak | Between Groups | 7.32 | 2 | 3.66 | 0.94 | 0.40 |
| | Within Groups | 182.54 | 47 | 3.88 | | |
| | Total | 189.87 | 49 | | | |
| Clip 13 Hazard Peak to Peak | Between Groups | 4.32 | 2 | 2.16 | 0.66 | 0.52 |
| | Within Groups | 151.38 | 46 | 3.29 | | |
| | Total | 155.71 | 48 | | | |
| Clip 15 Hazard Peak to Peak | Between Groups | 1.29 | 2 | 0.65 | 0.67 | 0.51 |
| | Within Groups | 44.21 | 46 | 0.96 | | |
| | Total | 45.50 | 48 | | | |
| Clip 16 Hazard Peak to Peak | Between Groups | 37.02 | 2 | 18.51 | 4.25 | **0.02** |
| | Within Groups | 200.26 | 46 | 4.35 | | |
| | Total | 237.28 | 48 | | | |

Post-hoc Tukey analysis

**Multiple Comparisons**

Tukey HSD

| Clip | Participant Group | Participant Group Comparison | Mean Difference | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| 1 | Learner | Inexperienced | -0.30 | 0.52 | 0.83 | -1.56 | 0.96 |
| | | Experienced | 0.24 | 0.54 | 0.89 | -1.06 | 1.55 |
| | Inexperienced | Learner | 0.30 | 0.52 | 0.83 | -0.96 | 1.56 |
| | | Experienced | 0.54 | 0.46 | 0.46 | -0.56 | 1.65 |
| | Experienced | Learner | -0.24 | 0.54 | 0.89 | -1.55 | 1.06 |
| | | Inexperienced | -0.54 | 0.46 | 0.46 | -1.65 | 0.56 |
| 2 | Learner | Inexperienced | -0.32 | 0.48 | 0.79 | -1.48 | 0.84 |
| | | Experienced | -0.52 | 0.50 | 0.55 | -1.72 | 0.68 |
| | Inexperienced | Learner | 0.32 | 0.48 | 0.79 | -0.84 | 1.48 |
| | | Experienced | -0.20 | 0.42 | 0.88 | -1.22 | 0.81 |
| | Experienced | Learner | 0.52 | 0.50 | 0.55 | -0.68 | 1.72 |
| | | Inexperienced | 0.20 | 0.42 | 0.88 | -0.81 | 1.22 |
| 3 | Learner | Inexperienced | -0.34 | 0.84 | 0.91 | -2.38 | 1.70 |
| | | Experienced | -0.41 | 0.88 | 0.89 | -2.53 | 1.71 |
| | Inexperienced | Learner | 0.34 | 0.84 | 0.91 | -1.70 | 2.38 |
| | | Experienced | -0.07 | 0.74 | 1.00 | -1.85 | 1.72 |
| | Experienced | Learner | 0.41 | 0.88 | 0.89 | -1.71 | 2.53 |
| | | Inexperienced | 0.07 | 0.74 | 1.00 | -1.72 | 1.85 |
| 5 | Learner | Inexperienced | -1.13 | 0.54 | 0.10 | -2.43 | 0.17 |
| | | Experienced | -0.78 | 0.56 | 0.35 | -2.13 | 0.57 |
| | Inexperienced | Learner | 1.13 | 0.54 | 0.10 | -0.17 | 2.43 |
| | | Experienced | 0.35 | 0.47 | 0.74 | -0.79 | 1.49 |
| | Experienced | Learner | 0.78 | 0.56 | 0.35 | -0.57 | 2.13 |
| | | Inexperienced | -0.35 | 0.47 | 0.74 | -1.49 | 0.79 |
| 6 | Learner | Inexperienced | -1.53 | 0.69 | 0.08 | -3.19 | 0.14 |
| | | Experienced | -0.28 | 0.72 | 0.92 | -2.01 | 1.45 |
| | Inexperienced | Learner | 1.53 | 0.69 | 0.08 | -0.14 | 3.19 |
| | | Experienced | 1.25 | 0.60 | 0.11 | -0.21 | 2.71 |
| | Experienced | Learner | 0.28 | 0.72 | 0.92 | -1.45 | 2.01 |
| | | Inexperienced | -1.25 | 0.60 | 0.11 | -2.71 | 0.21 |
| 7 | Learner | Inexperienced | -0.48 | 0.53 | 0.64 | -1.77 | 0.81 |
| | | Experienced | 0.19 | 0.55 | 0.94 | -1.15 | 1.53 |
| | Inexperienced | Learner | 0.48 | 0.53 | 0.64 | -0.81 | 1.77 |
| | | Experienced | 0.67 | 0.47 | 0.33 | -0.46 | 1.80 |
| | Experienced | Learner | -0.19 | 0.55 | 0.94 | -1.53 | 1.15 |
| | | Inexperienced | -0.67 | 0.47 | 0.33 | -1.80 | 0.46 |
| 10 | Learner | Inexperienced | -1.44 | 0.47 | **0.01** | -2.59 | -0.29 |
| | | Experienced | -0.12 | 0.50 | 0.97 | -1.33 | 1.09 |
| | Inexperienced | Learner | 1.44 | 0.47 | **0.01** | 0.29 | 2.59 |
| | | Experienced | 1.32 | 0.42 | **0.01** | 0.29 | 2.34 |
| | Experienced | Learner | 0.12 | 0.50 | 0.97 | -1.09 | 1.33 |
| | | Inexperienced | -1.32 | 0.42 | **0.01** | -2.34 | -0.29 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | Learner | Inexperienced | -0.60 | 0.50 | 0.46 | -1.80 | 0.61 |
| | | Experienced | -0.05 | 0.51 | 0.99 | -1.30 | 1.19 |
| | Inexperienced | Learner | 0.60 | 0.50 | 0.46 | -0.61 | 1.80 |
| | | Experienced | 0.54 | 0.43 | 0.43 | -0.50 | 1.58 |
| | Experienced | Learner | 0.05 | 0.51 | 0.99 | -1.19 | 1.30 |
| | | Inexperienced | -0.54 | 0.43 | 0.43 | -1.58 | 0.50 |
| 12 | Learner | Inexperienced | -0.99 | 0.73 | 0.38 | -2.76 | 0.79 |
| | | Experienced | -0.50 | 0.75 | 0.78 | -2.33 | 1.32 |
| | Inexperienced | Learner | 0.99 | 0.73 | 0.38 | -0.79 | 2.76 |
| | | Experienced | 0.49 | 0.63 | 0.72 | -1.04 | 2.02 |
| | Experienced | Learner | 0.50 | 0.75 | 0.78 | -1.32 | 2.33 |
| | | Inexperienced | -0.49 | 0.63 | 0.72 | -2.02 | 1.04 |
| 13 | Learner | Inexperienced | -0.74 | 0.68 | 0.52 | -2.37 | 0.90 |
| | | Experienced | -0.67 | 0.70 | 0.61 | -2.37 | 1.03 |
| | Inexperienced | Learner | 0.74 | 0.68 | 0.52 | -0.90 | 2.37 |
| | | Experienced | 0.07 | 0.59 | 0.99 | -1.37 | 1.50 |
| | Experienced | Learner | 0.67 | 0.70 | 0.61 | -1.03 | 2.37 |
| | | Inexperienced | -0.07 | 0.59 | 0.99 | -1.50 | 1.37 |
| 15 | Learner | Inexperienced | -0.37 | 0.36 | 0.57 | -1.25 | 0.51 |
| | | Experienced | -0.08 | 0.38 | 0.98 | -0.99 | 0.84 |
| | Inexperienced | Learner | 0.37 | 0.36 | 0.57 | -0.51 | 1.25 |
| | | Experienced | 0.29 | 0.32 | 0.63 | -0.48 | 1.07 |
| | Experienced | Learner | 0.08 | 0.38 | 0.98 | -0.84 | 0.99 |
| | | Inexperienced | -0.29 | 0.32 | 0.63 | -1.07 | 0.48 |
| 16 | Learner | Inexperienced | -2.10 | 0.78 | **0.03** | -3.98 | -0.22 |
| | | Experienced | -0.69 | 0.81 | 0.67 | -2.64 | 1.27 |
| | Inexperienced | Learner | 2.10 | 0.78 | **0.03** | 0.22 | 3.98 |
| | | Experienced | 1.41 | 0.68 | 0.11 | -0.24 | 3.06 |
| | Experienced | Learner | 0.69 | 0.81 | 0.67 | -1.27 | 2.64 |
| | | Inexperienced | -1.41 | 0.68 | 0.11 | -3.06 | 0.24 |
| **Bold denotes significant at the .05 level** | | | | | | | |