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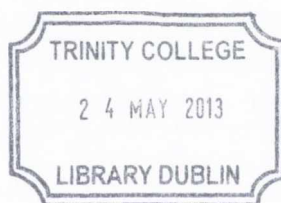
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The Contribution of Cognitive Control and Perceptions of Risk to Problematic Driving Among Young Adults

A thesis submitted to
The University of Dublin, Trinity College
for the degree of
Doctor of Philosophy

Fearghal O'Brien
School of Psychology
University of Dublin, Trinity College

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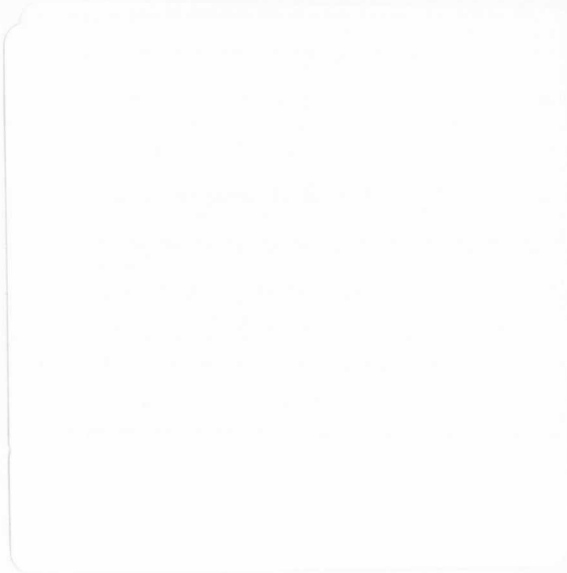


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Summary

Every year, millions of drivers throughout the world lose their lives in traffic incidents and young drivers make up a disproportionate number of those killed on the road. There has been no shortage of explanations for these high rates though an increasingly popular explanation points to the underdeveloped brains of young people which lead them to engage in greater risks. Laurence Steinberg has developed the most comprehensive of such theories claiming that young people are higher risk takers because their underdeveloped neural systems lead them to lack sufficient cognitive control. The assumption of many of these theories is that young people appreciate the risks of their behaviour and that less time should be spent trying to increase their awareness of the risks. This thesis aims to test both the hypothesis that cognitive control underlies problematic driving among young people and the hypothesis that young people do understand the risks of dangerous driving.

Chapter 1 reviews the literature relating to problematic driving among young people and compares this behaviour with other risk taking behaviours among this age group. A number of categories of theories were explored which may explain increased risk-taking in this age group. Rational theories (such as the theory of planned behaviour) suggest that risk taking results from a lack of understanding of the risks while dual process theories emphasise the reactive nature of decision making in emotional situations. Developmental theories describe risk-taking in this age group as the result of biological factors such as the differential development of separate brain systems. Developmental theories have received much less attention in the literature.

Chapter 2 seeks to investigate the relationship between problematic driving and impulsivity for young drivers (aged 17-21). It consists of a large online survey that investigated the relationship between psychometric measures of impulsivity, the Barratt Impulsiveness Scale (BIS) and self-reported violations; a subscale of the Driver Behaviour Questionnaire (DBQ). All of the subscales of the BIS were found to have a positive relationship with violations suggesting that more impulsive individuals committed more violations.

Chapter 3 details the selection of participants from the online survey who indicated a particularly small number of violations or a particularly large number. The performance of these participants was compared on a number of reaction-time tasks,

such as the Go/NoGo and Stop-Signal Tasks, performance in which has been associated with neurological areas thought to be still developing for young people. The problematic and non-problematic groups had almost identical results on these tasks.

Chapter 4 details two studies which addressed issues of the identification of dangerous drivers. In study 2 above, the DBQ was used to identify problematic drivers. Study 3 presents the results of a confirmatory factor analysis of this scale to determine if its factor structure held for young drivers. The results were in line with previous estimates which found a moderately good fit for the structure, though not a particularly strong one. Study 4 was a replication of study 2 except that it did not rely on self-report measures to identify problematic drivers. Problematic drivers were young people who were attending a driving course having been apprehended for speeding by the police. In this study, offending drivers performed worse on the Go/NoGo task but not on any other measures. On the Go/NoGo task, offenders made more commission errors (indicative of poor inhibitory abilities) while they also responded faster to trials.

Chapter 5 details the results of two studies which focused on young people's understanding of the risks and benefits associated with dangerous driving and the accessibility of their risk and benefit attitudes. Study 5 revealed that problematic young drivers rated dangerous driving as being less risky than their less problematic peers but that the latter group did rate their chances of being in an accident as higher. A much greater difference between the groups was found for perception of benefits with problematic drivers rating dangerous driving as being much more beneficial than non-problematic drivers. Study 6 found that even when non-problematic drivers did endorse a benefit of speeding, problematic drivers were much faster at indicating their agreement with this benefit. This was interpreted as indicating that problematic drivers had a greater accessibility to positive speeding attitudes.

Chapter 6 presents a discussion of the findings of the thesis and assesses the relevance of developmental theories for explaining dangerous driving among young people. The results do add some support to development theories such as Steinberg's, though a number of outcomes were not as would be predicted by the theory. The relevance of these findings for driving interventions and for differences in problematic driving between males and females is also discussed.

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Publications arising from the present work

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Chapter 1: Introduction

Around the world driving represents an unfortunate paradox. Cars and other forms of motor vehicles have given us historically unparalleled freedom and have had a remarkable economic and cultural influence since their mass production began in the early twentieth century. However, these benefits have been at the cost of fatalities and injuries of a truly staggering proportion. Though there is huge variation in the number of traffic-related fatalities across the world, in almost every country road deaths represent a massive public health issue. The World Health Organisation estimates that about 1.2 million people die every year in road traffic accidents which amounts to about one death every 25 seconds. An interesting distinction can be found between developed and developing countries in terms of both the nature and number of road traffic accidents. Amazingly, over 90% of road traffic fatalities occur in low and middle-income countries despite the fact that high-income countries have more than half the world's registered vehicles. Furthermore, while the majority of road deaths in high-income countries occur for car occupants, about 70% of road deaths in developing countries are made up of pedestrians, cyclists and motorcyclists (WHO, 2009).

Throughout the developed world one of the most consistent patterns is the number of young drivers who are killed and injured on roads every year. In absolute figures, young drivers are generally not the most frequent victims of road traffic accidents. However, when considered in terms of accidents per number of licensed drivers, young drivers are massively overrepresented in crash statistics. In the US, the National Highway Traffic Safety Administration (NHTSA) reports that in 2009, drivers aged 16-20 had the highest involvement rate in fatal crashes with 39.12 licensed drivers per 100,000 killed while driving (2010). This number drops to 32.71 for the next age group (21- 24 year-old drivers) and drops much further to 23.7 for 25-34 year-olds. This same trend can be seen for crashes that involved injury with almost 3% of all young drivers (16-20) suffering some kind of injury. In absolute terms, over 5,000 young drivers were killed and just fewer than 370,000 injured in one year alone in the US. In fact, about 10% of drivers aged 16-20 are involved in some sort of crash compared with 5% of 25-34 year olds.

These figures are not unique to the US; similar patterns are found across most OECD¹ countries (OECD, 2006). It's estimated that about 35% of all deaths for young people (15-24) in OECD countries are traffic related and that this amounts to about 25,000 people a year. As a proportion of their representation in the population, drivers aged 18-20 had the highest fatality rate in a number of (mostly European) OECD countries in 2004, and this rate decreased for each subsequent age group. Ireland certainly conforms to these general trends with young people over-represented in crash statistics every year. For 2008, the Central Statistics Office (CSO) estimated that there were almost 2.8 million licensed drivers in Ireland and that about 6.5% of these were aged 20 years or younger. However, of the 110 car drivers killed in road accidents, almost 14% of these were young drivers and a similar proportion of young drivers were injured in traffic accidents that year. The high rate of accident involvement among young people is not just observed in the western world. The International Association of Traffic and Safety Sciences compared different age groups in Japan in 2007 in terms of number of accidents. Drivers aged 16-19 years had 272 accidents for every 10,000 licence holders while those aged 25-29 had about 113 (IATSS, 2008).

Another common trend in almost every country is the difference between males and females in terms of crash risk. In Ireland, male drivers are almost three times as likely as females to be killed in road traffic accidents (CSO, 2009). Similar statistics arise in the US with ~33,000 male driver deaths in 2009 compared with ~12,000 females drivers (NHTSA, 2010). Among these stark differences in gender representation, two interesting observations can be made. Firstly, the differences between the genders are greatest when considering fatal injuries. However, in terms of crashes that result in injury, the differences are much less. According to the NHTSA, 1.5 million males in the US were involved in a crash that resulted in injury to the driver themselves compared with over 1.2 million female drivers. In Ireland, women drivers are actually involved in proportionately more accidents that result in driver injury (CSO, 2009).

The second interesting observation relates to the similarities in the proportion of fatal road accidents for male and female drivers across the different age groups. Comparisons of this kind are difficult to make for Irish drivers given the lack of females drivers involved in fatal car accidents each year. However, owing to its larger population,

¹ The Organisation for Economic Co-operation and Development consists of 34 "advanced and emerging" countries.

figures from the US reveal an interesting trend. The proportion of males to females remains relatively constant across the different age groups and the smallest difference is actually found for 16-20 year old drivers (see Table 1.1). However, a chi square analysis of the number of fatal crashes for male and female drivers finds that the differences are not statistically different across age groups. Consequently, while young males are proportionately involved in more fatal accidents than any other group in most western countries, their fatality rates as drivers, compared with female drivers, are no greater than what would be expected given the differences between the genders in all other age groups. However, in a study that focused on injury rates rather than fatalities, Tavis, Kuhn, and Layde (2001) found that young males had a much higher injury rate due to loss of control accidents than young females. This difference gradually decreased up until about 60 years of age. Despite these differences, the young male and female drivers in their study had almost identical rates of crashes with other vehicles.

Table 1.1. *Rates of fatal accidents among male and female drivers in different age groups in the USA in 2009 (NHTSA, 2010)*

Age	Males	Females
16-20	53.46 ¹	24.12
21-24	48.93	16.24
25-34	35	12.43
35-44	30.24	10.33

¹ Figures given are driver involvement rates per 100,000 licensed drivers in each category.

The above findings all relate to traffic incidents in the developed world. As noted above, accidents are far more frequent in lower income countries. Unfortunately, comparisons between the impact of age in high- and low/middle-income countries are difficult to make due to the relative lack of reliable statistics for developing countries. While developed countries quite meticulously document almost all serious road incidents and generally produce yearly reports, rich accident information is often unavailable in developing countries. What does emerge from some of the research is that the profile of those involved in fatal accidents is quite different. For example, in South Africa (considered a middle-income country by the WHO (2009)), 15-25 year olds had one of the

smallest rates of death (relative to number their population size) in road traffic accidents (SSA, 2009). However, the WHO reports that 25% of those killed in road traffic accidents in South Africa were drivers of 4-wheel vehicles compared with 51% in the US, while about 40% of deaths in South Africa were pedestrians compared with just 11% in the US. The types of accidents that lead to deaths on the roads in low and middle income countries appear to be quite different and, consequently, the profile of those individuals involved in these incidents is likely to differ as well. It is thus difficult to determine if young drivers are as risk-prone a group in these countries as they are in developed ones.

There are really only three logical reasons underlying the different crash statistics of younger and older drivers and these will be referred to as driving conditions, driving skill and driving style. Driving conditions refers to the circumstances in which an individual is driving. This covers a number of factors from the time of day, the type of car, the purpose of the trip, the type of roads, the condition of the driver (are they fatigued or drunk?) and, for the present discussion, amount of time spent on the road will also be considered under this category. It could be the case that young drivers frequently drive under different conditions compared to other drivers. Driving skill is another possible explanation given that young drivers are much more likely to have less experience than their older counterparts. The final explanation for the over representation of young people in road accidents is that their driving style differs; specifically that young people are more likely to drive in a risky manner. Driving skill and style will be discussed in the same section as the distinction between the two is not always easy to make; an issue that will be discussed in greater detail in section 1.2 .

1.1 Driving Conditions

In order to understand if different driving conditions may explain the rate of crash incidents among young people, it is first necessary to identify those conditions that have been found to influence crash risk. The potential conditions that will be investigated are type of car, time of day, mileage, seatbelt use, passengers, fatigue and drink-driving. The contribution of these factors will be discussed individually along with their potential role in the young driver problem. It may seem unusual for drink-driving to be listed as a “condition” rather than as a “behaviour” given that it is generally included in the latter category. While it is true that the entire process of drink-driving is a choice behaviour,

even if an element of addiction is involved, the “behaviour” category in the present discussion refers to the specific way that an individual generally drives incorporating things such as speeding, aggressiveness and disregard of road laws. Consequently, for the purpose of classification, alcohol is grouped with situational factors rather than behavioural ones.

1.1.1 Car size

When a collision occurs, the types of cars involved can have a huge impact on the outcome for the drivers involved. Broughton (2008) divided cars into six different sizes and compared the number of drivers killed in the UK in all combinations of accidents. He found that there was a pronounced asymmetry in the number of fatalities when cars of different sizes crashed. For example, from 2001 to 2005, in all accidents that involved a mini/supermini car and a small saloon², 91 drivers of small saloon cars died compared with 211 drivers of minis. Broughton points out that these findings are not altogether surprising considering that the laws of physics tell us that for collisions involving objects of different mass, the smaller object will decelerate faster. Interestingly, Broughton also found that the asymmetric risk between drivers in different size cars was greatest on non-built-up roads compared with built-up ones. He suggests that it is the higher speeds involved on built-up roads that reduces the relative safety of larger vehicles as any crash has a higher risk of being fatal when the speeds are high. Trowbridge, McKay, and Maio (2007) found these same trends in the US for teenage drivers. Young SUV drivers were less likely to be in a fatal collision compared with those driving regular passenger vehicles.

It could well be the case that younger people on average drive smaller cars; however, figures for overall car ownership of different age groups are not well known. However, less direct research can be used to determine if car type plays a role in the young driver problem. Fu, Ahern, and Kelly (2011) found that, in Ireland, disposable income was one of the most important deciding factors in what size engine car to purchase. It's estimated that the two age groups with the lowest median income (before tax) in the UK are under 20s and 20-24 (HMRC, 2012). Given these separate findings, it seems reasonable to conclude that younger drivers may very well be more likely to have smaller, and less safe, cars than older drivers.

² Broughton states that Minis/Sumpermins includes cars such as Austin/Rover Metro, Ford Fiesta, VW Polo. Small saloons included cars such Ford Escort, Peugeot 306, Vauxhall Astra, VW Golf.

1.1.2 Mileage and time of day

Annual mileage and the amount of time driving at night and at the weekend are important factors in determining crash risk for all drivers. Lourens, Vissers, and Jessurun (1999) found that, among Dutch drivers, mileage was positively associated with crash risk but that young drivers still had the highest rate of accidents even when mileage was accounted for. Interestingly, they found that males and females had the same accident rate when mileage was controlled. Shope and Bingham (2008) discuss a number of studies that have found that driving at night and during the weekends is dangerous for all drivers but is especially so for younger ones. Young drivers appear to have a crash rate that is above what would be expected from their mileage and their time spent driving at risky times, suggesting that even when these important variables are controlled for, there is still something unique about young drivers. As will be covered below, potentially differential effects of sleep deprivation for different age groups may be a candidate for explaining this.

1.1.3 Seat belts

There is abundant evidence that the use of seat belts dramatically reduces the chances of injury or death. Shope and Bingham (2008) suggest that young people are less likely to wear a seat belt and that this contributes to their increased risk of death or injury on the road. However, much recent evidence suggests that differences between young drivers and other drivers are not very pronounced with regard to seatbelt use. In their review of the SARTRE³ data, Gormley and Fuller (2005) found that across all EU states (excluding Ireland) males were much less likely than females to report “wearing a belt frequently” but that there was no difference between drivers aged less than 25 and those aged between 25 and 39 inclusive. For the Irish data, they found that those males age 24 or less were actually more likely than any other male group to report frequent seat belt use and that they were even more likely than young females to do so. While the young female group did have the lowest number of frequent wearers of seat belts (93%), this was only 5 percentage points below both the 25-39 and 40-54 female groups. Furthermore, the proportion of drivers in Japan (IATSS, 2008) who were not wearing a

³ The Social Attitudes to Road Traffic Risks in Europe (SARTRE) was an EU wide study involving interviews with at least 1000 active drivers in each of the 15 member states during 2002/2004.

seat belt when killed in an accident was the same across most age groups below 40. An OECD report (OECD, 2006) cites the NHTSA as finding that the proportion of non-driver occupants who were unrestrained was the same across all age groups under the age of 45.

1.1.4 Fatigue and alcohol

Two main factors that have been found to adversely impact on the physiological condition of drivers are fatigue and alcohol. Sleep related accidents have been estimated to contribute about 4% of motor vehicle fatalities (Lyznicki, Doege, Davis, & Williams, 1998) while Horne and Reyner (1999) estimate that about 20% of all car accidents are sleep related. Despite the perception that fatigue is predominantly an issue for commercial drivers, only 3% of sleep-related crashes involved drivers of large trucks. However, the influence that fatigue has on the young driver problem is unclear. On the one hand, Dahl (2008) suggests that due to a number of biological factors (e.g. changes in the circadian system at puberty), behavioural factors (e.g. additional homework) and social factors (e.g. more autonomy) young people may not be getting an optimal amount of sleep. These factors coupled with inflexible, early school times may leave young people in a heightened state of fatigue. While this could well be the case, it is worth noting that Philip et al. (2003) found that, in a simulation study, young people's driving was less affected by fatigue than older participants. These results contrast with more recent findings by Filtiness, Reyner, and Horne (2012) in which they found the opposite effect; their younger sample (aged 20-26 years) performed worse in a driving simulator after a restricted 5 hours of sleep when compared with an older driving group (52-74 years). These two studies did utilise quite different methodologies which may explain these differences. Filtiness et al.'s findings could explain the findings of Shope and Bingham (2008) which suggest that young people are at an increased risk of crashing at night even when their exposure is accounted for. However, more research on the impact of fatigue for different age groups is needed to resolve the inconsistent findings reported above. Fatigue in this context refers to time of day rather than length of journey. It is currently unclear from the literature whether young drivers typically engage in longer journeys than adults.

The dangers of driving with even small levels of blood alcohol are now well known. If alcohol is to contribute towards our understanding of the young driver problem, then

two questions must be addressed: do young people engage in more drink driving than other age groups and does alcohol have the same impact on them. The SARTRE results suggest that young people (<25) in Europe were no more likely than other age groups to drive after having a small amount of alcohol (Gormley & Fuller, 2005). However, when it came to driving over the drink-driving limit, 10% of young males reported having done so at least once which was higher than any other group – though only two percentage points ahead of male drivers aged 25-39. There was no difference between female drivers in these age groups. Interestingly, in Ireland young males and females were among the lowest ages to report drink driving. These self-report findings are not completely in line with official statistics of alcohol levels in fatal road crashes in Ireland. Bedford (2006) found that those aged 19-24 years were one of the age groups most likely to be driving while over the limit. In the US, the proportion of drivers involved in fatal crashes with a blood alcohol content of .08 or greater was highest for 21-24 year olds and decreased steadily with age (NHTSA, 2010) – note that alcohol is much less readily available to those under 21 in the US. With regard to the effects of alcohol on young people, Keall, Frith, and Patterson (2004) found that for New Zealand drivers, those under 20 years of age had a much steeper increase in crash risk with each drink than those aged 20-29 who in turn had a greater risk per drink than those aged 30 or older.

1.1.5 Passengers

The presence of passengers has a complicated relationship with crash risk. Passengers can influence a driver situation either directly; they may distract drivers or block the driver's view of a mirror or the road, or indirectly; drivers may feel pressured to drive in a certain way simply by the presence of others. In an observational study, Simons-Morton, Lerner, and Singer (2005) found that the presence of male teenage passengers led to an increase in dangerous driving among both male and female teen drivers. However, these groups were only compared with all other traffic (regardless of passenger numbers) and the researchers did not investigate the impact of passengers for other age groups. Accordingly, they are unable to conclude whether, by their methods of observation, the impact of teenage male passengers is a unique effect for just young drivers. Arnett, Offer, and Fine (1997) found, in a self-report study, that young drivers reported having driven faster when alone and with friends than when accompanied by an adult while, in another self-report study, Heck and Carlos (2008) found that almost 40% of

high school students reported having been distracted at some stage by a passenger. Again, neither of these studies compared young drivers with other age groups and so it is difficult to conclude whether these findings are unique to younger people.

There are a number of studies that compare younger drivers with others with regard to the impact of passengers. Preusser, Ferguson, and Williams (1998) attempted to estimate the impact of passengers on crash risk for US drivers of all ages while taking into account exposure (i.e. how often does each age group drive with passengers). They found that passengers had a detrimental impact on drivers aged 16-24, no effect on drivers aged 25-29 and a positive effect on drivers aged 30 or older. They reported that this was in line with a number of previous studies of drivers in the US. This contrasts with findings of Engstrom, Gregersen, Granstrom, and Nyberg (2008) who reported that passengers were a protective factor for all age groups in Sweden including young drivers (16-24). They also suggest that their findings are consistent with a number of other European studies and that cultural differences may explain divergent findings with US drivers such as those found by researchers such as Preusser et al. However, their finding is a relatively anomalous one and the studies that they cite as being consistent with theirs (Doherty, Andrey, & MacGregor, 1998; Lam, Norton, Woodward, Connor, & Ameratunga, 2003) both seem to indicate that young drivers were at an increased risk with accompanying passengers.

1.2 Driving Style and Skill

The research discussed above does provide evidence that issues of driving conditions could relate to the young driver problem. Car size, impact of fatigue and alcohol and influence of passengers are all factors that may increase young drivers' crash involvement while mileage and seat belt use do not seem to differentiate this group from other drivers. Unlike car size and impact of fatigue and alcohol, influence of passengers is more of a predictive factor than an explanatory one. If this is one of the reasons that young people are involved in more fatal and injurious accidents, it still begs the question of what is different about this group that leads them to be so adversely affected by the presence of others. Based on the statistics provided above, it seems unlikely that these variables can fully account for the disproportionate accident rate of young people and so the discussion will explore the impact of driving style and skill.

Almost all young drivers are novices at what is a relatively difficult task. A reasonably sizeable literature has arisen in response to the issue of whether the large number of accidents among this group should be attributed to the effects of age or of inexperience. Unfortunately, the two are very difficult to disentangle given the small number of experienced young drivers and the relatively small number of novice drivers within all other age groups. Furthermore, it is not altogether clear what a deficit in skill actually refers to. Does skill refer simply to their ability to operate the car (e.g. respond effectively to changes in the environment), or should speed choice and degree of dangerous driving also fall into this category? While speeding might seem most aptly classed under driving style, surely the implicit or explicit knowledge of what speed is most appropriate on a given stretch of road is also a skill that must be learned. These two issues, separation of age and experience and the definition of skill, make it difficult to decide whether the statistics described at the beginning of this chapter underlie a *young* driver problem or a *novice* driver problem. The section below will first attempt to decide if driving style is related to crash risk, for if it is not, then the question of whether age or experience contribute to driving style is a moot point. This will then be followed by an investigation of whether young drivers do actually differ in driving style. The final part of this section will address the question of whether any differences found should be attributed to age or experience.

It is a commonly held belief that many young people, particularly young men, drive in a dangerous and aggressive manner and that this is what leads them to be more accident-involved. Driving style is a very broad concept that could encompass any number of behavioural parameters (e.g. how often a driver changes gear, the driver's typical position on a road, their frequency of horn use, etc.). While many of these behaviours could be related to crash risk, the focus here will be on those behaviours that are typically classified as 'dangerous driving', particularly speeding. The link between dangerous driving and accident involvement is not as easy to establish as it may seem at first. For example, in one of the most comprehensive studies of its kind, Streff (1991) examined the police reports associated with over 1.8 million crashes in the US, 50% of which had a 'cause of accident' assigned to them. From their description, it is apparent that the criterion for being a cause was whether a given behaviour was involved in the accident or not. They found that speeding was involved in almost 17% of accidents, careless driving in about 6% and disregard of traffic signals in 5%. Studies such as these

are often cited as support for the hypothesis that behaviour plays a large role in accident involvement. However, calculating the crash risk of a driving behaviour on the basis of the presence of that behaviour in accidents ignores base rates. For example, imagine a study found that yellow colour cars were involved in proportionately fewer accidents than red, black or silver ones. Would such a finding suggest that yellow cars are safer to drive? A more reasonable explanation would be that there are fewer crashes involving yellow cars because there are simply much fewer yellow cars on the road compared to red, black or silver cars. This same reasoning applies to the above findings regarding speeding and other dangerous behaviours. For example, if 17% of the population are engaging in speeding most of the time, then a finding that 17% of accidents involve speeding would be relatively uninteresting. If a higher proportion than 17% of the population were involved in speeding then the above finding might suggest (though would certainly not prove) that speeding was actually a protective factor, and if less than 17% were speeding then this might suggest that speeding is a contributing factor to accident involvement. Note that the above is not meant to suggest that speeding could be harmless. Related to the discussion of car size in section 1.1.1 it is uncontroversial that, where a collision does happen, the higher the velocity of the car(s) involved, the more serious the injuries of those involved in the collision will be. Furthermore, it follows logically that if a particular driver decreases their speed, they will have less chance of crashing due to decreased difficulty in the task (Fuller, 2005). However, it is not altogether clear that those who drive at higher speeds are at a greater risk than other drivers who drive slower. For example, a novice driver driving at 60km/h may have a greater chance of crashing compared with an experienced driver driving at 70km/h. This same reasoning applies to other types of dangerous driving – tail-gating, ignoring traffic signs, etc.

Despite these limitations, a number of approaches have been devised which do suggest that there is a link between speeding and crash involvement. There has not been a great deal of this type of research for other dangerous driving behaviours probably due to their relative subjectivity compared with speeding. Cooper (1997) examined police records to investigate the relationship between drivers' non-crash speeding convictions and their subsequent accident involvement. They found that drivers who had been convicted for exceeding the speed limit or for excessive speeding (breaking the limit by 40km/h or more) in non-crash situations were involved in more accidents on average

than those who had non-speed-related convictions. Increased numbers of non-accident speeding incidents were associated with an increased chance of being involved in an accident and this effect was greatest for those who had been convicted multiple times of excessive speeding. Jun, Guensler, and Ogle (2011) used in-vehicle monitoring technology to investigate the difference in speed between participants who had previously been in an accident and those who had not. They found that crash-involved drivers drove at faster speeds than non-crash-involved participants and that they were more likely to break the speed limit. In their review of the literature, Aarts and van Schagen (2006) conclude that, on the basis of multiple studies with a number of different methodologies, speed is related to crash risk both for individual cars and for particular road sections. Although all of the above studies relate only to speeding -for reasons mentioned above, their findings can be generalised to support the assertion that the way people drive does impact their likelihood of being involved in a collision.

Given the evidence above, the question “is driving style related to the young driver problem?” can now be addressed. In the SARTRE study (Gormley & Fuller, 2005), young people (aged 24 or younger) across the EU were less likely to indicate that they rarely or never broke the speed limit and they were the most likely to say that they generally drove faster than other drivers. Furthermore, in all age groups, males indicated more speeding than females. In an investigation of Northern Irish male drivers, Gormley and Fuller (2008) found that reports of dangerous driving decreased with age and that the probability of breaking the speed limit by 30km/h also decreased with age, though this latter finding was just short of statistical significance with a p value of exactly .05. In a self-report study of anti-social driving behaviour (not including speeding) among young Australian drivers, Palk, Freeman, Kee, Steinhardt, and Davey (2011) found that over half of their sample had engaged in such behaviours, that males were more likely to do so and that these behaviours were related to self-reported crash-involvement. Simons-Morton et al. (2005) found that young drivers, and particularly young males, drove at a closer distance to the car in front when compared with the rest of the population. In a simulator study, Leung and Starmer (2005) found that young drivers (18-21) engaged in more ‘risky driving’ compared with older drivers (25-35). Another source of insight into the different driving styles of young drivers can be found through comparisons of the types of accidents that they are involved in. In their review of accidents among Canadian drivers, Zhang, Fraser, Lindsay, Clarke, and Mao (1998) found that while the actions of

“middle aged” drivers (25-64) were deemed to be “normal” in about 64% of crashes, this number dropped to 47.8% for young drivers (16-24). Young drivers were driving too fast for the conditions in 17.8% of crashes and were exceeding the speed limit in 8.1% – compared with 9.5% and 3.3% respectively for middle aged drivers. For UK drivers, those under 25 were involved in a far higher number of loss-of-control accidents than older drivers (Clarke, Ward, Bartle, & Truman, 2010). While lack of driving skill most certainly contributes to losing control of a car, Clarke et al. estimated that about 75% of these accidents (for all age groups) were characterised by excessive speed.

As mentioned at the beginning of this section, one of the big questions surrounding young drivers is the question of whether their crash rates are due to age (maturity) or experience. In Clarke, Ward and Truman’s (2005) review of accidents among young people in the UK, they found that about 50% of their accidents could be attributed to what they called “voluntary risk-taking”. These included actions such as knowingly breaking the speed limit, driving in an obviously reckless manner or driving while intoxicated. They contrasted these with skill based causes such as driving too fast for the limit (or being ignorant of the limit), insufficient observation and being distracted. Their conclusion is that both issues of skill and risk-taking play a role in dangerous driving among young people. However, they do not compare the young drivers with an older sample so it is unknown whether the proportion of accidents associated with “voluntary risk-taking” is unique for this age group. In a similar study of US drivers, McKnight and McKnight (2003) concluded that experience was a more important factor than age. However, in their study, they had no information regarding the amount of experience that their young drivers actually had. Furthermore, they appear to classify inappropriate speed as being an issue of experience and they also had no information in their study as to whether drivers knew that they were travelling too fast or not. In a study from the early 1990s, Maycock, Lockwood and Lester found that 30-year-old drivers who indicated little driving experience had a lower crash likelihood compared with 20-year-old drivers with the same experience (as cited in Groeger, 2006). Vlakveld found that in terms of crashes per million kilometres driven, drivers in the Netherlands who were licensed at 21 had about 25% less crashes in their first year compared with those who had received their licence when they were 18 years old (as cited in OECD, 2006).

None of the above is meant to suggest that age is all that matters and that experience is unimportant. The above is also not intended to address the relatively

prosaic question of which is more important: age or experience? On the contrary, most of the studies cited above found that experience was still a very important factor for all drivers and in a review of the literature, McCartt, Mayhew, Braitman, Ferguson, and Simpson (2009) found that while there was a separate contribution of both age and experience, the contribution of experience appeared to be greater. The information provided so far is intended simply to convey the fact that there are many possible contributions to the over representation of young people in crashes. However, among these different explanations it is at least possible, and quite probable, that part of the reason for young people's involvement in such a high number of fatal and injurious traffic incidents is due to a higher rate of dangerous driving, particularly with regard to speeding. The next section will make the argument that the driving behaviours of young people are consistent with general risk-taking patterns of this age group. Finally, theories will be provided which attempt to explain higher levels of dangerous driving and general risk-taking among young people. This discussion will then lead to the overall aims of the present thesis.

1.3 Risk-Taking

Adolescence is a unique period in life and probably receives more attention in the risk-taking literature than any other age. It is a time in people's lives when they begin to enjoy unprecedented freedom from parental supervision and generally spend a great deal of their time in the company of their peers. This section will cover four of the most common types of risk-taking associated with this age group –smoking, alcohol use, drug use and unsafe sex. These topics are discussed in order to present the argument that from a perspective of general risk-taking, dangerous driving is not a unique phenomenon for this group. As a topic, risk-taking can be difficult to discuss in even a general sense. Is an individual engaging in risk-taking if they do not believe the activity to be risky? Before the dangers of smoking were fully understood, those who smoked can hardly be considered to be risk-takers. Even in modern times where the negative effects of smoking are widely known, would somebody who does not believe the evidence and continues to smoke be a risk-taker? They are certainly risking something in the broad meaning of the word given that they presumably know that they could be wrong in their denial of the ill effects of smoking. These examples just touch the surface of the issues

facing those studying risk (see Adams (1995) for a broad discussion of the theoretical and methodology challenges in the study of risk). A complication in the discussion of adolescent or youth risk-taking is a general lack of agreement on the exact age-range that should be focused on. A further complication arises from the distinction between what is often considered risky for youths but not for adults. For example, moderate alcohol use is often seen as a risky behaviour for adolescents rather than for adults. Reasons for this are generally due to arguments that alcohol use in adolescence has been associated with alcoholism in adulthood (Reyna & Farley, 2006). Although this is certainly an interesting and important issue, the aim of this section is to establish that adolescents and young adults are more likely to engage in behaviours that are considered risky for all individuals.

Smoking is considered a risky behaviour for all ages and the health risks are well known throughout most of the world. Though there has been a decline in the number of smokers in recent years, in the UK it's estimated that about 20% of the adult population are smokers (Cancer Research UK, 2012). In the UK, about 22% of 16-19 year-olds are smokers and the prevalence increases to just over 30% for 20-24 year olds. There is a gradual decrease for each age group following this, suggesting that peak smoking rates are probably around 22 years of age. Similar figures have been found in the US with the Centers for Disease Control and Prevention estimating that 18-24 year-olds had the highest rate of smoking –though they were very closely followed by 25-34 year olds (2011).

Evidence suggests that adolescents and young adults engage in binge drinking more than any other age group and this is a behaviour that can have adverse health effects. In a survey of drinking behaviour across different age groups in Australia, Livingston and Room (2009) found that female binge drinking (defined as 5 or more drinks in one occasion) peaked at about 18-19 years while the peak for males came slightly later at 20-24. In a UK study, males and females aged 16-24 had the highest percentage of binge drinkers for any age group (McMahon, McAlaney, & Edgar, 2007). These patterns can also be found in the use of illegal drugs as Piontek, Kraus, Pabst, and Legleye (2011) found that for both males and females, prevalence of cannabis use was greatest around 21 years of age. An EU report found that across all EU countries (with the exception of Cyprus and Portugal), the highest prevalence of cannabis use was in the 15-24 year old age range (European Monitoring Centre for Drugs and Drug Addiction, 2011), which is a particularly worrying finding given recent evidence that suggests that cannabis use within

this age group can have permanent neurotoxic effects (Meier et al., 2012). von Sydow, Lieb, Pfister, Hofler, and Wittchen (2002) found that 16-23 were the peak years for ecstasy use and that very few of their participants carried on taking ecstasy after this period.

Evidence suggests that young people are also one of the most 'at risk' groups when it comes to sexual practices. Kan, Cheng, Landale, and McHale (2010) used multilevel modelling to estimate the trajectory of number of sexual partners and found that for males and females in the US, this peaked at about 19/20 years of age. Furthermore, in the UK the 16-24 year old group are at the highest risk of being diagnosed with a sexually transmitted disease and they make up about 65% of all cases of chlamydia (Health Protection Agency, 2008).

The above all illustrate examples of real world behaviour in which adolescents and young people do appear to take more risks. Interestingly, these age differences have been difficult to replicate in a laboratory environment (see Figner & Weber, 2011). However, most of these studies take place in relatively obscure environments that do not reflect the situations in which adolescent risk-taking typically takes place (Steinberg, 2004). A number of studies have addressed this issue with participants completing tasks in the company of peers or tasks being altered so as to elicit more emotion. Gardner and Steinberg (2005) had participants complete a risk-taking driving game either by themselves or among peers. They found that adolescents, young adults and adults differed little in their risk-taking when completing the task by themselves but that in the presence of peers adolescents took much more risks than young adults who themselves took more risks than adults. Interestingly, adults were the only group whose risk-taking declined in the presence of peers. Figner, Mackinlay, Wilkening, and Weber (2009) compared young people and adults on two versions of the Columbia Card Task – a game intended to measure risky decision-making. They modified the task so that in one condition the decision-making was relatively *cold* – participants made their choices but did not receive much feedback. In another condition, *hot* decision-making was elicited by providing participants with constant feedback on their successes and failures. They found that all age groups performed similarly on the cold task but that adolescents took more risks than adults in the hot task.

1.4 Theories of Risk-Taking

Given that it appears to be the case that young people do take more risks than adults, the obvious next question is “Why?” Though it is not an exhaustive list, the discussion below will focus on three categories of theories: rational models; dual processing models; and developmental models. As will be seen below, the theories differ on a number of points. One of the key points of distinction lies in their conception of the role of risk perception or understanding in the risk-taking process.

1.4.1 Rational models

Although there are many “rational” theories of health behaviour, the most popular of these, the Theory of Planned Behaviour (TPB; Ajzen, 1985) will be the focus of the present discussion. This general-purpose theory seeks to explain the link between attitudes and subsequent behaviour and is very much a theory that views decision-making as the result of rational processes with “...the assumption that human beings usually behave in a sensible manner...” (Ajzen, 2005, p. 117). Since the emphasis is on the rationality of behaviour, the main focus of the theory is on the predictors of behavioural intentions. Although a number of variations do exist, the three classic predictors of behavioural intentions according to the TPB are attitudes, subjective norms and perceived behavioural controls. These concepts refer to whether an individual sees a behaviour as positive or negative (attitude), how much they believe others engage in the behaviour (descriptive norms) and what they think others’ view of their engagement would be (subjective norms), and how much an individual believes they are in control when it comes to performing or not performing the behaviour (perceived behavioural control). Figure 1.1 illustrates the structure and components of the TPB and it can be seen that perceived behavioural control is thought to contribute to behaviour both directly and indirectly (through intentions).

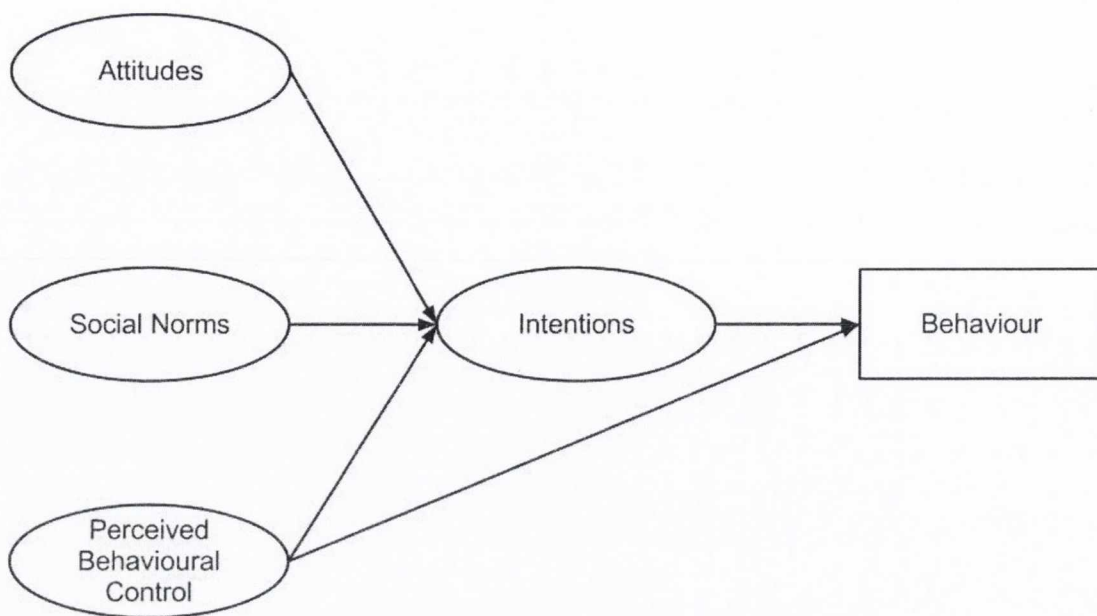


Figure 1.1. The theory of planned behaviour (Ajzen, 1985)

Although the theory is a general explanation for the link between attitudes and behaviours, it is often used in the health domain and many researchers have attempted to utilise TPB to explain risk-taking among all ages. Godin, Valois, Lepage, and Desharnais (1992) found that the three factors of the TPB (attitudes, subjective norms and perceived behavioural control) accounted for almost 40% of the variation in intentions not to smoke. However, the intentions component by itself explained about 15% of variance in past behaviour and this increased to 27% when perceived behavioural control was included. McMillan and Conner (2003) conducted a similar study with a sample of young adults (mostly aged 19 – 22 years) and found that about 42% of variance in past smoking behaviour was explained by intentions and perceived behavioural control. However, in a longitudinal study of intentions to quit and subsequent behaviour, Moan and Rise (2006) found that intentions, together with perceived behavioural control, accounted for only 7% of smoking behaviour in adolescents. The results of the above three studies suggest that the TPB accounts for less variability in behaviour when it comes to quitting smoking and also performs poorer when subsequent behaviour (as opposed to past behaviour) is the focus. Similar findings have arisen for other health behaviours. McMillan and Conner (2003) found that TPB components and perceived behavioural control accounted for about 27% of the variance in past alcohol behaviours for young adults. Gredig, Nideroest, and Parpan-Blaser (2006) found that while TPB components were successful in accounting

for about 33% of the variance in intentions to have safe sex with a new partner, these components along with 'Intentions' only accounted for about 7% of the variance in subsequent behaviour. However, for cannabis use among young people, Conner and McMillan (1999) found that the TPB accounted for over 70% of the variation in actual behaviour. They offer no explanation for this unprecedented percentage of variation explained.

The above studies indicate that the TPB has met with varying degrees of success in the domain of health risk behaviours. While no driving studies have focused specifically on adolescents, a number of studies have applied the theory of planned behaviour to dangerous driving. Parker, Manstead, Stradling, Reason, and Baxter (1992) used self-report measures to investigate the link between TPB components and intentions to commit driving violations and found that 47% of the variance of the latter was explained. They did find that age still made a significant contribution to the model but they did not attempt to link intentions with behaviour. Elliott, Armitage, and Baughan (2007) used a combination of self-report measures and driving simulators to investigate the contribution of the TPB to speeding. They found that intentions and perceived behavioural control accounted for 67% of the variance in self-reported speeding behaviour and between 30-40% of the variance in simulator behaviour. Paris and Broucke (2008) found that while the TPB could predict self-reported speeding behaviour, the prediction of actual speeding (measured using GPS) was not significantly predicted by the model. Similar results were found by Conner et al. (2007) in a study that utilised both simulators and on-road cameras of which the participants were unaware. They found that after demographic factors had been accounted for, TPB measures accounted for an additional 20% of the variance of speeding in the simulators and an additional 12% of behaviour on the road.

The above findings suggest that the TPB certainly has some predictive ability for health risk behaviours and for driving in particular, but that there is still a long way to go. Aside from the unexplained variance revealed in the studies above, another short-coming of the TPB is its inability to account for the behaviour of adolescent drivers since it makes no explicit reference to higher risk-taking among young people. Reyna and Farley (2006) suggest that the explanation offered by rational models for dangerous driving (and other risky behaviours) among young people is that young people do not fully understand the risk associated with their behaviours. Indeed, this is the assumptions of most rational

models – if an individual engages in a risk behaviour, then it is due to their lack of understanding since they are presumably rational actors.

1.4.2 Dual process models

The defining feature of dual processing theories of decision-making (e.g. Epstein, 1994) is that they posit the existence of two types of processing that are involved in decision-making. Type 1 reasoning typically refers to more heuristic-based reasoning which is more intuitive and unconscious in nature while Type 2 reasoning is seen as being more analytical and calculated (Eysenck & Keane, 2005). People automatically deploy these two types of reasoning when addressing different types of decisions and while Type 1 reasoning provides fast and mostly successful responses, in laboratory circumstances it can lead people astray (e.g. the availability heuristic (Tversky & Kahneman, 1974)). Variations of this theory have been developed for health behaviours and perhaps the best known of these is the prototype willingness (P/W) model (Gibbons & Gerrard, 1995; Gibbons, Gerrard, Blanton, & Russell, 1998). The P/W model takes the success of the TPB as its starting point. Gibbons et al. (1998) suggest that intentions, the focus of the TPB, have quite a strong relationship with health behaviours that involve a degree of planning (e.g. exercising and health screening). However, as described in section 1.4.1, for behaviours that involve risk with less time for deliberation, a large degree of variation is left unexplained by rational models such as the TPB. The P/W model proposes that a separate “reactive” decision-making process can occur in risk-taking situations, particularly the kinds of social situations in which adolescent risks typically take place. As can be seen in Figure 1.2, the model shares much in common with the TPB and the direct antecedents of behaviour are behavioural intentions and behavioural willingness. The former of these is taken directly from the TPB and is seen as playing an important role when the risk behaviour in question allows for deliberation and/or is not a socially focused one. The two most important additional factors of the P/W model are *behavioural willingness* and *prototypes* (referred to as risk images in Figure 1.2).

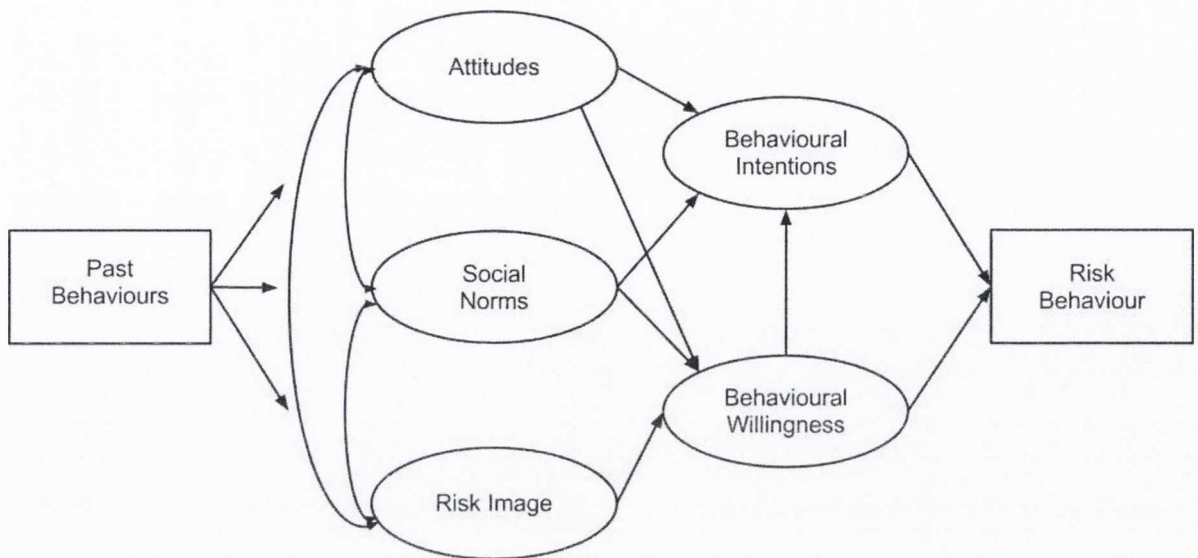


Figure 1.2. The Prototype Willingness Model (Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008)

Behavioural intentions are the degree to which an individual intends to engage in a particular behaviour. However, behavioural willingness refers to the fact that while people may not indicate a specific intention to engage in a risk behaviour, they may indicate that they would be willing to do it. Gibbons et al. (1998) suggest that this willingness is a better indicator of risk behaviour in a reactive situation. While willingness is in part determined by traditional TPB components, a major contributing factor is the image an individual has of the typical person who engages in the behaviour – their prototype. Gibbons et al. state that in social risk situations, people believe that they will acquire this image for themselves if they engage in the risk behaviour. Consequently, the more positively they view this image, the more likely they are to engage in the behaviour. However, the relationship between prototypes, behavioural willingness and risk behaviour is complicated by the fact that engaging in a risk behaviour has been found to lead people to have a more positive prototype for that behaviour (Gerrard, Gibbons, Benthin, & Hessling, 1996); a process similar to cognitive dissonance (Festinger & Carlsmith, 1959). This model is particularly relevant to the present discussion as it was specifically formulated to address risk-taking among adolescents. Firstly, Gibbons et al. point out that most adolescent risk-taking takes place in a social situation meaning that prototypes play a particularly important role. Secondly, they cite a number of studies

that suggest that adolescents are more conscious of their image than adults and so this factor will contribute to their behaviour to a greater degree. Lastly, as will be discussed below, research has found that the model explains more variance for adolescent risk behaviour than for older age groups.

Though less research has been conducted on the P/W model compared with TPB, evidence suggests that the former does offer additional explanatory power over the latter. Since the theory was designed specifically for adolescent behaviour, most research has been conducted with this age group. In a longitudinal study, Gibbons et al. (1998) found that for adolescent smoking, willingness explained additional variance in behaviour after intentions had been accounted for. In a full test of the P/W model Hukkelberg and Dykstra (2009) found that the additional P/W elements created a stronger predictor of smoking among Norwegian adolescents and that only willingness was a significant predictor of smoking while intentions were not. Zimmermann and Sieverding (2010) found that the P/W model explained additional variance in alcohol consumption but oddly enough this result only emerged for the males in their sample. Interestingly, this study was carried out with adults with a mean age of about 25. The full P/W model has not been conducted with dangerous driving; however, separate parts of the model have been applied in the domain. Gibbons and Gerrard (1995) found that prototypes were connected to reckless driving among US college students while Ravis, Abraham, and Snook (2011) found that TPB and P/W constructs predicted willingness to drink and drive among males and that it did so to a greater extent among younger males (17-29) than among older ones (>30).

The lack of research on the P/W model's ability to account for actual behaviour makes it difficult to conclusively decide whether it represents a major improvement over the TPB. However, the above studies do suggest that it has had some success as a predictive and explanatory tool. The P/W model is not the only dual processing theory that has focused on health behaviours. The fuzzy-trace theory (Reyna & Farley, 2006) also attempts to explain risk-taking among adolescents and shares much in common with the P/W model. While the P/W model focuses on the impact of risk images on reactive reasoning, the fuzzy-trace theory focuses instead on the purportedly poorly developed intuitive skills of adolescents and young adults. Much like the P/W model, fuzzy-trace theory suggests that attitudes towards, and understanding of, risk are not the components that underlie increased risk-taking behaviour among adolescents. However,

unlike the P/W model, fuzzy trace theory has had very little application in real-world risk-taking studies (e.g. adolescent smoking, etc.).

1.4.3 Developmental models

The previous theories contain elements that seek to explain the risk-taking behaviour of young people. While these elements may be developmental in nature, they need not explicitly be so. For example, the P/W model suggests that young people are more image-conscious and so this leads their risk prototypes to play a bigger role in their risk-taking behaviour (Gibbons et al., 1998). This proposed difference in image consciousness could be due to biologically based developmental factors or it could just be to do with the types of social environments that young people find themselves in (e.g. unsupervised parties for the first time). In recent years, many researchers and journalists have expressed the opinion that young people's risk-taking (particularly dangerous driving) is due to their underdeveloped brains. Writing for the Irish Times, the lawyer and journalist Rory Fitzgerald (2010) states that evidence "clearly shows that young people's brains...are not fully wired up until they are in their early 20s". This is not a unique opinion piece with articles of a similar sentiment appearing in the Daily Mail in the UK (Massey, 2007) and the Washington Post (Williamson, 2005). Efforts have even been made to show greater leniency for young adult offenders on the basis that their brains have not fully developed (Beckman, 2004). Though a number of researchers have suggested that neurodevelopment may underlie adolescent risk-taking, Laurence Steinberg (2008) has provided perhaps the most explicit and encompassing theory in a paper that has attracted considerable attention since its publication –Google Scholar estimates that over the last four years or so, it has been cited more than 400 times (as of the 24th September, 2012). Steinberg does not provide an explicit name for the theory and so, for this discussion, it will be referred to as the Dual Systems Model (DSM). The evidence in favour of this theory will be discussed in detail in chapter 2 and chapter 3 and so only a cursory description is given here.

The starting point for the DSM is the argument that, despite their apparently illogical behaviour, adolescents are just as capable of rational reasoning as adults are (Steinberg, 2007). Furthermore, Steinberg states that no evidence exists that indicates that adolescents are lacking in knowledge. Like the dual processing theories discussed previously, the DSM assumes that young people are just as aware of risk as adults are.

The DSM proposes that adolescent risk-taking has its roots in the development of two separate neurological systems. Firstly, changes in limbic and paralimbic areas of the brain occur in early adolescence resulting in changes to young people's socio-emotional systems associated with reward. Specifically, he suggests that in the presence of peers this network increases in activation and leads people to have increased sensitivity to social stimuli. The second system that Steinberg proposes is a self-regulatory one, primarily based in the frontal and prefrontal cortices, which continues to develop well into early adulthood and leads to decreased risk-taking as adolescents mature into adults. Risk-taking during adolescence is seen as resulting from a struggle between the socio-emotional system and the cognitive control one. Steinberg (2008) cautions that the theory is still relatively speculative, especially given the enormous complexity of brain development from adolescence to early adulthood. While this section refers predominantly to the work of Laurence Steinberg, there are other developmental theories of risk-taking with Casey, Getz, and Galvan (2008) describing the causes of youth risk-taking in roughly similar ways. Bingham, Shope, Zakrajsek, and Raghunathan (2008) have examined a less neurologically-focused developmental explanation for the gradual decrease in risk-taking during late adolescence. Instead, they focus on psychosocial maturation, a construct that refers to the degree to which an individual has taken on adult roles, and have successfully demonstrated an association between it and problematic driving.

The evidence marshalled to support the above theory, particularly with regard to the development of the second "cognitive control" system, will be discussed in chapter 2. However, it's worth noting that very little of this research comes from studies of adolescent risk-takers. In fact, in comparison to the TPB and the P/W model, this theory has received nowhere near the amount of real-world support to justify claims made in popular science articles such as those discussed above. Much like dual processing theories of risk-taking, the DSM makes a very specific claim about adolescent risk perception. It proposes that young people understand risk just as much as adults do and this contrasts with more rational models, which assume that if somebody is taking part in a risky behaviour they do not fully understand the risks involved. Since this point is a key distinction between the theories, it forms the basis of the next section.

1.5 Risk Perception

The popular perception of young people is that they think that they have less chance of coming to harm or that they even see themselves as being in some way invulnerable. In an interview with the journalism organisation Politico, the executive director at the Center for Healthcare Decisions in California, Marge Ginsburg, expressed regret at the fact that young people do not apply for health insurance because “They don’t believe they’re going to die” (Lovley, 2009). The logical extension of this is that young people are lacking in either knowledge or reasoning skills compared with adults. As mentioned in the previous section, Steinberg (2007) presents evidence that neither of these are the case. Young people appear to be able to logically reason just as well as adults can and they appear to have the same appreciation of their vulnerability and the inherent dangers of many risky activities. This latter concept relates to the question of whether young people have a deficit in risk perception and it is such a vital issue to the present thesis that it requires further investigation. Reyna and Farley (2006) suggest that there are three types of approaches that can establish possible distortions in adolescent risk perceptions: do adolescents underestimate the risks when compared with official estimates; do adolescents see themselves as less vulnerable compared with other age groups; and do adolescent risk-takers see themselves as more at-risk than adolescents who are not taking risks. These questions, and particularly the third one, will be explored further in chapter 5 but a brief summary will be given here.

Firstly, are adolescents more likely to underestimate risk compared with official statistics? Millstein and Halpern-Felsher (2002) gave participants a number of natural hazard scenarios such as “You are having a picnic and lightning strikes, how likely are you to be killed?” Participants were asked to rate from 0% to 100% what their chances of dying would be. Participants were also presented with a number of risk-taking activities and asked, using the same scale, to indicate the likelihood of a negative outcome (e.g. the likelihood of getting an STD after having unprotected sex). They compared the responses of young people (aged 12-15) with adults (aged 20-30). Although all participants were apt to overestimate the absolute risk of the events, the younger participants did so by a larger amount for all of the risks. This finding runs contrary to the traditional conception of young people not knowing the risks; in a relatively simple and absolute way, they seem to see activities as more risky than adults do. While these differences do support the

concept that young people view risks differently to adults, the difference in direction that is not what would be expected based on rational models.

What about the difference between adults and adolescents in terms of perceived vulnerability? Quadrel, Fischhoff, and Davis (1993) asked adolescents and adults to rate the probability that they would be involved in eight separate negative events over the next five years. The events included those such as being in a car accident, being mugged and being injured in a fire. Furthermore, adolescents and adults were asked to rate the likelihood that their parents or children, respectively, would be involved in each negative event. Firstly, they found that both groups rated the likelihood of the adolescent being involved in the events as being greater. Secondly, participants who chose the option “no chance at all” for any of the risks were categorised as displaying absolute invulnerability. They found that adolescents were no more likely to display this kind of invulnerability than adults while Millstein and Halpern-Felsher (2002) found that, using the same classification, adults were actually more likely to display absolute invulnerability. Again, these findings are not what would be expected based on the usual narrative of adolescents seeing themselves as being less at risk or even invulnerable.

The final line of inquiry suggested by Reyna and Farley (2006) is to see if adolescents engaging in risk-taking perceive the risks differently from adolescents not engaging in the same risks. Of the three approaches, the largest amount of research has been directed towards this question. Brynin (1999) asked young smokers and young non-smokers to indicate if they thought “smoking was extremely dangerous” and found that smokers were more likely to say “no” compared with non-smokers. This would suggest that risk-taking during adolescence could be to do with altered risk perception. However, Sneed et al. (2001) found that sexually active adolescents were more likely to see themselves as being at risk of contracting HIV. Mills, Reyna, and Estrada (2008) suggest that both kinds of responses make sense when discussed separately. Seeing an activity as less risky may lead an individual to take part in it more while at the same time, those engaging in a risky activity may realise that they are at a greater risk. However, it is difficult to explain the existence of both types of findings particularly when they emerge in the same study. Johnson, McCaul, and Klein (2002) found that when they asked participants about the absolute risk of an activity (e.g. “how risky is smoking”), there was a negative relationship between risk-taking and perceptions (i.e. those who smoked more rated the activity as less risky). However, when they asked participants about the

risk of a particular outcome (e.g. “how likely is it that you will get lung cancer”), there was a positive relationship between behaviour and perception –smokers saw themselves as being at a greater risk. The significance of this finding and others will be discussed in greater detail in chapter 5, but the principal message of these findings is that it is unclear whether high-risk adolescents understand their risks. While a number of the studies described above suggest that young people are as aware of the risks as adults, there is a degree of ambiguity surrounding the extent to which high-risk adolescents understand the risks of their behaviour.

1.6 Summary and Thesis Aims

Driving represents a huge health concern in countries across the world and, in the developed world at least, young people are at greater risk of driving related injury and death than any other age group. This increased risk may stem from a number of different factors such as the conditions that young people drive under (e.g. type of car, alcohol use) or their lack of experience as drivers. However there is evidence that young people are more likely to drive in a risky manner. This risky behaviour is not necessarily an isolated phenomenon among young people as they are more likely to take risks in a number of domains (e.g. smoking, binge drinking, unprotected sex). A number of different theories have been proposed to explain this increased risk-taking. The TPB suggests that young people take more risks as they do not understand the true riskiness of these behaviours. The P/W model emphasises the reactive aspect to decision-making and that young people’s risk-taking can be predicted better by the image they have of a typical risk-taker and their willingness, as opposed to intentions, to engage in the behaviour. Steinberg’s social neuroscience theory suggests that adolescent risk-taking results from activation of a socio-emotional neural network which is insufficiently counteracted by an impulse control system due to the latter not fully developing until early adulthood. While the theory of planned behaviour suggests that young people have a deficit in risk perception, the latter two theories propose that this is not an issue. Separate investigation of risk perception has revealed an ambiguous relationship between it and risk behaviours among adolescents.

The focus of this thesis is on the contribution of developmental factors to dangerous driving among young people. Any increased understanding of driving

behaviour could be of benefit in reducing road fatalities and there are two reasons why developmental factors are of particular interest. First, rational models (e.g. TPB) and dual processing models (e.g. P/W model) have received a degree of testing with regard to both dangerous driving among young people and risk-taking in general. However, despite providing perfectly plausible explanations for youth risk-taking, developmental models have received very little direct testing. The second reason why such theories are of particular interest is that they seem to have captured the attention of the public. The opinion pieces described in this introduction are all written as though there is clear evidence to suggest that young people drive dangerously because they are neurologically immature. However, such evidence is entirely lacking and so the present thesis attempts to test some of the predictions and assumptions of these theories. There are two main ways that the theory will be tested.

Firstly, Chapters 2, 3 and 4 will describe a number of studies that investigate the proposal that the development of cognitive control in the late teens and early twenties is related to dangerous driving and, hence, risk-taking. Cognitive control makes up only part of Steinberg's DSM. Nonetheless, this aspect of the model will be the focus of the first part of this thesis with little investigation of differences in the other system described in the model –the socio emotional one. As described in chapters 2 and 3, this focus on the cognitive control aspects of the model is based on the fact that these systems are still undergoing development when individuals first learn to drive. This second focus of this thesis is on the topic of risk and risk perception. While risk perception does not play as direct a role as cognitive control in neurological theories such as Steinberg's, it is still of great relevance to the overall approach. Indeed, one of Steinberg's justifications for developing the DSM is the assertion that traditional conceptions of adolescent risk-taking as resulting from a lack of knowledge about risks are incorrect (2008). While it would still be possible to maintain a neurodevelopmental theory even if adolescents were shown to lack an understanding of the risk, the need for such a theory would be reduced. Chapter 5 presents an investigation the role of risk perception in dangerous driving using a novel attitude accessibility approach. The overall aim of these two separate strands of research is to determine whether developmental factors are likely to underlie the disproportionate accident rates of young people.

Chapter 2: Impulsivity and Problematic Driving

2.1 Introduction

As described in the introduction, the Dual Systems Model (DSM) of adolescent risk-taking (Steinberg, 2008) proposes that there are two separate systems underlying increased risk-taking during adolescence. The first is a socio-emotional one which increases in the early teens and leads young people to seek out and engage in risky behaviour more often, particularly in the presence of peers. This increased risk-taking is curbed during the late teens and early adulthood as neural systems responsible for cognitive control develop and lead individuals to become more measured in their behaviour. It should be noted that this focus on competing neurological systems is not entirely unique to Steinberg with other researchers (e.g. Casey et al., 2008) having proposed theories that, although different, provide essentially the same narrative of risk-taking among young people. Furthermore, Steinberg's DSM is also related to a number of dual processing theories, such as the Reflective Impulsive Model (RIM; Strack & Deutsch, 2004), that attempt to explain health decisions in general. Descriptions such as the RIM attempt to explain behaviour when an immediate impulse (e.g. a desire for chocolate) interferes with a rationally-based long term desire (e.g. the desire to have a healthy diet (see Hofmann, Friese, and Wiers (2011) for discussion of the specifics of such models)). However, what distinguishes the DSM and other recent neurological theories from these general health theories is that the former address the specific neurological systems that may underlie these processes and, additionally, they focus on the particular issue of risk-taking among adolescents.

Implicit in the DSM's description of the changes across adolescence is that differences in risk-taking between people, or at least between adolescents, result from differences in these two systems. In almost every country, young people are not allowed to drive until their late-teens, and there are often restrictions while they are learning to drive (e.g. mandatory accompaniment by an experienced driver). These restrictions aim to reduce opportunities to drive dangerously. This being the case, the phenomenon of dangerous driving among young people emerges long after the socio-emotional system has developed. Consequently, reductions in levels of dangerous driving from the late teens to the early twenties should, according to the DSM, be due to developments in the second system, that of cognitive control. If cognitive control is truly responsible for

reducing risk-taking behaviour, then those young people who have greater control should engage in less dangerous driving than their peers with less control. This is a relatively innocuous inference from the DSM though it faces one immediate issue. Steinberg, and other researchers for that matter, never explicitly state what exactly “cognitive control” is.

Steinberg’s ideas are expressed in a relatively atheoretical way and while he mentions phrases such as “cognitive control” and “self-regulation”, he is not explicit about what these are or why they may lead to reductions in risk-taking. On its own, it is not entirely clear why cognitive control might play any sort of role in risk-taking among young people. Steinberg bases his theory of increased cognitive control with reference to two types of information – neurodevelopment and cognitive performance. While the former will be examined in greater detail in the next chapter, it is necessary to look at the latter now as it gives some insight into what exactly Steinberg believes cognitive control to be.

Steinberg (2008) cites a number of studies as evidence for differences in cognitive control between adolescents and adults. A number of behavioural tasks are used in these studies which include: the Tower of London (Steinberg et al., 2008), a test of task-switching (Crone, Donohue, Honomichl, Wendelken, & Bunge, 2006) and an anti-saccade task (Luna et al., 2001). In the Tower of London task participants are presented with three balls placed in a certain configuration on three pegs. They are shown an image of the goal position that the balls must be changed to and they can only move one ball at a time. One peg can hold three balls, one can hold two and one can only hold a single ball. There are many variations of the task, with Steinberg et al. using a computerised version and presenting participants with a number of trials that require varying amounts of moves in order to reach the goal configuration. The measure that they were interested in was the amount of time that a participant took before making the first move and they found that for the harder tasks (those involving five or more moves) older participants took a longer time before responding when compared with young participants. The authors suggest that this is due to the younger participants lacking the cognitive control needed to prevent them from just diving into a task before thinking clearly about it. Tests of task-switching generally require participants to respond to similar trials using different rules. For example, Crone et al. asked participants to press one key if a picture of a tree was presented and another if a picture of a house appeared. However, there were two

types of cues that could precede these trials (a circle or a triangle) and these cues determined which key was matched with which stimulus (i.e. a circle cue indicated that the left key should be pressed for a house and the right key for a tree, while a triangle indicated the opposite). They found that children and teenagers performed similar to each other on this task but both groups were substantially worse than adults. The authors suggest that the younger participants' poorer performance was due to underdeveloped systems mediating flexible rule use. The final task type that will be discussed is the anti-saccade task in which participants have to resist looking at a stimulus. In Luna et al.'s version, a green cue indicated that participants were to look directly at the subsequent stimulus which would appear in the peripheral of screen (pro-saccade trial). However, a red cue indicated that they were to look in the opposite direction of the stimulus (anti-saccade trial). They found that across their participants, error rates on the anti-saccade trials dropped significantly with age.

The purpose of these task descriptions is to illustrate what cognitive control actually means in the DSM. Aside from differences in performance across age groups, these tasks do share a number of characteristics. Firstly, similar neurological areas are associated with performance in all of these tasks, though this is an issue that will be explored further in chapter 3. Additionally, the tasks all involve a kind of self-control. In the case of the anti-saccade task, participants must stop the near-automatic response of looking towards a newly presented stimulus. For the test of task-switching the aim is to stop previous information or responses from interfering in a different trial. The Tower of London involves a higher order type of self-control with participants having to resist rushing into the task in order to have a better strategy for completing it. These characteristics arguably contribute to the psychological construct of impulsivity, which has been researched extensively. Consequently, an exploration of this topic may elucidate what the cognitive control aspect of the DSM actually consists of.

2.1.1 Impulsivity

As in many areas of psychology, impulsivity avoids easy definition and has different meanings for different researchers. It is typically construed as a multidimensional construct incorporating aspects such as behavioural disinhibition, risk-taking, sensation seeking and poor planning (Petry, 2001). However, with definitions as all-encompassing as this, the meaning of the construct is difficult to discern. Risk-taking

and poor planning both appear on Petry's list and yet these are very different concepts. Mountain climbers often take great risks in the pursuit of their sport, but these risks are often preceded by substantial amounts of planning. Accordingly, many researchers have attempted to produce a more concise definition of impulsivity without entirely denying it a multidimensional nature. Confusingly, Eysenck and Eysenck (as cited in Kahn, Kaplowitz, Goodman, & Emans, 2002) suggest that impulsivity is an overarching construct made up of impulsiveness -the tendency to act or speak without thinking, and venturesomeness – the actual seeking out of risky or stimulating activities. Despite the confusing titles, this description is backed by a number of different researchers who see impulsivity and sensation seeking as two distinct concepts (e.g. Dahlen, Martin, Ragan, & Kuhlman, 2005; Pedersen & McCarthy, 2008). Impulsivity is generally measured through the use of questionnaires and an investigation of the scales and items of these different questionnaires is an instructive way to understand how impulsivity is generally conceptualised in psychological research. In the present discussion, "impulsivity" and "impulsiveness" are used interchangeably and preferred usage is given to the former.

Eysenck's Impulsiveness, Venturesomeness and Empathy (IVE) questionnaire (see Butler & Montgomery, 2004), commonly referred to as the Eysenck Impulsivity Questionnaire or the I-7, was one of the first questionnaires to contain a scale for Impulsiveness that separates it from sensation seeking (referred to as Venturesomeness in the IVE). Although the title of the questionnaire suggests three factors of interest, research suggests that Impulsiveness and Venturesomeness are reliable scales with the items of the third factor, Empathy, typically serving as buffer questions to reduce monotony (Caci, Nadalet, Baylé, Robert, & Boyer, 2003). The impulsiveness scale of the IVE represents a relatively limited view of impulsivity focusing on the degree to which individuals think about their immediate situation before acting (e.g. "Do you usually make up your mind quickly?").

The Barratt Impulsiveness Scale 11 (BIS; Patton, Stanford, & Barratt, 1995) is one of the most common measures of impulsivity in psychological research (Stanford et al., 2009). It offers a more encompassing view of impulsivity compared with the IVE producing a number of separate impulsivity scores where the IVE assigns individuals just one. Stanford et al. describe how older versions of this scale had three subscales; Cognitive Impulsiveness, Motor Impulsiveness and Non-Planning Impulsiveness. Cognitive Impulsiveness referred to the tendency to make quick decisions; Motor

Impulsiveness involves acting without thinking things through; and Non-Planning Impulsiveness relates to how future-oriented an individual is. The latest version of the questionnaire still contains the latter two factors but the first has been replaced with an Attention Impulsiveness scale. While this number of factors does present a reasonably broad view of impulsivity, it is still more focused than the description at the beginning of this section as it excludes concepts such as risk-taking and sensation seeking. Broadly speaking, the BIS assesses the degree to which an individual can pay attention and focus on a task and the amount of time that they spend thinking before they act. The Motor Impulsiveness scale bears a theoretical resemblance to the Eysenck's impulsiveness scale and, indeed, this was the only BIS scale that Caci et al. (2003) found to be correlated with the impulsiveness scale of the IVE. In their summary of impulsivity measures, Whiteside and Lynam (2001) state that the Non-Planning Impulsiveness scale of the BIS has been replicated less often than the other two factors, which have been found to be quite stable.

Dickman (1990) presents a relatively unique model of impulsivity defining this trait as the tendency to deliberate less than others. His starting point is that impulsivity need not necessarily be a negative trait and that his own research found that on very simple experimental tasks, impulsive participants performed them faster with very few additional errors. He proposed that there are two types of impulsivity, functional and dysfunctional, and found support for this in his factor analysis of a number of items referring to deliberation. The Functional Impulsivity scale contained items such as "Most of the time, I can put my thoughts into words very rapidly" and Dickman describes this factor as encompassing issues that do not cause individuals difficulties and are even a source of pride for them (e.g. "People have admired me because I can think quickly"). In contrast to this, the items that loaded onto the Dysfunctional Impulsivity factor could generally be classified as ones that reflected difficulties for the individual (e.g. "I often get into trouble because I don't think before I act"). While Dickman's distinction is an interesting one, it is questionable whether the first scale really addresses impulsivity as it is generally understood. This scale seems more to do with cognitive ability rather than a propensity to act in a particular way. The items belonging to his second factor resemble more typical impulsivity questions and bear a much closer resemblance to both the overall BIS and IVE questionnaires. Caci et al. (2003) found a high correlation between Dickman's Dysfunctional Impulsivity scale and the Impulsiveness scale of the IVE and, in

an attempt to factor analyse multiple impulsivity questionnaires, Whiteside and Lynam (2001) found that the Dysfunctional scale loaded onto the same factor as the Impulsiveness scale of the IVE and the Motor Impulsiveness and Non-Planning Impulsiveness scales of the BIS. Interestingly, they did not find the Functional Impulsivity scale to load very strongly onto any of the higher-order factors

2.1.2 Impulsivity and risk-taking

If impulsivity is to be a possible candidate for the cognitive control aspect in the DSM, then there should be some relationship between this construct and risk-taking. A number of studies from areas such as sexual risk, gambling and drug taking have indicated that such a relationship does appear to exist. Impulsive high school and undergraduate students are more likely to take part in a number of risky behaviours such as drug use, drunk driving and seatbelt non-use (Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996). Specifically, Stanford et al. identified high impulsive participants using the BIS and asked them to indicate their involvement in the risk-behaviours mentioned above. For girls in this age group, impulsivity (as measured by the IVE) has been found to predict risky sexual behaviours (Kahn et al., 2002). Impulsive girls were found to have had more sexual partners, to be less likely to use contraception and to have had sexual intercourse for the first time at an earlier age when compared with less impulsive girls. Petry (2001) found higher levels of impulsivity to be associated with pathological gambling. In a slightly older population, though all participants were undergraduates, Butler and Montgomery (2004) measured risk-taking on the basis of past ecstasy use. Using the IVE questionnaire, they found that those participants who were high ecstasy users reported higher levels of impulsivity than low ecstasy users and that both groups had higher levels than non-drug-users. It is possible that the higher impulsivity among drug users is a consequence rather than a cause of the behaviour. However, in a review of the link between impulsivity and drug use, Verdejo-Garcia, Lawrence, and Clark (2008) highlight a number of studies that have found that a) children of those with substance use disorders tend to have higher impulsivity and b) impulsivity in adolescence does predict future drug use. These findings, among others, led the authors to conclude that impulsivity may well have a causal influence on drug use. In this review they found links between impulsivity and the use of cocaine, heroin and alcohol. A relationship between impulsivity and risk-taking has also been found when the latter is measured using a behavioural task, as

opposed to self-report ones (Upton, Bishara, Ahn, & Stout, 2011). Upton et al. found a correlation between scores on the impulsiveness scale of the IVE and performance on the balloon analogue risk task. In this task, participants receive increased points the more they inflate a virtual balloon. The more the balloon is inflated, the higher the risk that it will burst (losing the participant all their points), and they found impulsive participants inflated the balloon more than less impulsive ones.

2.1.3 Impulsivity and driving

A relatively small number of studies have focused on the relationship between dangerous driving and impulsivity and so it is possible to provide a more comprehensive review of these findings. Driving under the influence of alcohol, unsafe driving and aggressive driving have been the most frequent issues focused on in this area though the last of these is defined by some researchers as being synonymous with unsafe driving (e.g. Berdoulat, Vavassori, & Sastre, in press). While almost all of the studies on the relationship between risky driving and impulsivity have measured the latter using questionnaires, driving behaviours themselves have been obtained either by self-report measures or official records. Treloar, Morris, Pedersen, and McCarthy (2012) utilised the Urgency, Perseverance, Premeditation and Sensation Seeking (UPPS) questionnaire to identify the different types of impulsivity that may be associated with drink driving. The scale contains three different impulsivity factors (and a sensation seeking one) and yet all of these were found to have a similar positive relationship with frequency of driving under the influence and with alcohol quantity when such behaviour occurred. Treloar et al.'s study was based on self-reported drinking and driving behaviour and is in line with previous research comparing these variables (Ryb, Dischinger, Kufera, & Read, 2006). However, similar impulsivity findings have emerged for comparisons between individuals with drinking and driving convictions and those without (Curran, Fuertes, Alfonso, & Hennessy, 2010).

Though the focus of a study by Berdoulat et al. (in press), was the link between aggressive driving (e.g. horn beeping, gesturing) and impulsivity, they also administered the Driver Behaviour Questionnaire (DBQ; Lajunen, Parker, & Summala, 2004) to participants. They found that driving violations had a strong relationship with overall score on the UPPS. Though Dahlen et al. (2005) used different questionnaires for both dangerous driving and impulsivity, they found a similar relationship between the

constructs. Constantinou, Panayiotou, Konstantinou, Loutsiou-Ladd, and Kapardis (2011) used the violations subscale of an older version of the DBQ and looked at the relationships between the subscales of the BIS. They found that Motor Impulsiveness was positively associated with both ordinary and aggressive violations on the DBQ and that Non-Planning Impulsiveness had a similar association with just ordinary violations. Using a non-standard measure of impulsivity, Ryb et al. (2006) found a relationship between a number of separate driving-related risk behaviours and impulsivity. Though it was with motorcyclists, Cheng and Lee (2012) found a positive relationship between BIS scores and driving violations with a Chinese sample.

A very different approach to the measure of impulsivity was taken by Paaver, Eensoo, Pulver, and Harro (2006) who note that previous research has found a link between impulsivity and serotonergic functioning and they measured the latter through analysis of platelet enzyme monoamine oxidase (MAO). Using questionnaire measures, they found that high risk drivers (those who had reported exceeding the speed limit by more than 20km) scored higher on measures of functional impulsivity. While the differences in platelet MAO levels were not quite as clear, they did generally find that higher risk participants had higher levels. The complication in their result was that this emerged only for those high risk drivers who realised they were at risk. Taken together, the results above suggest that problematic driving does seem to be related to levels of impulsivity. As described in chapter 1, driving accidents are a huge health risk for young people. Accordingly, the utility of the DSM would be called into serious question if it could offer no explanation for rates of risk-taking in this area and so the above does offer some support to it.

2.1.4 Impulsivity and age

The DSM suggests that young people take fewer risks as they get older due to the development of cognitive control systems. The positive relationship between levels of risk-taking and impulsivity described above does support the present proposal that the latter is a good candidate for the otherwise poorly defined “cognitive control” concept described by Steinberg (2008). However, if impulsivity is to fit this profile, then it must also be shown to decline during the ages that the DSM proposes that people should be reducing their risk-taking – the late teens and early twenties. Despite differences in questionnaires, research design and exact age groups used, findings from a number of

studies have been roughly in line with this description. In a comparison between high-school and undergraduate students, Stanford et al. (1996) found that the former had a total BIS score that was significantly higher than the undergraduates. Leshem and Glicksohn (2007) found the same trend using both the BIS and IVE with their 20-22 year old group indicating lower impulsivity than 14-18 year olds on both questionnaires. Steinberg et al. (2008) used a combination of some of the items of the BIS with individuals aged 10-30 years and found a downward trend in impulsivity as age increased with the youngest group having the highest score. Interestingly, they also administered a measure of sensation seeking and found a slightly different trend, with the youngest group (10-11 year olds) having one of the lowest scores. The sensation seeking score increased for the next group (12-13 year olds) and gradually decreased after that. They suggest that this is in line with the DSM with the sensation seeking scores demonstrating the changes in the socio-emotional system while the impulsivity scores represent the changes in the cognitive control system. Harden and Tucker-Drob (2011) carried out a study similar to this with 12-24 year olds using different measures of impulsivity and sensation seeking. They found an almost identical trend for both measures. Kasen, Cohen, and Chen (2011) measured only impulsivity in their participants (aged 10-25 years) and found a pattern that more closely related to that of sensation seeking in the two previously mentioned studies (i.e. the younger participants scored low, followed by an increase until about 15 and a decrease thereafter). However, they used a custom impulsivity questionnaire that contained a number of items that bore little resemblance to the construct of impulsivity as it is generally understood (e.g. "I get into trouble at school or work"). The results of these studies are very promising for the suggestion that impulsivity may be at least one of the constructs that describe the kind of cognitive control to which the DSM refers.

2.1.5 Impulsivity and gender

A shortcoming of many attempts to explain risk-taking among young people is that they offer very little explanation for the discrepancies between males and females, particularly with regard to dangerous driving. For example, Tavriss et al. (2001) found that males, and young males in particular, were much more likely to be hospitalised due to loss of control while driving compared with females. In his discussion of the DSM, Steinberg (2008) emphasises the differences in risk-taking between adolescents and adults but almost entirely ignores the differences between males and females. In a

survey of over 1400 participants, Stanford et al. (2009) found no difference between males and females on either the total BIS score or on any of the three subscales. It is possible that the factors underlying the differences in risk-taking are entirely different from those associated with age changes. For example, Figner and Weber (2011) suggest that males perceive the risks associated with recreational risk-taking as being lower than women do and that this is what leads them to engage in risks such as dangerous driving more often than women do. As described in chapter 1, there is a similar reduction in crash risk across the ages for both genders and so it may well be the case that the DSM explains reductions in risk-taking only associated with age while another explanation, such as the one given by Figner and Weber explains gender differences at all ages.

2.1.6 Why might impulsivity be linked to risk-taking?

The discussion above has addressed the suitability of the construct of impulsivity to be a key determinant in the cognitive control system in the DSM. The areas that have been examined include the different conceptions of what exactly impulsivity is, its relationship to dangerous driving, and other examples of risk-taking, and its developmental trajectory towards the end of the teens and the early twenties. However, none of this explains *why* impulsivity is related to problematic driving or why it might be appropriate in the investigation and elucidation of the DSM of adolescent risk-taking. The investigation of impulsivity is a relatively atheoretical exercise for most researchers. In many of the risk-taking studies above, the justification for the measurement of impulsivity is simply that past research has found it to be related to engagement in the risk behaviour they are investigating (e.g. Butler & Montgomery, 2004; Curran et al., 2010; Kahn et al., 2002; Stanford et al., 1996).

Dahlen et al. (2005) explain their measurement of impulsivity by suggesting that those who are high in this trait may engage in more risk-taking as they lack self-control. While this at least represents an effort to theoretically justify the measurement of impulsivity, it is still a relatively simplistic description, failing to mention any models such as the DSM. Treloar et al. (2012) reference the acquired preparedness model (McCarthy, Kroll, & Smith, 2001) to explain their interest in impulsivity, but this model is specific to alcohol use and concerns a number of personality traits - not just impulsivity. Furthermore, based on McCarthy et al.'s description of the model, their conception of impulsivity seems to be closer to sensation seeking (e.g. "According to this model,

disinhibited individuals have an overreliance on an active, reward-seeking response style” (p. 390)). In their review of the relationship between impulsivity and drug use, Verdejo-Garcia et al. (2008) suggest that impulsivity may play different roles at different stages of addiction. For example, those who act without thinking may be more likely to try a drug in the first place, and people with substance-use disorders may find it hard to quit drug-taking if they cannot resist their impulses. Again, while this is an entirely plausible description of the role of impulsivity in risk-taking, it is offered in isolation of any already established model or framework. Furthermore, it is obviously a description that does not apply to dangerous driving, or any other non-substance related risks.

2.2 Study 1

The present study is a questionnaire-based one and serves two primary purposes. First, it is a replication of past research that has linked impulsivity with self-reported driving behaviour. The BIS and the DBQ are, respectively, the most common measures of impulsivity and dangerous driving. Furthermore, the BIS offers a more nuanced breakdown of impulsivity than some of its counterparts (e.g. the IVE) and the DBQ has a specific scale related to problematic driving, the Violations scale. A number of studies, described above, have investigated the relationship between impulsivity and problematic driving, but they have focused on different scales or on older age groups. While Constantinou et al. (2011) is the only other study to use both the BIS and the DBQ, their study included drivers slightly older than would be covered by the DSM. If impulsivity is to fit the role of the second system in the DSM, then it should be the case that there is a relationship between these important measures for a younger age group (i.e. 17-21 year olds). Furthermore, Constantinou et al. used an older, less standard version of the DBQ. The second purpose of this study is to provide a pool of participants for the next study. As will be described in chapter 3, one of the aims of the present thesis is to investigate, through individual testing, the specific aspects of impulsivity that may be related to problematic driving. Accordingly, a pool of participants consisting of safe and dangerous drivers, who were also available for further research, was required.

2.2.1 Hypothesis

The sole hypothesis of the present study was that there is a positive relationship between self-reported dangerous driving and impulsivity for young drivers.

2.2.2 Method

2.2.2.1 Design and participants.

This study consisted of an online questionnaire, the link to which was posted on a number of forums and was emailed to students in a number of departments within Trinity College, Dublin. The survey was completed by 1295 participants in total (675 males, 620 females) with a mean age of 25.3 years. Participants were only accepted if they were aged 17-21 which led to the removal of 671 for the main analysis. The remaining 624 participants were made up of 276 males and 348 females and had a mean age of 19.1 years. Participants were told that, by taking part, they would be entered into a raffle for a prize of a voucher.

2.2.2.2 Measures and procedure.

When participants followed the link to the online study, they were presented with a consent form/information sheet. The questionnaire itself can be seen in appendix 1 and was made up of a number of basic driving questions (see Table 2.1), the DBQ and BIS 11. Participants all completed the questionnaires in the order shown in appendix 1. The DBQ is a 27-item questionnaire that asks participants how often they engage in each behaviour using a 6 point Likert scale (*Never to Nearly all the time*). It is composed of three subscales: Lapses, Errors and Violations. While other studies have divided the violations scale into aggressive and ordinary violations (e.g. Özkan, Lajunen, Chliaoutakis, Parker, & Summala, 2006), the present study utilises a combined violations scale. The BIS asks participants to respond, on a 4 point Likert scale, to 30 different items. The options range from *Rarely/Never to Almost Always/Always* and it is made up of three scales: Attention Impulsiveness, Motor Impulsiveness and Non-Planning Impulsiveness (Patton et al., 1995).

Table 2.1. *Basic Driving Questions*

Type of licence
Engine size
Distance travelled in last year
Length of time since first started driving
Number of penalty points
Number of accidents where participant was the driver
Number of accidents where participant was at fault
Number of accidents in which damage was done to a vehicle but no injury
Number of accidents that resulted in injury or death

2.2.2.1 Assumptions.

Some of the analyses in this chapter are conducted with an ANOVA. The assumptions that were checked are listed in this section. Owing to its length, this will not be repeated in subsequent chapters with the present section serving as a reference. Despite there being no mixed-factorial ANOVAs in this chapter, the assumptions of these analyses will also be listed in this section to reduce fragmentation.

Assumptions of independent groups ANOVA The statistical assumptions assessed for the independent groups factorial ANOVAs in this study were normality of the distribution within each group and homogeneity of variance between the groups (Field, 2009). Normality was assessed using a Shapiro-Wilk test and homogeneity of variance was assessed through a Levene’s test of homogeneity of variance. For any variables in which the assumptions of normality or homogeneity of variance were breached, attempts were made to transform the data to fit them to the assumptions. In any instance where data were transformed, the transformed data were only used for statistical analysis with the untransformed data being used in tables and figures. If the data could not be transformed, non-parametric tests were carried out. If these tests revealed the same findings, then only the parametric ones were reported and no mention of non-parametric tests was made. In instances where there was a conflict between the parametric and non-parametric results, this was noted and the non-parametric tests were reported since these tests are less affected by departures from normality and homogeneity of variance.

Assumptions of mixed-factorial ANOVA Not all sources are in agreement on the assumptions that should be met in order for a mixed design ANOVA to be interpreted reliably. It is generally accepted that for a mixed design ANOVA, the assumptions pertaining to both independent groups and repeated measures ANOVAs should be assessed. To complicate matters further, most treatments of the topic assume that the repeated measures variables in a mixed design ANOVA (or in repeated measures ANOVAs) contain three or more conditions (e.g. Field, 2009; Girden, 1992). Girden states that the main assumptions for a repeated measures design are normality, equality of variance-covariance and sphericity and that in a mixed design these assumptions should be assessed within each group.

As the normality assumptions underlying a repeated measures *t* test and a one-way repeated measures ANOVA (with three or more conditions) are different, it is unclear which assumptions should be adopted in a factorial design consisting of multiple repeated measures variables that each contain only two levels (as in the studies in the present thesis). For example, Field (2009) states that normality of the individual distributions for each condition in a *t* test is unimportant but that the distribution of the difference scores of each participant should be normal. However, for a one-way repeated measures ANOVA (with more than two conditions), Girden (1992) states that there should be multivariate normality among the different conditions. Meyers, Gamst, and Guarino (2006) explain that since many standard statistical packages (e.g. SPSS) do not easily allow multivariate normality to be checked, it is generally acceptable to simply establish the normality of the distribution for each condition.

The next assumption that Girden (1992) identifies as being important in a mixed-factorial ANOVA is homogeneity of variance. Mixed-factorial ANOVAs require this assumption due to their independent groups ANOVA aspects. Girden suggests that there should be homogeneity of variance for each separate condition. The final assumption is the equality of variance-covariance, which is generally assessed with a Box's test. Field (2009) cautions that this lack of multivariate normality can negatively lead Box's test to be non-significant even in cases where the variance-covariance matrices are not equal for the groups. Accordingly, tests of normality should be examined before the results of Box's test can be interpreted accurately.

It is often argued that ANOVA is a "robust" test and remains relatively reliable even when its assumptions have been breached. However, as Field (2009) points out, this

is not always the case. Specifically, in instances where sample sizes are unequal, lack of normality and/or heterogeneity of variance can impact on the type I and type II characteristics of the test. In the mixed-factorial ANOVAs in this thesis, assessments of normality, homogeneity of variance and equality of variance-covariance will be made. Breaches of assumptions for mixed-factorial ANOVAs were treated in the same manner as in independent groups ANOVAs.

2.2.2.2 Analysis.

Participants' scores on the three subscales of the DBQ – Lapses, Errors and Violations were correlated against age, mileage and the three subscales of the BIS using Pearson correlations. As described in Table 2.1, there were a number of questions regarding the numbers and types of accidents in which participants were involved. Participants were asked to indicate the number of accidents they had been involved in, the number of these that they were at fault for, the number of accidents that resulted in damage to property and the number that resulted in injury or death. However, very few participants had ever been involved in an accident and even fewer participants had been involved in more than one. Consequently, only two accident variables were used for analysis: had participants ever been in an accident (yes vs. no) and had participants ever been in an accident where they were at fault (yes vs. no). Two sets of independent groups ANOVAs were conducted. One set of ANOVAs used gender and accident status as the two independent variables (IVs) and the BIS and DBQ scales as the dependent variables (DVs). The other set of ANOVAs were conducted on the same DVs but the IVs were gender and at-fault status (i.e. had the participants ever been involved in an accident where they were at fault). A number of the questions were collected for analysis in chapter 3 (e.g. Type of licence) and are not discussed below.

2.2.3 Results

2.2.3.1 Assumptions.

A Shapiro-Wilk test found that the distribution of violations was not normal for male and female non-accident involved groups. This lack of normality was also found for those participants who had never been involved in an accident where they were at fault. Furthermore, a Levene's Test of Equality revealed a lack of homogeneity of variance for

both ANOVAs. Both log and square root transformations failed to address these departures from parametric assumptions.

2.2.3.2 *Correlations and main effects.*

Age was found to have no significant correlations with the DBQ scales. Mileage was found to correlate with violations ($r = .24, p < .001$) and it was very weakly correlated with Errors ($r = .08, p < .05$). Age had a significant negative correlation with the Attentional Impulsiveness scale of the BIS, $r = -.09, p < .05$. There were a number of significant correlations between the DBQ subscales and those of the BIS and these are displayed in Table 2.2 below. These correlations remained significant with very few changes when the variance associated with mileage was accounted for in a partial correlation.

Table 2.2. *Correlations between the DBQ and BIS subscales.*

	1.	2.	3.	4.	5.
1. Lapses	-				
2. Errors	.6	-			
3. Violations	.4	.46	-		
4. A. I.	.36	.31	.2	-	
5. M. I.	.24	.24	.27	.44	-
6. NP. I.	.22	.24	.19	.49	.4

Note. All correlations were significant at the $p < .001$ level. A. I. = Attentional Impulsiveness; M. I. = Motor Impulsiveness; NP. I. = Non-Planning Impulsiveness.

Accident status was found to have a main effect for all three of the DBQ scales with those involved in accidents having a higher score in all cases: Lapses, $F(1,620) = 4.1, p < .05, \eta_p^2 = .007$; Errors, $F(1,620) = 8.01, p < .01, \eta_p^2 = .013$; and Violations, $F(1,620) = 30.7, p < .001, \eta_p^2 = .05$.⁴ However, a non-parametric follow-up found no difference between the groups on the Lapses scale, $U = 15569, z = 1.9, p = .058, r = .08$. Gender was found to have a main effect only for Violations, $F(1,620) = 10.5, p < .01, \eta_p^2 = .017$, with

⁴ Partial Eta Squared (η_p^2) is used as the effect size for ANOVAs reported throughout the present thesis. As suggested by (J. Cohen, 1988) .01, .06 and .13 will be interpreted as small, medium and large effect sizes respectively.

males scoring higher than females. There were no interactions between gender and accident status for any of the DBQ subscales. There was no main effect of accident status on any of the BIS subscales and there were no significant differences between males and females on these scales. Furthermore, there were no interactions between accident status and gender for any of the subscales of the BIS. Similar results emerged when accident at-fault status was used instead of accident status (i.e. participants were divided into those who had never been in an accident where they felt they were to blame and those who had been in such an accident).

2.2.4 Discussion

The results of this study are in line with previous findings and suggest that problematic driving is related to impulsivity when both constructs are measured psychometrically. The Violations scale of the DBQ was the primary focus of this study and while it had a significant relationship with all three of the BIS scales, its strongest relationship was with the Motor Impulsiveness one. The other two subscales of the DBQ, Lapses and Errors, were also related to the three BIS scales. Of the three BIS scales, the Violations subscale had the largest relationship with Motor Impulsiveness, though this relationship was still a modest one of .27 and was not much higher than its relationship with the other two subscales.

The implications of these differences are difficult to disentangle as many studies that look at the BIS scores between risk-takers or typically impulsive individuals (e.g. those with ADHD) find the latter group to be significantly higher on each of the three measures (e.g. Cheng & Lee, 2012). This is not surprising given the high correlations generally found between the three measures (as in the present study). However, Constantinou et al. (2011) did find, in a study with much fewer participants than the present one, that Motor Impulsiveness was the only BIS scale that correlated with aggressive traffic violations and that it had the highest correlation with ordinary violations. In an investigation of compulsive buying disorder, the difference between healthy controls and those with the disorder was greatest for the Motor Impulsiveness scale with the differences on the other two scales just barely reaching significance (Black, Shaw, McCormick, Bayless, & Allen, in press). In his development of an executive functioning scale, Spinella (2005) found that Motor Impulsiveness had a very strong

negative correlation with his impulse control scale. This scale contained items related to “maladaptive risk-taking”, swearing and inappropriate sexual behaviour.

In the DBQ, Lapses and Errors refer to those negative driving behaviours that are not intended (Reason, Manstead, Stradling, Baxter, & Campbell, 1990). Accordingly, their higher relationships with the Attentional Impulsiveness scale do make sense given that this scale relates to the degree to which individuals are able to stay focused on what they are doing. However, the Violations scale of the DBQ relates specifically to those behaviours that are intentional and so the issue of attention is less relevant. As applied to dangerous driving, the DSM suggests that young people drive more dangerously because they are less able to control those impulses that arise from being in a situation where there is an incentive to take a risk. Based on the research described above, the Motor Impulsiveness scale fits this profile more so than the other BIS scales and so its relationship with the Violations scale of the DBQ does offer some support for the DSM. However, Lapses and Errors were also found to be related with Motor Impulsiveness and though these relationships were not quite as high as that for Violations and Motor Impulsiveness, they were not far off.

2.2.5 Additional findings

There were a number of additional findings that, while they do not relate directly to the hypothesis, are still of interest. There was no correlation found between age and either the DBQ or the BIS scales. This is somewhat counter to previous findings with a number of studies revealing a negative relationship between age and Violations (e.g. Åberg & Rimmo, 1998; Westerman & Haigney, 2000). Stanford et al. (1996) found a similar trend for BIS scores. However, the range of ages in the present study was extremely limited at 17-21 years of age, inclusive. Since age was coded in years, this means that participants could belong to only 5 different age categories; not an ideal amount for a correlational analysis. It would not be surprising if the reducing effect of age found in previous studies was not detectable over the general variability that exists in individuals' DBQ scores. In the present study for example, scores on the Violations subscale ranged from 11 to 55 out of a maximum of 66. The DSM suggests that risk-taking reduces during late adolescence and the lack of decrease in BIS scores across age does not match this prediction. However, while the theory assumes that cognitive control is increasing during this age group, it is not a necessary, or even expected,

condition that individuals of the same age should be at roughly similar levels of this trait. As with the DBQ, the degree of individual variance over such a short age range may have masked the relationship between age and the BIS subscales.

Males and females were found to differ only on the Violations scale of the DBQ. This is in line with previous research with Åberg and Rimmo (1998) finding that the effects of both age and gender were greatest for the Violations scale. Furthermore, this fits with crash-risk trends described in chapter 1 with males being found to have a greater accident rate across all age groups. Since the present study is predominantly concerned with the relationship between Violations and Impulsivity, the finding that males and females differed in the expected direction for the former does suggest that there was some degree of accuracy in the reporting of violations among the sample. The lack of any gender differences for the BIS subscales is also in line with past research (e.g. Stanford et al., 2009) and this has a number of possible implications. It could be the case that impulsivity does not fit the role of cognitive control as described by Steinberg (2008) since the latter plays an important role in reducing risk-taking in young people and since male drivers typically drive more dangerously than females in this age group. However, the DSM does not suggest that cognitive control is the only variable that can lead to a reduction in risk-taking. For example, Figner and Weber (2011) present a particularly interesting explanation for differences between males and females in risk-taking. Firstly, they suggest that there may be a number of types of risk-taking. Two that they describe are recreational risk-taking, which covers much of what has been discussed in the present chapter, and social risk-taking, which alludes more to the idea of being socially open or even daring. They describe previous research that suggests that, while males engage in more recreational risk-taking, females are more likely to take social risks. Furthermore, they found that in both cases, the different behaviours could be explained, in part, by the perceived risks and benefits that individuals had for specific situations. Their research suggests that females perceive recreational risks as being riskier than males perceive them, while the reverse is true for social risks. Chapter 5 will explore the role of risk attitudes in dangerous driving but, for the present, it is important to note that a lack of difference between males and females for BIS scores does not necessarily indicate a shortcoming of either the DSM or the suitability of Impulsivity as the construct referred to as cognitive control in the theory itself.

On the basis of the DSM, and given the relationship between dangerous driving and accident involvement, a relationship was predicted between the latter and the BIS scales. However, as in Dahlen et al.'s (2005) study, no relationship was found between these variables. This could be due to the small number of participants in the present study who reported having been involved in accident while driving (~10%). Furthermore, as Dahlen et al. point out, accidents happen for a number of reasons, including the actions of other drivers, and so the relationship between impulsivity and accident involvement is probably very small. Violation scores were also compared between those participants who had been in an accident where they believed they were at fault and those who had not. No difference was found between these groups, though even fewer participants were involved in this analysis. A shortcoming of this method is that it requires participants to decide who was at fault in their accident.

2.2.6 Limitations and further study

There are a number of limitations in the present study. Number of violations was determined on the basis of self-report measures rather than official statistics. af Wahlberg (2009) discusses research that suggests that people can often have quite a poor memory for past driving incidents such as accidents. A number of studies have used official records to identify and contact problematic drivers (Curran et al., 2010). No infrastructure or legislation presently exists to facilitate such an approach in Ireland. A shortcoming with the use of the DBQ is that it does not take into account the amount of time that an individual spends driving. A person who rarely drives may not break the speed limit very often purely because they do not have the opportunity to do so. While there is no way to perfectly address this, participants did supply an estimate of their mileage in the last year and, as described in the results section, the relationship between Violations and the BIS scales remained relatively unchanged when the variance associated with mileage was accounted for. Most of the participants in the present study were undergraduate students and so they may not be an entirely accurate representation of the young driver population at large. However, as detailed above, the findings of this study are in line with previous ones that utilised samples from different countries and age groups, and this suggests that the relationship is quite robust.

While the above limitations are not desirable, their presence is not so severe as to totally invalidate the results. However, the self-report nature of the impulsivity measure

represents a much more serious limitation. The use of a questionnaire-measure of impulsivity is in line with the research discussed in the introduction and does reveal an interesting relationship. The items in these questionnaires are designed to tap into behaviours that are thought to stem from poor self-control, (e.g. "I do things without thinking"). It is for this reason that the construct of impulsivity appears to be such a suitable candidate for the general cognitive control element in the DSM. However, as with all observational research, there is no way to be sure of the direction of the relationship. The DSM is very much a causal theory that states that those with poorer self-control end up taking more risks. However, an alternative interpretation of the present findings is that people who are more likely to drive dangerously simply enjoy acting on the spur of the moment, but not for reasons of poor self-control. A number of researchers have attempted to measure impulsivity through behavioural tasks such as the Go/NoGo and Stop-Signal Tasks and, as will be described in the next chapter, the comparison of problematic and non-problematic drivers on tasks represents a logical extension of the results in this study.

2.3 Conclusions

The results of the present study are in line with previous research that suggests that impulsivity is related to risk-taking behaviour. This study was carried out to test the prediction of the DSM of adolescent risk-taking which suggests that those who take more risks during late adolescence and early adulthood do so because of lack of cognitive control, which itself results from underdeveloped neuronal systems. The hypothesis of this study was that there is a positive relation between driving violations and impulsivity. The results did support this with dangerous drivers being found to score higher on all of the BIS scales. There were no differences between males and females on the impulsivity measures. The relationship between all of the BIS and DBQ scores were somewhat similar though which is not explained by the DSM. The use of behavioural tasks to measure impulsivity could be a more appropriate test of the DSM given that questionnaire measures do not necessarily reflect a deficit in self-control. The relationship between these behavioural tasks and the DSM will be discussed in the next chapter which describes a follow-on study to the present one and looks at the relationship between

dangerous driving and impulsivity as measured through the Go/NoGo Task, Stop-Signal Task and Information Sampling Task.

Chapter 3: Response Inhibition, Reflection Impulsivity and Problematic Driving

3.1 Introduction

The previous chapter reviewed evidence that suggests that impulsivity fits the description of the relatively vague “cognitive control” system of the Dual Systems Model (DSM) of risk-taking. As previously discussed, impulsivity is typically seen as a tendency to act without thinking or to not plan for future events. It is typically measured through questionnaire measures such as the Eysenck’s Impulsiveness, Venturesomeness and Empathy (IVE) questionnaire or the Barratt Impulsiveness Scale 11 (BIS). As in previous work, the results of chapter 2 did indicate a relationship between questionnaire-measured impulsivity and self-report traffic violations with more impulsive individuals generally committing more driving violations. The DSM proposed that adolescents engage in more risk-taking because of underdeveloped neuronal systems which result in poorer cognitive control. However, scores on impulsivity questionnaires are not necessarily indicative of differential cognitive skills. A person may agree with the item “I do things without thinking”, not because they have an inability to stop themselves, but because they embrace a lifestyle in which they try to “live in the moment” and not deliberate too much. However, there are alternative ways to measure impulsivity which do not rely on questionnaires. This chapter details a study which attempts to relate problematic driving with performance on a number of behavioural tasks thought to measure different aspects of impulsivity such as response inhibition and reflection impulsivity.

One of the key assumptions of the DSM is that significant neurological changes are still occurring during adolescence and early adulthood (Steinberg, 2008). While a great deal of research has focused on neural development during childhood and early adolescence, there has been less investigation of changes during the late teens. Although less dramatic than in earlier years of life, there are, nonetheless, many changes that occur during later adolescence. An attempt to document all of these changes would be not only long and tedious, but would not address the central aims of the present thesis. No supporters of the DSM suggest that *all* the neurological changes in the late teens relate to cognitive control or self-regulation. The first part of this introduction will document neurological changes occurring in this age group that relate to the tasks that Steinberg refers to in his initial formulation of the DSM. Not all of the changes described below

relate directly to these tasks with some of the descriptions serving to convey the extent of the changes occurring during these years. Where the developmental differences do not relate directly to Steinberg's tasks, an attempt has been made to link them with the overarching issues of impulsivity and adolescent risk-taking.

Before reviewing these changes during adolescence, it is necessary to discuss the neurological areas that have been associated with the tasks upon which Steinberg bases the second part of his theory. The main tasks that he focuses on are the anti-saccade task, the Tower of London task and task switching tests and the nature of these tasks is described in the previous chapter. Luna et al. (2001) found that a number of brain regions displayed activation during the anti-saccade tasks including the dorsolateral prefrontal cortex (DLPFC), anterior cingulate cortex (ACC) and a number of regions primarily associated with eye control (e.g. the frontal eye field and supplementary eye fields). They found that activation in the DLPFC was the same for children and adults, but was higher for adolescents (14-17 year olds). They suggest that this increased activation was due to adolescents finding the task more difficult than adults did, while children did not try as hard at the task, since they found it too difficult, and thus displayed less activation. The Tower of London task has also been found to be associated with activation in the DLPFC along with the superior parietal region (Newman, Carpenter, Varma, & Just, 2003) and increased task difficulty was associated with increased activation. This study did not look at age related changes but, as detailed in the previous chapter, this is a task in which older participants tend to perform better at (Steinberg et al., 2008). Interestingly, while Newman et al. (2003) found that both the right and left DLPFC showed increased activation during difficult trials, their results suggest that the right DLPFC was associated more with task planning while the left side had a greater involvement during the actual execution of the plan. Furthermore, on the basis of previous research, they suggest that the superior parietal region was associated with the visuo-spatial aspects of the task. The last test that Steinberg refers to is a task-switching one. Rubia et al. (2006) found that there was right DLPFC and ACC BOLD activity for adult participants during a switch task while for adolescent (10 – 17 years of age) activity was found to occur in other areas, namely the inferior parietal and superior temporal areas of the brain. The DLPFC (particularly the right) and the ACC are two main areas of interest that emerge from studies of the types of tasks used to back the DSM of adolescent risk-taking. Indeed, this is in line with previous summaries of the role of the DLPFC with Giedd

(2004) describing it as being “...linked to the ability to inhibit impulses, weigh consequences of decisions, prioritize, and strategize” (p. 83). The ACC has also been described as having a role in cognitive control, particularly where tasks are difficult or involve a high cognitive load (Braver, Barch, Gray, Molfese, & Snyder, 2001).

The research described above refers to tasks in which adolescents perform less well than adults and it also provides a brief summary of the neural correlates of these tasks. However, the entire point of neurodevelopmental theories is that, by definition, they focus on neurological changes across ages. Demonstrating that younger people perform less well on tasks that are associated with particular regions only tells half the story. The other major questions are “What neurological changes are this age group going through?”; and, more specifically, “Are there changes in those neurological areas discussed above (the DLPFC and the ACC)?” Steinberg (2008) has provided a brief summary of neurodevelopment among this age group. However, his review is not focused on the DLPFC and ACC. Furthermore, given the wealth of neurodevelopmental evidence, many studies are missing from his review. A review incorporating a number of different studies is necessary to ensure that sufficient evidence does exist to support the theory. Another issue relates to the differences between males and females. As described in chapter 1, there is a reasonably established difference between males and females in terms of dangerous driving and involvement in car accidents. While rational and dual-processing theories do not offer direct explanations for this difference, the DSM really doesn’t address it at all. The section below will give an overview of the changes observed from early adolescence to early adulthood and will discuss some of the differences between males and females.

3.1.1 Structural changes

3.1.1.1 Grey matter.

In their review of the development of grey matter in childhood and adolescence, Gogtay and Thompson (2010) describe a number of important characteristics and developmental trends. On the basis of a number of studies, they suggest that grey matter development is characterised by a prepubescent increase in volume followed by a decrease throughout adolescence. Although this decrease is thought to be related predominantly to the pruning of an excess number of synapses, other processes such as continued intra-cortical myelination are also theorised to play a role. Gogtay and

Thompson describe these changes as not being homogenous across the major lobes. The frontal lobes seem to have the greatest grey matter volume at about 11 years of age while maximum volume in the Temporal lobes is not reached until about 14 years. Reduction in grey matter volume was found to continue right up to 30 years of age. However, Steinberg (2008) describes the reduction of grey matter volume as occurring predominantly in the frontal lobes during adolescence and that this reduction is mainly observed during pre and early adolescence. The findings of Sowell, Thompson, Tessner, and Toga (2001) are not in line with this as they found significant decreases in grey matter density of the DLPFC right up to the late 20s and Giorgio et al. (2010) describe the DLPFC as being the last area of the brain to mature at around this age.

Sex differences have been observed in overall grey matter as females were found to display peak grey matter volumes about 1-2 years before their male counterparts (Gogtay & Thompson, 2010). However, Groeschel, Vollmer, King, and Connelly (2010) found in their study of overall grey matter development that females reached peak grey matter volume before five years of age, compared with 12 years for males. Females were found not only to have a higher grey matter volume to total brain volume ratio during the second decade of life but they also displayed a sharper decrease in grey matter following peak volumes. Giedd (2004) investigated developmental changes in a number of different brain regions and the differences between males and females in terms of overall grey matter development. While he found that the DLPFC was the last area to reach maturity and that males and females did differ in terms of overall trajectory of grey matter development, he did not combine these approaches to see if males and females differed in grey matter changes for specific areas (such as the DLPFC). Although their research was with adults (aged 20-80), Mann et al. (2011) did find that there were significant differences between the sexes in the rate of grey matter reduction for the ACC. While these differences support a view of different developmental trends between the sexes, few authors have theorised as to what the psychological impact of these differences is likely to be. However, they do highlight the possibility of developmental theories being able to account for some of the differences between the males and females in adolescent behaviours such as risk-taking.

3.1.1.2 White matter.

White matter volume and distribution are also subject to change throughout adolescence as a comprehensive review by Paus (2010) reveals. The patterns of change follow a very different developmental trajectory compared with grey matter. White matter makes up about half of the brain and is characterised by its dense population of myelinated axons. Although hugely important for distal communication between different brain regions, white matter also plays a role in local connectivity—such as between those neurons sharing a cortical column or those in close proximity on the same layer. Large increases in white matter volume occur during childhood and adolescence and there are sex differences in this development. The increase in volume follows a quadratic curve for the major cerebral lobes, but follows a more linear pattern for the corpus callosum. Groeschel et al. (2010) found that females reached their peak white matter volume at about 20 years of age, while males had maximum white matter volume at about 25. Despite these relatively late ages of peak volume, the most dramatic changes occur during childhood—with about 80% of maximum volume reached by the age of 8.5 years in males and 6.5 in females.

It is not just changes in gross volume that occur during childhood and adolescence as there are also changes in the microstructure of the white matter. Water diffusion is an important characteristic of white matter and mean diffusion levels are subject to developmental changes. Furthermore, fractional anisotropy (FA), a measure of the unidirectionality of water diffusion used as an indicator of white matter maturation, is found to change throughout childhood and adolescence. Schmithorst, Holland, and Dardzinski (2008) found that in a sample of 5-18 year olds there was an interaction between age and sex for FA in the left frontal lobe. Boys displayed a positive correlation between age and FA while girls were actually found to have a negative correlation. Again, while these patterns do indicate differences between males and females, very little has been said about the implications of this. Differences between the sexes in gross development (of both grey and white matter) do establish that during adolescence males and females can markedly differ in brain structure, even if these gross differences do not tell us specifically where in the brain they are likely to differ.

3.1.2 Electrophysiological changes

Electroencephalography (EEG) is the recording of the brain's electrical activity across the scalp, particularly that activity related to cortical pyramidal cells. Spontaneous brain activity is the total activity of these cells while an individual is at rest and this activity changes along with brain maturation. A number of bands of electrical frequency are of interest in EEG analyses: delta, theta, alpha, and beta. Delta and theta waves are typically associated with sleeping or near-sleeping states while alpha waves are generally observed while an individual is resting but is still awake. Beta waves are related more with alertness and attention and are observed primarily in frontal regions. Segalowitz, Santesso, and Jetha (2010) describe a number of studies that investigated adolescent brain maturation through spontaneous EEG activity. Developmental changes in relative band strength occur first in posterior regions of the brain with slower bands (e.g. theta) being replaced with faster ones (e.g. alpha). These same changes occur later in the occipital regions and finally progress on to more frontal ones. The decrease in grey matter volume witnessed during the adolescent years is accompanied by an overall decrease in the bands of electrical activity listed above. However, despite this decrease, the frontal lobes do show more activity during executive functioning for adults compared with children. Delta, theta and alpha bands decrease monotonically across the lifespan while beta waves decline until about 20 years of age and increase slightly in the years following this (Boord, Rennie, & Williams, 2007). Although changes in grey and white matter volume do not account for all of the variance in EEG activity during development, it is thought that they are closely related to changes in EEG activity (Segalowitz et al., 2010). Accordingly, these findings are a reminder that although some of the structural changes in adolescence, particularly towards the end, may not be hugely dramatic, they can have a sizable impact on functioning, as estimated by EEG activity.

Changes are also found in sleep EEG during adolescence and these too have been hypothesised to reflect fundamental anatomic and metabolic brain alterations. Feinberg & Campbell (2010) discuss a number of sleep EEG findings in relation to adolescent development in a review of the topic. Interestingly, the initial hypothesis that significant maturational brain changes occur during adolescence stemmed from studies of sleep EEG. There are two main kinds of sleep: rapid eye movement (REM) and non-rapid eye movement (NREM). During a night's sleep, an individual will alternate between REM and NREM sleep a number of times and NREM sleep accounts for about three quarters of

sleeping activity. EEG activity during REM is relatively similar to waking activity whilst NREM is characterised by an increase in slow wave activity, particularly delta waves. However, during adolescence there is a gradual decline towards adult levels in delta wave activity during NREM sleep. Delta activity at the beginning of sleep is generally proportionate to the amount of waking time prior to sleeping; the greater the waking time beforehand, the higher the delta activity at the beginning of sleep and the decrease thereafter. This has led to the hypothesis that waking activity is accompanied by changes in neuronal activity that are then reversed during sleep (Feinberg & Campbell, 2010). NREM sleep is then seen as having a kind of homeostatic effect, restoring some neural systems to their levels found at the beginning of the previous day. A gradual decrease in this activity during adolescence could have two possible explanations. Older adolescents and adults either have a poorer ability to recuperate from waking activity or they have less activity from which to recover. The former explanation is logically unlikely as insufficient recovery from waking activity would confer a detrimentally cumulative effect. Accordingly, the decrease in NREM delta wave activity reflects a decrease in the intensity of waking brain activity (i.e. they have less recovery to do). Feinberg & Campbell (2010) suggest that this reduction may be caused by the same synaptic pruning that leads to a reduction in grey matter volume during these same years. The elimination of excess neuronal branching would result in generally faster processing times and, accordingly, lower brain activity.

The above findings all refer to research in which EEG activity is measured while an individual is in a state of rest or is sleeping. However, EEG analysis can also be used to examine responses to particular stimuli or during cognitive tasks through the measurement of event-related potentials (ERPs). While EEG does not have the same spatial accuracy as functional magnetic resonance imaging (fMRI) or positron emission tomography (PET), it has much greater temporal accuracy (Giedd, 2008). The use of ERP analysis has revealed that negative amplitudes in response to errors, believed to originate in the ACC, do not display adult-like patterns until late teens (Davies, Segalowitz, & Gavin, 2004). A similar study found that within a sample of children and teenagers, ACC activity for error-related conflict can be found to change with age (Ladouceur, Dahl, & Carter, 2004). In this latter study, two groups consisting of teens aged 9-14 and 14-17 completed a flanker task (an interference task similar to a Stroop). They found that although the younger and older groups displayed EEG activity after committing an error, the older

group displayed greater anticipatory activity before making such errors. Furthermore, the older groups displayed greater anticipatory EEG activity in response to incongruent trials (regardless of whether they responded correctly or not). The anticipatory EEG activity described in this study has previously been localised to the ACC.

According to the conflict monitoring hypothesis (Botvinick, Braver, Barch, Carter, & Cohen, 2001), the ACC is particularly important in the detection of conflict. The hypothesis suggests that the degree of cognitive control devoted to a task is proportional to the amount of conflict detected by the ACC (i.e. situations in which a large degree of conflict is detected are ones in which a greater amount of cognitive control is required). Ladouceur et al.'s (2004) findings suggest that this ability to detect conflict that may lead to an error is not fully developed until late adolescence. Younger people may be less able to recognise those situations in which they will very shortly need to invest a greater amount of cognitive control. In an investigation of gender difference in EEG activity during an inhibitory task, Liu, Zubieta, and Heitzeg (2012) found that patterns of activation were different between males and females. Interestingly, they found that ACC activity had a greater correlation with inhibition for males. Previous research suggests that the ACC displays greater activation during inhibition for people rated as being impulsive. Accordingly, they suggest that their findings may be in line with research that suggests that males are more impulsive than females. Note that their study was not a developmental one and that all of the participants were mostly around 25 years of age. Nevertheless, their findings do point to the possibility of gender differences in ACC functioning that could have implications for adolescent risk-taking.

3.1.3 Neuro-dopaminergic changes

Dopamine is a neurotransmitter that has long been associated with both the promotion and regulation of motivational behaviour. One of the primary dopaminergic systems that plays a role in this behaviour is the mesolimbic pathway which is composed of the ventral tegmental area (VTA), medial prefrontal cortex (mPFC) and a number of limbic structures – primarily the amygdala, hippocampus and the nucleus accumbens (Pierce & Kumaresan, 2006). Dopamine release occurs in the nucleus accumbens in response to signals from cortical areas which induce dopaminergic activity in the VTA and these processes are thought to play a key role in the mediation between motivational states and their related behaviours (R. A. Chambers, Jane, & Marc, 2003). The direct

study of neurochemical aspects of the brain is greatly complicated by the lack of non-invasive techniques. However, what evidence that is available suggests that the dopaminergic system goes through major changes during adolescence (Wahlstrom, Collins, White, & Luciana, 2010). Much of the evidence in this area comes from work with animal studies – predominantly with non-human primates and rodents. Because of this reliance on animal research, it is difficult to determine at what age many of these changes are likely to occur for humans, if they do at all. The dopaminergic changes experienced during adolescence can be divided into changes in concentration, innervation and receptor density.

In the lead-up to adolescence in primates concentrations of dopamine shift gradually to anterior regions of the brain (Wahlstrom et al., 2010). Dopamine levels in most posterior regions reach their highest in early childhood – long before adolescence, while in the prefrontal cortex, dopamine concentrations peak only after adolescence is reached. Furthermore, among both rats and non-human primates, there is greater dopaminergic innervation in the prefrontal cortex for adolescents compared with both children and adults (Spear, 2000). This effectively means that prefrontal areas have the capacity to receive more dopamine-related input during adolescence. The densities of the two main types of dopamine receptors (D_1 and D_2) for adolescents are higher in both cortical and subcortical areas compared with adults (Wahlstrom et al., 2010). Interestingly, cortical and subcortical areas display different patterns of change in dopamine receptor density during adolescence resulting in a difference in relative subcortical-cortical densities during these years (Steinberg, 2008).

A number of lines of evidence suggest that the dopamine system may play a large role in the increased levels of risk-taking among young people. Individual differences in dopaminergic responsiveness has been associated with extraversion (Rammsayer, 1998) and thus, increased concentrations of dopamine in the prefrontal and subcortical areas may account for some of the increased levels of adolescent risk-taking. The imbalance in cortical and subcortical dopamine receptor density has been identified as a possible basis for the changes in teen behaviour. For example, Spear (2000) suggests that the greater number of receptors in prefrontal cortex relative to subcortical areas may lead adolescents to suffer from a kind of “reward deficiency syndrome”. Spear suggests that adolescents may experience less enjoyment from typical rewards and so they seek out additional appetitive reinforcers. However, as Steinberg (2008) points out, this

explanation does not really capture the difference in dopaminergic activity between adolescents and adults. One important observation is that activity in the nucleus accumbens in response to anticipation and receipt of rewards is actually exaggerated in adolescence compared with adults and children (Galvan et al., 2006). As noted above, the nucleus accumbens plays an important role in the mesolimbic pathway. This pathway plays an integral role in motivational and appetitive behaviour and is considered to be particularly important in the mediation of the effects of emotions and affective information on behaviour (Pierce & Kumaresan, 2006). If adolescence was indeed characterised by a reward deficiency, one would not expect proportionately greater accumbens activity in reward scenarios for this age group.

An alternative description of the role of altered dopamine levels in risk-taking is that the increased dopamine may effectively 'overdose' the prefrontal region for adolescents and thus disrupt those behaviours that require prefrontal modulation (Wahlstrom et al., 2010). Conversely, the 'overdose threshold' of subcortical systems may be higher than those in the prefrontal cortex. Since subcortical systems are associated with incentive-motivated behaviour, particularly the nucleus accumbens (Galvan, Hare, Voss, Glover, & Casey, 2007), their increased (but not overdosed) activity may go unchecked by disrupted (overdosed) prefrontal functioning that leads to the kind of risk-taking behaviour typical of adolescents. This altered dopaminergic systems hypothesis may also be able to account for some of the individual differences in levels of risk-taking behaviour among adolescents. While structural changes follow a relatively similar pattern for most adolescents, genetic factors lead to quite a variance in dopamine activity among individuals. Biologically-based differences impact on the production of amino acids and enzymes associated with the synthesis of dopamine. This can lead to very different responses among individuals in similar situations. For example, higher levels of brain activation during both anticipation and response to rewards have been observed among individuals possessing genes positively associated with synaptic dopamine availability (Dreher, Kohn, Kolachana, Weinberger, & Berman, 2009).

Since the processing of much socioemotional information occurs in the same networks that are implicated in motivational processing, dopaminergic changes may also impact on adolescents' interactions in social groups during these years. In fact, the ventral striatum and medial prefrontal areas, which appear to be sensitive to variations in reward magnitude, also display activation in response to social stimuli for adolescents

(Nelson et al., 2007, as cited in Steinberg, 2008). Specifically, Nelson et al. found that when peer acceptance and rejection were experimentally manipulated among adolescent participants, neural regions associated with reward salience showed much greater activation in response to acceptance as opposed to rejection. This suggests that, at least during adolescence, social acceptance by peers may be processed in the same way as non-social rewards.

3.1.4 Driving and the brain

Driving is a complex task that involves the coordination of a number of different visual and motor skills. In order to successfully negotiate a road trip, drivers must operate a number of mechanical controls simultaneously (e.g. the clutch and gear stick), maintain awareness of the changing road conditions, adjust their speed and direction in response to changes and anticipate events before they actually happen (e.g. a child stepping out onto the road). Neuroimaging research offers an interesting way to further our understanding of the kinds of cognitive processes that are involved in driving and the order in which these processes occur. A number of researchers have utilised fMRI, PET and EEG to directly or indirectly examine the neural correlates of different aspects of driving. An important question for the present thesis is whether any brain areas that change during late adolescence have been found to be related to the task of driving. As will be discussed below, driving studies that take place in a neuroimaging environment have obvious issues of ecological validity and so the results of the studies below should be interpreted with caution.

One of the earliest studies was carried out by Walter et al. (2001) in which participants used a simple control pad to play a popular driving videogame whilst in an fMRI scanner. While Walter et al. (2001) were simply interested in the general neural correlates of driving, this same methodology, involving an fMRI scanner and simple control pad, has been used to assess neural activity associated with maintaining a safe driving distance (Uchiyama, Ebe, Kozato, Okada, & Sadato, 2003), driving while listening to audio information (Just, Keller, & Cynkar, 2008) and the differences between driving on familiar and unfamiliar roads (Mader et al., 2009). Walter et al. compared participants' performances on a passive task and an active one and found that the active task differed only in activation that was indicative of perceptual-motor integration. Accordingly, the authors concluded that driving does not engage areas concerned with higher cognitive

ability. However, as the authors point out themselves, not only does the use of a crude simulator reduce the “real-world” aspects of their study, but in the simulator task itself, participants were really only required to drive straight and not to brake or respond to road incidents. The results of the study may instead indicate the cognitive systems underlying driving straight in a computer game. Calhoun et al. (2002) conducted a similar study but gave participants directions so to increase the validity of the study. Participants were told to stay within a certain speed and had to avoid collisions with other cars. They found that a number of brain regions activated in response to different types of driving situations. Of note, activation in the frontal areas and ACC was found to be strongly associated with speed. The ACC has also been related to ability to maintain a constant distance from the car in front (Uchiyama et al., 2003). In a study of London taxi drivers, Spiers and Maguire (2007) looked at the neural correlates of specific behaviour (e.g. turning, reversing, etc.). While they found different correlates for each behaviour, they did find that the processing of road traffic rules was associated with the right lateral prefrontal cortex.

While all of the studies described above utilised fMRI technology in their investigation, PET and EEG methods have also been used to examine the neural substrates of driving. One advantage of PET is that it does not rely on a magnetic field like MRI does. While MRI studies must use specially designed equipment which is not adversely affected by this magnetic field, PET studies are much less restricted in this regard. For example, Horikawa et al. (2005) were able to use a full simulation steering wheel and acceleration pedals in their study adding a little more validity to the task. They found that predominantly motor areas (e.g. the cerebellum) and visual areas (e.g. the occipito-parietal region) were active during the driving task. However, the authors point out that, similar to the fMRI of Walter et al. (2001), there was no traffic in their task and there were no directional decisions for a participant to make. Another interesting property of PET scanning is that it allows for the observation of neuronal activity that takes place before the scanning session itself. The use of (^{18}F)2-deoxy-2-fluoro-D-glucose (FDG) in a PET scanner allows what Jeong et al. (2006) describe as a “metabolic trapping” in which neuronal activity 30-60 minutes after injection can effectively be stored. Jeong et al. used this technique in a study of driving behaviour in which, after receiving an FDG injection, participants drove an actual car on quiet roads around university where testing was being conducted. They found that their results were in line with those in previous

simulator-based studies adding a degree of validity to these. However, their study was only able to assess the correlates of general driving behaviour and not those associated with specific behaviours (e.g. speeding). A final study that is worth noting is an investigation of EEG activity in a high-tech simulator by Jancke, Brunner, and Esslen (2008). They found that during speeding and general rule-breaking, there was decreased activity in the right DLPFC which they concluded was indicative of the role that inhibition plays in reducing these kinds of behaviours.

3.1.5 Summary of neurodevelopment

The DSM suggests that young people take greater risks because they have underdeveloped cognitive control systems. Steinberg's support for these statements comes from comparisons between adults and adolescents on their performances in a number of standard tasks such as the Tower of London test. Though many different neural regions have been associated with these tests, many of them are associated with activity in the DLPFC and the ACC. Steinberg's second line of support for the theory of deficient cognitive control in young people is that they are still undergoing neurological changes that are relevant to this ability. Evidence suggests that changes in volume of grey and white matter occur throughout the late teens and into the early 20s. The DLPFC is one of the last areas of the brain to reach adult levels of grey matter. The sexes do differ in the trajectory of grey and white matter changes, though much of the work in this area has focused on gross anatomical changes rather than focusing on specific brain regions. EEG analysis has also found changes in brain activity during the teens and early adulthood. Both resting state EEG activity and ERP responses to tasks showed marked differences across age groups. Activity in the ACC during inhibitory tasks is one of the more pronounced differences between adults and adolescents with the latter group appearing to display less activity in response to error in inhibition. Another area of change during this age period is in the dopamine systems of the brain. Specifically, relative differences in number of dopamine receptors in cortical and subcortical regions for young people may be a cause of their increased risk-taking.

Interestingly, many of the areas that appear to still be developing during the teenage and young adult years have been found to be involved in driving. A number of studies have found that the DLPFC and ACC play important roles during driving simulator tasks specifically with regard to rule-following and speeding. It's worth noting that some

of the terms used to distinguish between age groups in the above studies are a bit vague (e.g. “young people”, “adolescents”). This is a persistent issue in the study of developmental change. Researchers use a large variety of age groups in their studies and there are no established rules for which ages should be grouped together. Accordingly, while some studies compared 10-17 year olds with 18-30, others grouped the participants into smaller age chunks whereby teenagers are not just compared against all adults. This difference across studies makes it hard to draw an exact picture of the development of brain regions.

3.1.6 Response inhibition

Most cognitive processes can be conceptualised as requiring inhibition. In order to complete an action, irrelevant information must not be acted upon, however automatic the reactions to the new information may be. Furthermore, changes in the situation must be responded to, even if the initially planned action is almost complete. Despite the huge interest in inhibitory processes, particularly in the neuropsychological literature, there are quite varied definitions as to what exactly it is. Inhibition is sometimes viewed as an essential and relatively broad skill of being able to stop non-relevant information from entering working memory (Band, van der Molen, Overtoom, & Verbaten, 2000). However, Garavan, Hester, Murphy, Fassbender, and Kelly (2006) distinguish between three types of inhibition: cognitive inhibition, which involves overcoming interference (as in the Stroop task); perceptual inhibition, which occurs when distracters must be ignored; and motor inhibition, which involves the cessation of inappropriate motor actions. Dillon and Pizzagalli (2007) describe motor inhibition as the least contentious form of inhibition and one of the most documented.

Two commonly used measures of response inhibition are the Go/NoGo Task (Nielson, Langenecker, & Garavan, 2002) and the Stop-Signal Task (Logan, Schachar, & Tannock, 1997) and since these tasks are used in the present study as well as being discussed below, a brief description of them is appropriate. While there are many variations of the Go/NoGo Task, they all contain trials in which a participant presses a response key (go trials) and trials in which they do not respond (nogo trials). The task is made difficult for participants as trials are presented in quick succession with a high percentage of go trials which leads participants into a rhythm of pressing the key. When a nogo trial does arrive, it can be difficult to break out of this rhythm and not press the

response key. In the Stop-Signal Task participants are presented with one of two stimuli at a time and are asked to press one button (e.g. left button) when one stimulus type is presented (e.g. an “X”) and a different button (e.g. the right button) for the other stimulus type (e.g. a “Y”). On some trials, the presence of a secondary stimulus, which occurs soon after the X or Y is presented, indicates that the participant should not respond on that trial. This *Stop-Signal* often takes the forms of a red box appearing on the screen or an auditory tone. Interestingly, the Stop-Signal Task provides an exact measure of the speed at which a participant can inhibit a response referred to as the stop-signal reaction-time (SSRT) and this is described in greater detail by Logan et al. (1997). A fast SSRT indicates that an individual is very competent at inhibiting responses. Comparisons of the tasks have found that while they are both associated with activation in a number of similar brain areas, they each have a degree of unique activation, leading Swick, Ashley, and Turken (2011) to suggest that they may address slightly different aspects of response inhibition.

In their review of the neural correlates of response inhibition, C. D. Chambers, Garavan, and Bellgrove (2009) speculate that the role of the DLPFC in response inhibition may not be entirely straightforward. The authors cite evidence that in very simple response inhibition tasks (e.g. press a key for a green stimulus but not for a red one, there is little activity in the DLPFC). However, when slightly more complicated rules for inhibition are introduced (e.g. where participants must take account of the number of preceding stimuli, right DLPFC activity is observed). They suggest that this latter task differs in terms of working memory involvement and so the DLPFC may play a role in inhibitory tasks that take place while working memory load is high or while sustained attention is required. Research that has investigated both inhibition and working memory separately does suggest that the DLPFC plays an important role in both processes (Garavan, Ross, & Stein, 1999). Garavan et al. (1999) suggest that this does make sense if one considers not just the role that working memory may play in response inhibition (e.g. remember the rules for the inhibitory task) but also the role of inhibition in successful working memory – functioning working memory requires non-relevant information to be inhibited and kept out of it.

Research also suggests that the role of the ACC is not as simple as being responsible for inhibition. In their study of the specific role of the ACC, Braver et al. (2001) describe how in past research, activity in this region has been associated with a

diverse range of tests such as stem-completion, divided attention and Go/NoGo Tasks. They hypothesise that the role of the ACC is to monitor the degree of conflict in information processing in order to determine how much cognitive control is required in a particular task. In their fMRI study, they presented participants with a number of cognitive control tasks (e.g. the Go/NoGo Task). For each task, participants were presented with an equal frequency condition (where go and nogo trials occurred with the same frequency) and a low frequency condition (where only 17% of the trials were nogo). They predicted that in the low frequency condition, the repetitive nature of the go trials would lead to a prepotent response which would cause conflict when a nogo response was required and so the ACC should show activation during the nogo trials in just this condition. Their findings were consistent with this hypothesis as the ACC was activated for the infrequent condition across a number of quite different tasks but displayed no activation for the equal frequency condition. Accordingly, they classify the ACC as a kind of generic conflict detector. Garavan, Ross, Murphy, Roche, and Stein (2002) have suggested that there may be two different neural systems underlying inhibition – a prefrontal one (involving areas such as the DLPFC) and a cingulate one. Citing findings similar to those of Braver et al., they suggest that the ACC may be more active under difficult inhibitory tasks while the DLPFC plays a more important role in maintaining working memory during less difficult tasks.

So far, this discussion of response inhibition has relied on results from experimental tasks with healthy participants. The shortcoming of this evidence is that, on its own, it calls into question whether inhibition is a real-life phenomenon at all or whether it is just a laboratory-invented idea that has no bearing in the real world. To resolve some of the ambiguity outlined above it is necessary to look at individuals who are typically considered to be impulsive or to have inhibitory deficits of some kind and to see: a) whether they have structural or functional neurological characteristics regarding the DLPFC and ACC and b) whether they differ on typical inhibitory tasks. For the tasks, particular emphasis will be given to the Go/NoGo and Stop-Signal Tasks given that these two measures of inhibition will be used in the present study. Both tasks were used in the present study given that both purport to measure the central focus of this chapter, response inhibition. Both tasks were utilised as opposed to just one since previous research has suggested that they may measure different aspects of response inhibition (Rubia et al., 2001).

Perhaps one of the most typical examples of individuals with poor impulsivity and inhibitory functioning can be seen in Attention Deficit Hyperactivity Disorder (ADHD). Seidman et al. (2006) review of a number of papers that suggest that the DLPFC and ACC, along with the orbitofrontal cortex, typically have smaller volumes in children with ADHD. In their own study, they found that adults diagnosed with the disorder had a smaller volume of grey matter compared with controls and that this was particularly pronounced in the DLPFC and ACC regions. Male adolescents with conduct disorder have also been found to have smaller grey matter volume in their DLPFC along with the lingual gyrus and cerebellum (Dalwani et al., 2011). Functional neuroimaging studies have also revealed differences between cocaine addicts and non-addicts during tests of inhibition. Kaufman, Ross, Stein, and Garavan (2003) found hypoactivity in the ACC and right insula for drug users in comparison with healthy controls. Drug addiction, conduct disorder and ADHD are all very different conditions with different causes and treatments. However, each one is often associated with individuals who are thought of as having poor self-control. The findings above support the view that the DLPFC and ACC play an important role in allowing people to exercise cognitive control.

Another relevant issue is how the groups described above perform on tasks that purport to measure response inhibition. Logan et al. (1997) describe how children with ADHD have been found to perform poorly on a Stop-Signal Task and, in an interesting demonstration of the relationship between ADHD and inhibition, Tannock, Schachar, and Logan (1995) found that the same medication that decreases symptoms in ADHD, Methylphenidate, can lead to improved performance on this task. A number of studies have found that recreational drug use is associated with poor performance on inhibitory measures. Among adolescents, performance on a Stop-Signal Task has been found to predict alcohol and illicit drug use (Nigg et al., 2006). Among adults, cocaine users have been found to have poor performance on Go/NoGo Tasks (Kaufman et al., 2003) and similar poor performance has been found for chronic methamphetamine users on a Stop-Signal Task (Monterosso, Aron, Cordova, Xu, & London, 2005).

3.1.7 Reflection impulsivity

The discussion of cognitive control in this chapter has so far focused almost exclusively on response inhibition and a number of reasons have been given for this. The neurological areas associated with response inhibition have been found to continue to

develop during the teenage years and these areas have been found to differ structurally and functionally for groups of individuals typically considered to be impulsive. Furthermore, performance in these tasks has also distinguished between these groups. However, response inhibition is not the only form of impulsivity that fits the DSM of adolescent risk-taking (Steinberg, 2008). Reflection impulsivity is a concept that shows promise in the investigation of impulsivity, though it has not received nearly as much attention as response inhibition. Clark, Robbins, Ersche, and Sahakian (2006) define the concept as the degree to which an individual collects and evaluates information relating to their immediate situation before acting. For example, an individual with low reflection might simply glance over an exam question before diving straight into an answer. Clark et al. explain that the concept was first introduced in the 1960s and that it has typically been tested using a task called the Matching Familiar Figures Test (Kagan, 1966).

This test is essentially a series of "spot the difference" games, each of which involves a main picture and six variants of it with the goal being the identification of the variant that is identical to the original picture. There is generally a negative relationship on the task between the length of time individuals take on each trial and their overall accuracy. Clark et al. (2006) report that while the Matching Familiar Figures Test has been linked with drug use in both adults and children and ADHD in just children, the test has not been without its critics. The successful completion of the task involves not just the careful collection of information, but also functioning working memory and good perceptual skills. A measure of reflection impulsivity should not relate to either of these two latter skills and this led Clark et al. to design a computerised task called the information sampling task (IST).

In the IST, participants are presented with a number of grey squares each of which has one of two colours underneath. The participants can open as many grey boxes as they like before they must decide which colour they think is in the majority. The task places much less demand on working memory and perceptual skills since there are only 25 squares in each trial. The IST has another advantage in that the correctness of a participant's response is irrelevant. A participant's probability of being correct when they answered is calculated on the basis of the number of boxes opened and the colours that had been revealed so far and it is this measure that determines reflection impulsivity in the IST.

The task has predominantly been used with individuals suffering from substance dependence. In the study in which they first introduced the task, Clark et al. (2006) found that in comparison with healthy controls, current substance users (amphetamines and/or opiates) opened fewer boxes before making a response and that their probability of being correct at the time of responding was lower. Interestingly, users dependent on amphetamines were found not to differ from those dependent on opiates in their performance on the task suggesting that the deficit was due to a general aspect of addiction as opposed to the specific effects of one drug. Solowij et al. (2012) found similar effects for adolescent cannabis users. Those with drug addiction problems are not the only individuals who have been found to display poorer performance. Lawrence, Luty, Bogdan, Sahakian, and Clark (2009) found that problem gamblers collected less information before making a decision compared with controls. Furthermore, the performance of the problem gamblers was the same as a group of alcohol dependent participants in the study.

No measure of reflection impulsivity has been used in a brain imaging context and so it is unclear which areas of the brain are associated with performance (successful or otherwise) in this task. Furthermore, no developmental studies have viewed the trajectory of performance on the IST across different age groups. These last two observations make it difficult to determine how well the task fits with previous findings of adolescent development. However, the IST does match with Steinberg's rough depiction of what cognitive control actually is and, as described above, the task has had some success in distinguishing groups often considered to be impulsive.

3.1.8 Developmental differences

The discussion so far has examined the neurological areas associated with response inhibition and whether these areas undergo development during adolescence. Additional relevant questions relate to whether those people typically considered impulsive (e.g. people with ADHD) differ in their performance on measures of response inhibition and in terms of the neurological areas associated with these tasks. The last approach to examining the possible role of response inhibition according to the DSM is to see if performance on these tasks follows a developmental pattern that is in line with the theory. As will be discussed below, a consistent difficulty with reviewing the literature of the developmental patterns of performance on these tasks is the age groups into which

researchers divide participants. The ages of the participants in each study described below will be highlighted in order to communicate what age groups the respective authors believed (implicitly or explicitly) should be grouped together.

A number of variations of the Go/NoGo Task have been carried out with different age groups. S. J. Johnstone, Pleffer, Barry, Clarke, and Smith (2005) conducted a developmental study on three age groups with mean ages of 10, 20 and 36 years. They collated the results of a number of inhibitory tasks including an auditory Go/NoGo Task and a Stop-Signal Task and found that participants displayed superior inhibitory skills as age increased. Rubia et al. (2006) found similar differences between their two age groups on a regular Go/NoGo Task. The youngest group in their study was aged between 10 and 17 years while the adults were between 20 and 43 years of age. Stevens, Kiehl, Pearlson, and Calhoun (2007) compared 11-17 year olds with 18-37 year olds and found that the younger group committed more inhibitory errors on a Go/NoGo Task. However, not all studies of inhibitory tasks have found results in line with these. Using the same participants as their 2006 study, Rubia, Smith, Taylor, and Brammer (2007) found that there were no differences between their younger and older age groups on a Stop-Signal Task. Tamm, Menon, and Reiss (2002) found no correlation between age and commission errors (incorrect responses on nogo trials) in a Go/NoGo Task with participants aged 8-20 years. However, number of commission errors was just one of three dependent variables in a multiple regression with just 19 participants, and so lack of significance in this instance may be due to small sample size. Williams, Ponesse, Schachar, Logan, and Tannock (1999) conducted a Stop-Signal Task with a large number of participants ranging in age from 6-81 years. They grouped participants into seven different age groups and while they did find that the very young groups and the very old groups performed more poorly overall, they found very few differences between the three middle groups, 13-17, 18-29 and 30-44 years. The results of the above research do not conclusively indicate the degree to which inhibitory tasks may be able to tap into changes in adolescent brain systems. An interpretation of the overall trend in inhibitory functioning across adolescence is impeded by differences between studies in terms of the age of the groups that they used and by the relative size of these age groups. For example, Rubia et al. placed participants who were 17 years old in the same group as 10 year olds but in a different group to 20 year olds. Nonetheless, tentative evidence does exist to suggest that inhibitory tasks, particularly the Go/NoGo Task, may show a developmental pattern

with young adults (e.g. 20 year olds) performing better than adolescents. To date, there have been no studies of the development of reflection impulsivity over the age groups of interest and so its developmental trajectories, particularly as measured by the IST, are not known.

3.2 Study 2

The purpose of the introduction of this chapter has been to evaluate the general question of whether adolescent risk-taking may stem from neurodevelopmental factors. One of the key issues facing the DSM is its paucity of details. Those who advocate the theory describe adolescents as lacking cognitive control. However, this is a rather nebulous concept and if the theory is to be expanded, a much clearer idea of the exact cognitive processes that contribute to risk-taking must be established. It is not enough to simply state that impulsiveness (as measured by a questionnaire) leads people to take more risks or, in the case of the present thesis, leads people to drive dangerously. The concepts of response inhibition and reflection impulsivity are introduced above as they offer a more precise description of which exact cognitive systems may be relevant in this regard. The arguments for why these tasks (the Go/NoGo, Stop-Signal Task and IST) may be relevant for problematic driving have already been presented from a neurological perspective. However, there is also a good deal of superficial overlap in terms of what is required for safe driving and for successful completion of the tasks. In a response inhibition task, the goal is to try and overcome a strong impulse to respond. In these tasks, the impulse is due to either getting into a routine (as in the Go/NoGo Task) or having already begun a response (as in the Stop-Signal Task). In the case of dangerous driving, there are a number of potential impulses that must be overcome. To avoid speeding, people may have to inhibit behaviour that they might find enjoyable or that impresses their friends. While it might initially seem like a stretch to connect these kinds of inhibitions, previous research has found poor performance on these tasks to be related to behaviours such as drug abuse (e.g. Kaufman et al., 2003) which involve a more complicated kind of inhibition. A similar case can be made for reflection impulsivity. The IST involves collecting sufficient information before making a choice and many driving violations can be seen as executing an action without having fully assessed the situation.

There are a large number of tasks that could be used to investigate the cognitive control predictions of the DSM. For example, Steinberg (2008) refers to the Tower of London test and task switching tests in support of the theory. The present tasks are selected for those reasons provided above and since they are among those tasks most clearly associated with individuals typically thought of as lacking cognitive control (e.g. individuals with substance abuse disorders). Cheng and Lee (2012) have investigated differences between problematic and non-problematic motorcyclists in China using a Stroop colour task. They found that the problematic participants did perform worse at the Stroop task which does add support to the DSM. However, this study differs from the present in that the task is not generally seen as being a measure of response inhibition (see C. D. Chambers et al., 2009). In a study much more similar to the present one, Jongen, Brijs, Komlos, Brijs, and Wets (2011) compared performance on a Stop-Signal Task with driving behaviour in a simulator. They found that poorer inhibitory control predicted deviation from driving in a straight line but that it was not predictive of more serious driving behaviours such as speeding and red light running. While this is not particularly supportive of the DSM, the study did have the usual shortcomings associated with simulator designs (e.g. ecological validity).

The present study will also examine the relationship between sensation seeking and driving behaviour. Sensation seeking is typically distinguished from impulsivity with the former describing the characteristic of searching out novel activity while the latter relates more to being able to control oneself, perhaps in the presence of such activity (Harden & Tucker-Drob, 2011). Sensation seeking is particularly relevant to the first system described by the DSM (the socio-emotional system) given that this trait has been linked with a number of different neurotransmitters, including dopamine.

As described in chapter 1, a clear distinction can be made between the degree of problematic driving engaged in by males and females. The findings in chapter 2 support this general trend and have implications for the present study. This study compared a group of problematic drivers with non-problematic ones (all drivers were selected from the sample used in the study described in chapter 2). If participants were selected solely on the basis of their dangerous driving (as measured by the Violations scale of the Driver Behaviour Questionnaire (DBQ)), then the problematic group would most likely be over-represented by males and the non-problematic by females. As described in the preceding sections, there are developmental differences between males and females. Accordingly,

any potential differences between the driving groups on the tasks in the present study could be due to the gender differences between the groups. As will be covered in the method section of study 2 (Section 3.2.2), the division of participants into problematic and non-problematic groups within each gender was to ensure an equal number of males and females in each group. This is not the first inhibitory study to take such an approach. In their investigation of the relationship between impulsivity and response inhibition, Stadler and Janke (2003) identified impulsive individuals based on their questionnaire scores separately for each gender. The implications of this separate grouping strategy are addressed in the discussion section.

3.2.1 Hypotheses

The first hypothesis was that problematic drivers have higher levels of impulsivity than non-problematic drivers as measured psychometrically. This is not an entirely independent hypothesis of this chapter since the results of chapter 2 showed a relationship between responses on the Barrett Impulsivity Scale and self-reported dangerous driving and the participants for this study were selected from these online responses. However, the sampling of participants in this study is slightly different – participants were either particularly high in Violations or particularly low (see section 3.2.2.1 for further details). The second hypothesis was that problematic drivers are poorer at response inhibition tasks than age-matched safer drivers. For the reasons outlined in the introduction, participants in the problematic group should have higher levels of impulsivity as measured by these tasks. Although each task has a number of measures, the main focus will be on the number of commission errors in the Go/NoGo Task and the SSRT in the Stop-Signal Task as these most directly assess the concept of inhibition in each respective task. The third, and final, hypothesis was that problematic drivers are less reflective when making decisions compared with non-problematic drivers. Again, the reasons for this hypothesis follow directly from the discussion of the IST in the introduction. The most important measure in this task will be the average probability of being correct for each group as this algorithm was specifically designed to assess reflection impulsivity.

3.2.2 Method

3.2.2.1 *Participants and design.*

There were 58 participants (29 male) in this study. These individuals were recruited from among the participants who took part in the study 1. Participants were assigned to one of two groups – problematic drivers and non-problematic drivers, on the basis of their responses to the DBQ in the previous study. Specifically, participants who indicated that they would be willing to take part in future research (~50%) were grouped into males and females. The 30 males who had the highest and lowest score on the Violations subscale of the DBQ were contacted to take part in this study (see appendix 2 for contact mail) and 29 of these 60 participants did take part. Those participants with high and low DBQ were designated as the problematic and non-problematic drivers respectively. The same selection procedure was carried out for the female participants with 29 of the 60 contacted female participants coming for these additional tests.

There were 29 participants in the problematic drivers group (14 males) and 29 participants in the non-problematic drivers group (15 males). The male problematic drivers had a mean Violations score of 34.2 ($SD = 6.6$) while the female problematic drivers had a mean Violations score of 26.4 ($SD = 4.8$). The scores of the problematic drivers fell within the top 25% of violation scores among all respondents who completed the online questionnaire. The non-problematic male drivers had a mean Violations score of 14.5 ($SD = 2.1$) and the mean Violations for non-problematic females was 12.6 ($SD = 1.3$). The scores of the non-problematic drivers fell within the bottom 40% of violation scores among all respondents. All participants were aged between 17 and 21 inclusive with a mean age of 19.1 years.

Participants completed a number of reaction-time tasks and questionnaires in individual, quiet testing rooms. The three reaction-time tasks were the Stop-Signal Task, the Go/NoGo Task and the IST. The variables of interest in the Stop-Signal Task were average reaction-time, accuracy, probability of inhibiting on a stop-trial and SSRT. For the Go/NoGo, groups were compared on their reaction-times to go trials, number of omission errors, number of commission errors, speed of commission errors and difference in average number of trials preceding successful and unsuccessful inhibitions. On the IST, the variables of interest were the number of boxes opened, the number of incorrect guesses and the probability of being correct at the time of responding. Participants had already completed the BIS, the DBQ and a short demographic/driving information

questionnaire as part of the previous online study (described in chapter 2). Additionally, participants completed the Zuckerman Sensation Seeking Scale (SSS; Zuckerman, 1994) and the Vocabulary test of the WAIS-R, the latter of which served as a brief measure of IQ given its high correlation with overall IQ scores (see Helmers, Young, & Pihl, 1995). A measure of IQ was taken given its common relationship with reaction-time (Der & Deary, 2003). Testing took between 40 and 50 minutes and participants were paid 10 euro for their participation. Participants were told they would receive the payment even if they chose to stop taking part in the study before they had completed all the tasks. No participants chose to end their participation prematurely. The consent form and debriefing sheet for this study can be found in appendix 2.

3.2.2.2 Materials.

Participants completed the DBQ, the BIS and the demographic questionnaire as online questionnaires prior to testing sessions – data from these tasks are described in chapter 2. The SSS was completed as a paper and pen questionnaire during the testing session. The Vocabulary test was administered using the standard WAIS-R vocabulary presentation sheet and participants' responses were recorded. The computer tasks were presented either on a 17 inch monitor or on a 15 inch laptop screen. The computer used to deliver the tasks was a Dell Latitude 15 inch with a 1.8 GHz Intel Core 2 Duo processor and 2GB ram. The Stop-Signal Task was programmed using Presentation while the Go/NoGo was created using SuperLab. The IST was a custom-built application supplied by the author of the paper in which the task was first introduced (Clark et al., 2006). Participants responded to the Stop-Signal and Go/NoGo Tasks using only a keyboard while they responded to the IST using a mouse. Participants were required to wear headphones for the Stop-Signal Task. Testing took place in individual testing rooms and took about 50 minutes per participant.

3.2.2.3 Procedure.

Participants completed all questionnaires except the SSS as part of the previous study and the tasks were completed in a random order. The order that participants completed the tasks below was randomised in such a way as to ensure that they completed a behavioural task, a questionnaire (either the BIS or the WAIS), a behavioural task, the remaining questionnaire and the final behavioural task.

Stop-Signal Task. Participants were presented with written instructions on the computer screen and the experimenter talked them through these instructions to ensure that they understood precisely what the task involved. In the task itself, participants were presented with a number of Xs and Os (one at a time). They were asked to press the 'L' key on a keyboard if an 'X' was presented and the 'Z' key if an 'O' was presented. They were told not to focus too much on the letter names of the keys, but to conceptualise the responses as 'right-hand key for X and left-hand key for O'. They were told to respond to each letter as fast as possible when it was presented on screen and were then given 10 practice trials. After these, participants were told that on some trials, the presented letter would be accompanied by a clearly audible tone and that on these trials they should not respond to the letter. They were told that this tone would come at different times on different trials and that they would not be able to stop themselves from responding on all of these stop-trials. It was emphasised that they should still respond to the letters as quickly as possible and that they should only stop themselves from responding on stop-trials if they were able to. They were then given 18 more practice trials, six of which were stop trials (i.e. those accompanied by the tone). The main task consisted of 256 trials (128 Xs and 128 Os) and 64 of these (32 Xs, 32 Os) were stop-trials. Participants were given a break half way through for as long, or short, as they pleased.

Each trial consisted of an empty black screen for 1000ms, a fixation cross, '+', for 500ms and the target letter for 1000ms. All stimuli were white characters presented at the centre of the screen and were font type "Tahoma". The '+' was font size 24 while the target letters were size 70. Only the first response to each trial was recorded and responses did not impact the length of the trial. The stop tone was a 1,000Hz pure tone which lasted for 100ms. For the practice trials the tone was presented 100ms after the target letter. However, during the main task, the delay between the presentation of the letter and the tone was variable. For the first stop-trial, the tone came 250ms after the letter. If the participant was successful in not responding, then on the next presentation of the letter, the delay would be increased by 50ms. However, if the participant did respond on a stop-trial, then the delay would be reduced by 50ms on the next stop-trial. The delay could decrease to as much as 0ms (i.e. simultaneous presentation) but the tone would never come before the target letter was presented. The delay time was reset to 250ms at the halfway break.

Go/NoGo Task Participants were presented with written instructions on the computer screen that informed them that on this task the letters X and Y would be presented one at a time in an alternating fashion (i.e. 'X, Y, X, Y...'). They were instructed to push the space bar each time a letter appeared on screen. They were then told that occasionally the sequence would be broken by a letter repeating itself (e.g. 'X, Y, Y'). Participants were told that if a letter repeats itself, they should not press the space bar on its second presentation and that a letter would never be presented more than twice in a row. They were then given 25 practice trials of which 4 were nogo trials (ones in which they were not to press the space bar). The main task consisted of 315 trials of which 20 were nogo ones. Each trial consisted of an empty black screen for 400ms followed by the presentation of the target stimulus for 600ms. The stimuli were font size 100 and were coloured white. Though there are many versions of the Go/NoGo Task, the present one is closest to one by Roche et al. (2004) except that the blank screen and stimulus presentation times in their study were 300ms and 700ms respectively. This change was made to increase task difficulty since, unlike the Roche's study, the present one was not dealing with patients with traumatic brain injury. Unlike the Stop-Signal Task, participants were not told to respond as fast as possible, but were instead instructed to respond while the stimulus was still on screen.

Information Sampling Task The instructions for the IST were presented verbally to the participants. All participants completed the same practice trial as per the original study (Clark et al., 2006). Each trial consisted of 25 adjacent grey squares in a 5 X 5 design. At the bottom of the screen, there were 2 larger squares each a different colour (e.g. yellow and blue). Participants were told that clicking on a grey square would uncover one of the two colours underneath it and that these opened squares remained open for the duration of a trial. Their task was to open as many squares as they liked and, when they thought they knew it, to indicate which colour they thought was in the majority under all of the squares. They indicated their answer by clicking on one of the two larger squares below. For the practice trial, if they got the answer correct, they received 100 points and if they got it incorrect they lost 100 points. To remind them of this, "Win 100" and "Lose 100" were written in the top left of the screen. Participants were then free to complete the practice trial. Their points after this practice trial were then reset and the main task began.

For the actual task, there were two conditions. In the Fixed Win (FW) condition, the points system was the same as in the practice trial – if participants got the answer correct, they received 100 points and they lost 100 if they got it incorrect and these scores were not affected by the number of boxes a participant opened. In the Decreasing Win (DW) condition, participants began with the opportunity to win 250 points. However, each time they opened a box, this amount dropped by 10 points. If they got the answer correct, they won whatever points remained, while if they got it incorrect, they lost 100 points regardless of how many boxes they had opened. “Win (250-10K)” and “Lose 100” were written in the top left of the screen (where K was the number of boxes already opened). There was a variable delay between each trial of at least one second. If the participant finished the trial in less than 30 seconds, then the length of the delay would be 30 seconds minus the time they had taken to complete the trial (i.e. each trial lasted at least 30 seconds but there was no upper limit to how long each one could last). If participants took longer than 30 seconds, then the delay was only one second. During the delay between trials, participants were shown their present score. The order of the conditions (FW and DW) was randomly decided for each participant and there were 20 trials in total – 10 for each condition. The instructions for each condition were explained to participants before each respective condition began. The number of points that a participants won had no impact on their payment for participation.

3.2.2.4 Analysis.

For all of the analyses in this study, there were two IVs, each with two levels: driving group (problematic vs. non-problematic) and gender (male vs. female). Some of the analyses contained additional IVs, but these two were present for all analyses.

Demographics, driver details and WAIS-R. The four groups were compared for differences on a number of demographic and driver detail variables –age, type of license (learners permit vs. full licence), engine size, distance travelled last year, number of penalty points and number of accidents while driving. Any categorical variables were investigated using Chi-Square analysis while the continuous variables were analysed in a factorial independent groups ANOVA with driving group and gender as the fixed factors. The groups were also compared on their scores on the WAIS-R vocabulary score in an

ANOVA analysis. Unlike the analysis of the main tasks of this study, the tests of the statistical assumptions for these variables are not reported in the text.

Stop-Signal Task The four variables investigated in the Stop-Signal Task were reaction-time, accuracy, probability of inhibiting on a stop-signal trial and SSRT. Reaction-time was calculated for trials that were not stop-trials and that participants correctly responded to. Accuracy referred to whether a participant gave the correct response to trials which were not stop-trials. Participants' probability of inhibiting on a stop-trial was a function of the number of stop-trials that they successfully did not respond to divided by the total number of stop-trials. SSRT was based on an algorithm described by Logan et al. (1997) which relates directly to the nature of the timing of stop-trials as described in section 3.2.2.3. The stop-signal delay is, on a stop-trial, the time at which the trial begins and the time at which the stop-signal is presented. The task is set up such that when participants incorrectly respond on a stop-trial, the next stop-trial has a 50ms shorter stop-delay (i.e. the tone comes 50ms quicker compared with the last trial). The purpose of this approach is to estimate the stop delay at which a participant has a 50/50 chance of inhibiting. This 50/50 point is calculated by averaging all of a participant's stop-signal delay times. The SSRT is the average reaction-time to go trials minus the average stop-signal delay time. The groups were compared on all the variables using an independent groups factorial ANOVA for each variable. ANCOVAs were carried out for the reaction-time measures (reaction-time to go trials and SSRT), WAIS-R vocabulary scores were entered as a covariate in the analysis. Furthermore, the relationships between the four variables were investigated through Pearson correlations.

Go/NoGo Task The variables of interest in the Go/NoGo Task were reaction-time to go trials, number of omission errors, number of commission errors, speed of commission errors and number of go trials before successful and unsuccessful inhibition. The reaction-time to go trials was the average reaction-time of participants to all go trials that they did actually respond to. Omission errors were those go trials in which a participant did not respond. Commission errors were nogo trials in which a participant incorrectly responded and the speed of commission errors was the average speed at which participants responded on these incorrect trials. The above variables were all entered into separate independent groups factorial ANOVAs with driving group and

gender as the fixed factors. For the reaction-time measures (reaction-time to go trials and commission error reaction-time), WAIS-R vocabulary scores were entered as a covariate in the analysis. Number of preceding go trials was analysed in a mixed-factorial ANOVA with success as the repeated measures variable (successful vs. unsuccessful inhibition) and driving group and gender as the independent groups variables. Reaction-time to go trials and speed of commission errors were compared against each other in a mixed-factorial ANOVA with trial type (go vs. nogo) as the repeated measures variable and driving group and gender as the independent ones. Lastly, commission errors, omission errors, reaction-time to go trials and speed of commission errors were correlated against each other.

Information Sampling Task The variables of interest in the IST were the number of boxes opened, the number of incorrect guesses and the probability of being correct at the time of guessing. The number of boxes opened referred to the average number of boxes that a participant opened before making a decision on a trial. The number of incorrect guesses was simply the number of trials in which a participant gave an incorrect response. The probability of being correct at the time of guessing is an algorithm devised by Clark et al. (2006) which takes into account the number of boxes that a participant has opened and the colour that has been revealed under each one. The exact formula used to calculate this probability is:

$$P(\text{Correct}) = \frac{\sum_{k=A}^z \binom{z}{k}}{2^z}$$

Where $z = (25; \text{total number of boxes}) - \text{number of boxes open}$ and $A = (13 - \text{number of boxes of chosen colour})$. The above variables were entered into a mixed-factorial ANOVA with condition (FW vs. DW) as the repeated measures variable and driving group and gender as the independent groups variables.

Relationships across tasks and questionnaires. Participants' responses on the experimental tasks were compared with their scores on the SSS and the BIS using Pearson Correlations. Furthermore, participants' responses on each of the tasks were compared

with responses on the other tasks (e.g. reaction-time to go trials on the Go/NoGo Task and reaction-time to go trials on the Stop-Signal Task). Comparisons were also made between participants' responses across the two questionnaires.

3.2.3 Results

3.2.3.1 *Demographics, driver details and WAIS-R.*

The two driving groups (problematic vs. non-problematic) did not differ in their age, distance travelled last year, number of accidents involved in as a driver or engine size of car. Although information about penalty points was collected, no comparison was made for this variable as one group (non-problematic males) consisted of participants with no points. The driving groups did differ in the number of full licence holders, with proportionately more problematic drivers having a full licence compared with non-problematic drivers, $\chi^2(1, N = 58) = 4.1, p < .05$. The driving groups did not differ in their WAIS-R vocabulary score. Males and females were equal on all of the above variables with the exception of age with females ($M = 19.24, SD = 0.95$) being older than males ($M = 18.7, SD = 0.66$), $F(1,54) = 6.5, p < .05, \eta_p^2 = .11$.

Given that the groups were picked on the basis of their Violations score, it is not surprising that there was a significant difference between the groups for this variable, $F(1,54) = 223.7, p < .001, \eta_p^2 = .81$. However, there was also a significant difference between males and females for Violations, $F(1,54) = 18.7, p < .001, \eta_p^2 = .26$, and there was a significant interaction between gender and driving group, $F(1,54) = 6.95, p < .05, \eta_p^2 = .11$. This interaction was due to there being a larger difference between males and females in the problematic group, $t(27) = 3.65, p < .01, d = 1.35$, compared with the non-problematic group, $t(27) = 2.84, p < .01, d = 1.07$.

3.2.3.2 *Psychometric measures.*

Tests of statistical assumptions The normality of the distributions of responses for all SSS subscales (shown in Table 3.1) and for the total score, were assessed with a Shapiro-Wilk test. This was done for all four groups (male problematic, female problematic, male non-problematic and female non-problematic). All scales displayed normality with the exception of the Thrill and Adventure Seeking subscale which displayed a significant score in all four groups. A Levene's test for homogeneity of variance found equal variance across all four groups for the subscales and the total score.

Shapiro-Wilk tests found the distribution of responses in the three subscales of the BIS to be normally distributed for the four groups (see Table 3.1 for a list of the subscales). Homogeneity of variance was found for all of the subscales.

Table 3.1. *Subscales of the SSS and the BIS*

Sensation Seeking Scale	Barratt Impulsiveness Scale
Thrill and Adventure Seeking	Attentional Impulsiveness
Experience Seeking	Motor Impulsiveness
Disinhibition	Non-Planning
Boredom	

*Main effects and interactions*There was a main effect of driving group for three of the SSS subscales and for the total SSS score and these effects are depicted in Figure 3.1. The problematic group had a higher score on the Experience Seeking subscale, $F(1,54) = 4.5, p < 0.05, \eta_p^2 = .08$, Disinhibition, $F(1,54) = 14.2, p < 0.001, \eta_p^2 = .21$, and Boredom , $F(1,54) = 7.98, p < 0.05, \eta_p^2 = .13$. The problematic driving group also scored higher ($M = 25.9, SD = 4.1$) than non-problematic drivers ($M = 20.3, SD = 6.1$) on the overall sensation seeking score, $F(1,54) = 16.5, p < 0.001, \eta_p^2 = .23$. There was a main effect of gender for just the Boredom subscale with males ($M = 4.3, SD = 2.4$) scoring higher than females ($M = 3.1, SD = 2.2$), $F(1,54) = 5.1, p < 0.05, \eta_p^2 = .09$. There were no interactions between driving group and gender for any of the subscales or total.

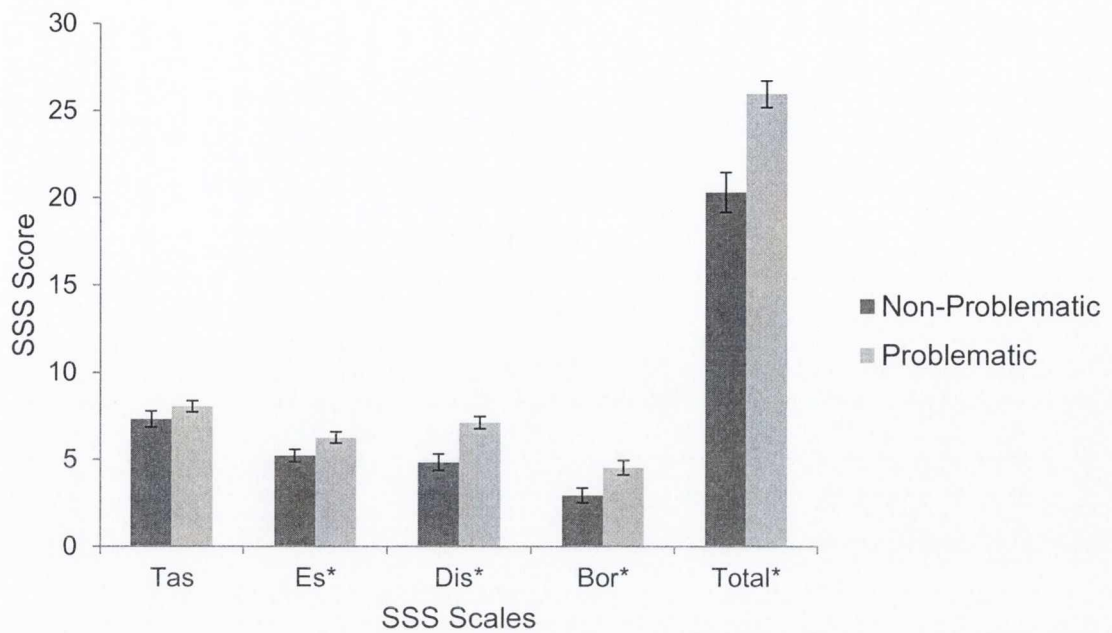


Figure 3.1. Comparison of problematic and non-problematic drivers on all four subscales of the SSS and on the total score.

Note. Tas = Thrill and Adventure Seeking; Es = Experience Seeking; Dis = Disinhibition; Bor = Boredom. Bars represent standard errors. * $p < .05$

There was a main effect of group for the three subscales of the BIS and the differences between the groups are displayed in Figure 3.2. Problematic drivers scored higher on Attentional Impulsiveness, $F(1,54) = 5.62, p < 0.05, \eta_p^2 = .09$, Motor Impulsiveness, $F(1,54) = 7.2, p < 0.05, \eta_p^2 = .12$, and Non-Planning, $F(1,54) = 7.3, p < 0.01, \eta_p^2 = .12$. There was a main effect of gender for the Non-Planning scale with females ($M = 26, SD = 5.8$) scoring higher than males ($M = 22.3, SD = 5.5$), $F(1,54) = 6.5, p < 0.01, \eta_p^2 = .2$. There were no interactions between driving group and gender.

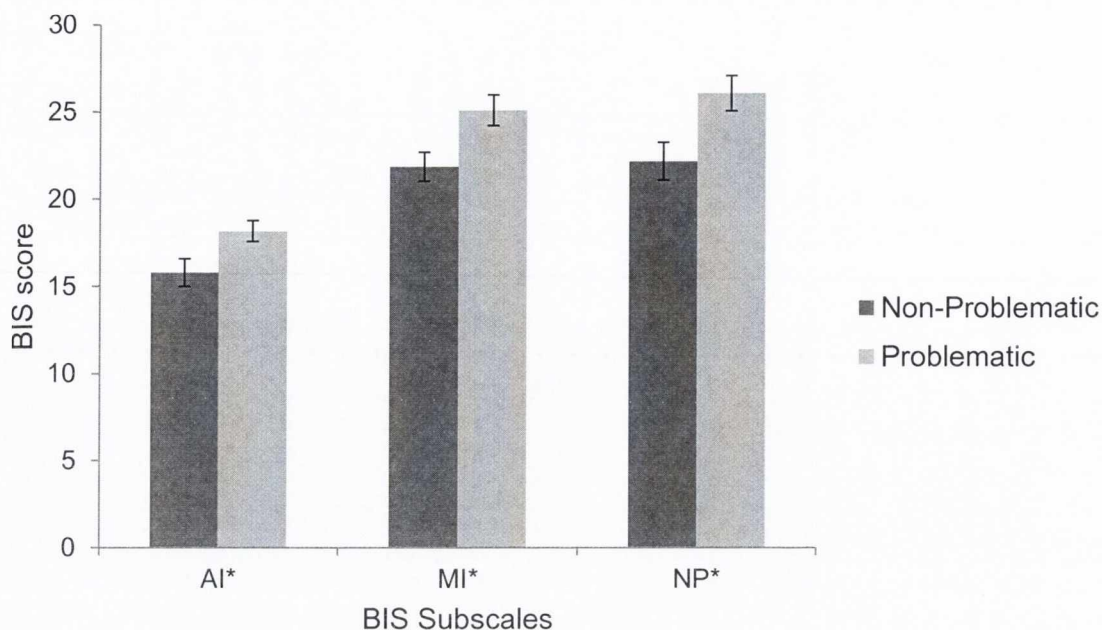


Figure 3.2. Comparison of problematic and non-problematic drivers across the three BIS subscales.

Note. * $p < .05$. AI = Attentional Impulsiveness; MI = Motor Impulsiveness; NP = Non-Planning. Bars represent standard errors.

3.2.3.3 Stop-Signal Task.

Tests of statistical assumptions A Shapiro-Wilk test found that SSRT was normally distributed for all of the groups. The probability of inhibiting was normal for all groups except for problematic males and reaction-time to go trials was normal for all groups apart from problematic females. The accuracy of participants to go trials was found not to be normal for all of the groups except for problematic males. Accuracy was the only variable in which a Levene's test was significant, $F(3,54) = 5.7, p < .01$. Log and square root transformations were unable to correct these departures from parametric assumptions.

Main effects and interactions. There was no main effect of driving group for reaction-time to go trials, probability of inhibiting or accuracy to go trials. The non-problematic drivers had a higher accuracy and a higher probability of inhibiting while the problematic drivers had a faster reaction-time to go trials. However, none of these differences were statistically significant. The non-problematic drivers did have a faster SSRT ($M = 205\text{ms}, SD = 46$) than the problematic drivers ($M = 221\text{ms}, SD = 45$), but this difference was not statistically significant, $F(1,54) = 1.85, p = .18, \eta_p^2 = .03$. There was a

main effect of gender for probability of inhibiting on a stop-trial with females having a higher chance than males, $F(1,54) = 5.9, p < .05, \eta_p^2 = .1$. Since probability of inhibiting was not found to be normally distributed and since non-parametric tests differed from parametric ones, the former are reported (as described in section 2.2.2.1). A Mann-Whitney U test did not support the main effect in the ANOVA. Females were not found to be significantly more likely to inhibit a stop-trial compared with males, $U = 320, z = 1.57, p = .12, r = .2^5$. There was no effect of gender on any of the other three variables. There were no interactions between driving group and gender for any of the variables. A one sample t test conducted for all of the participants found that their probability of inhibiting was not significantly different from .5, $t(57) = .63, p = .53, d^6 = 0.08$. With regard to the relationships between the Stop-Signal Task variables, probability of inhibiting on a stop trial was found to be positively correlated with reaction-time to go trials, $r(56) = .75, p < .001$, and negatively correlated with SSRT, $r(56) = -.41, p < .01$.

3.2.3.4 Go/NoGo Task.

Tests of statistical assumptions Number of commission errors, reaction-time to go trials, number of trials preceding successful inhibition and number preceding unsuccessful inhibition were normally distributed for all four groups according to the results of separate Shapiro-Wilk tests. Reaction-times for incorrect responses were normally distributed for all groups except for non-problematic males. This lack of normality was not corrected given that only one group was not normally distributed and that this variable is entered into a repeated measures analysis with reaction-time to go trials which was normally distributed. Number of omission errors was not normally distributed for any of the groups. This lack of normality was corrected with log transformations. Separate Levene's tests for homogeneity of variance found that there was equality of variance across the groups for all variables (i.e. the two groups did not differ in the variance of any of the independent variables). Box's test found that there was not equality of the variance covariance matrices for the groups for the mixed-factorial ANOVA comparing average reaction-time to go trials and average reaction-time for commission

⁵ Field (2009) recommends using r as an effect size measure in Mann-Whitney U and Wilcoxon T tests.

⁶ Cohen's d is used throughout the present thesis to measure effect size for t tests. J. Cohen (1988) suggests that a d of 0.2, 0.5 and 0.8 represents an effect size of small, medium and large respectively. It is worth noting that d and r are not directly comparable since d can exceed a score of 1.0.

errors. Box's test did find equality of the variance covariance matrices for the ANOVA comparing number of trials preceding successful and unsuccessful inhibition.

Main effects and interactions. Participants made an average of 11.1 commission errors in the Go/NoGo Task but there was no main effect of driving group or gender on the number of errors made. Problematic drivers actually made fewer errors but, as stated, this difference was not significant. The average reaction-time when making errors was 320ms but there was once again no impact of driving group or gender on this reaction-time. Participants made three omission errors on average but the groups did not differ significantly for this variable either. Participants' average reaction-time to go trials was 366ms and this did not differ between the groups. Reaction-time to error trials was found to be significantly faster compared with regular go trials, $F(1,54) = 73.8, p < .001, \eta_p^2 = .58$. This pattern was found to be the same across all groups. The mean number of trials before a successful inhibition was smaller than the number before an unsuccessful one, $F(1,53) = 6.4, p < .05, \eta_p^2 = .11$, but this again was not found to differ between any of the groups. No interactions between the independent variables were found in any of the analyses described above. Number of commission errors was found to be negatively related to both reaction-time to go trials, $r(56) = -.52, p < .001$, and commission error reaction-time, $r(56) = -.37, p < .01$. There was a strong positive relationship between reaction-time to go trials and commission error reaction-time, $r(56) = .867, p < .001$.

3.2.3.5 Information Sampling Task.

Tests of statistical assumptions A Shapiro-Wilk test was conducted to investigate the normality of all three variables in both conditions (FW and DW). The number of boxes opened was found to be normally distributed in both conditions for all four groups. A number of the groups were not found to have normal distributions for number of errors made in the task. For probability of being correct, normal distributions were found for all but one group (female problematic in the FW condition). These departures from normality could not be corrected with log and square root transformations. All variables were found to have equal variance among the groups with the exception of number of boxes opened in the DW condition, $F(3,54) = 4.2, p < .05$. This lack of homogeneity of variance was corrected by log transforming number of boxes opened in both the FW and

DW conditions. A Box's test found that the groups' variance covariance matrices were equal for all of the variables.

Main effects and interactions. Overall, participants made more errors in the DW condition compared with the FW one, $F(1, 54) = 42.4, p < .001, \eta_p^2 = .44$. There was no main effect of driving group or gender on the average numbers of errors but there was an interaction between driving group and condition, $F(1,54) = 6.05, p < .05, \eta_p^2 = .1$. Figure 3.3 suggests that non-problematic drivers made more errors than problematic drivers in the FW conditions, while this difference was reversed for the DW with problematic committing more errors. However, neither of these differences by themselves were statistically significant, $t(56) = 1.5, p = .13, d = 0.41$, and $t(56) = -1.3, p = .2, d = 0.3$, respectively. Both groups made more errors in the DW conditions, but this difference was more pronounced for problematic, $t(28) = 6.9, p < .001, d = 1.3$, compared with non-problematic drivers, $t(28) = 2.7, p < .05, d = 0.5$.

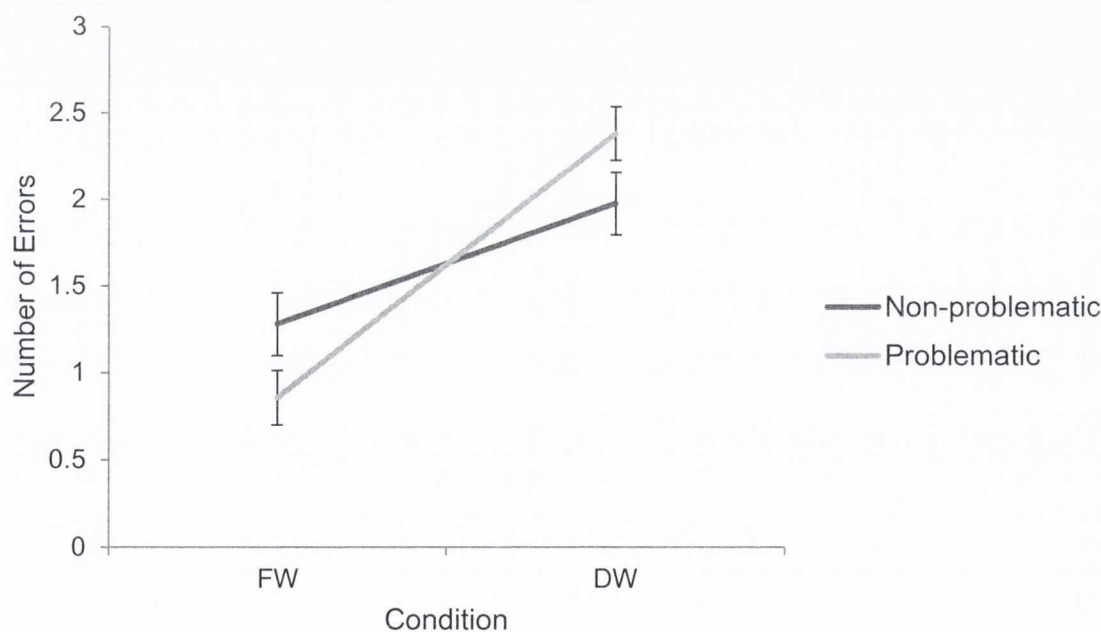


Figure 3.3. Average number of errors made by each group in the FW and DW conditions. Note. Bars represent standard errors with Cousineau-Morey adjustments (Cousineau, 2005; Morey, 2008)

Participants opened more boxes in the FW condition compared with the DW one, $F(1,54) = 73.8, p < .001, \eta_p^2 = .58$. However, there was no main effect of driving group or gender and there was no interaction between any of the independent variables.

Participants had a higher probability of being correct when they responded in the FW condition compared with the DW one, $F(1,54) = 79.1, p < .001, \eta_p^2 = .59$. There was no main effect of driving group or gender but there was a significant interaction between driving group and condition, $F(1,54) = 5.4, p < .05, \eta_p^2 = .09$. As shown in Figure 3.4, problematic drivers had a higher probability of being correct when responding in the FW conditions while non-problematic drivers had a higher probability of being correct in the DW condition but neither of these differences were statistically significant, $t(56) = 1.4, p = .17, d = 0.37$ and $t(56) = .996, p = .32, d = .26$, respectively. The non-problematic drivers had a higher probability of being correct in the FW condition compared with the DW one, $t(28) = 4.9, p < .001, d = 0.96$, while the problematic drivers displayed the same pattern, $t(28) = 7.8, p < .001, d = 1.46$, the difference was greater for this group.

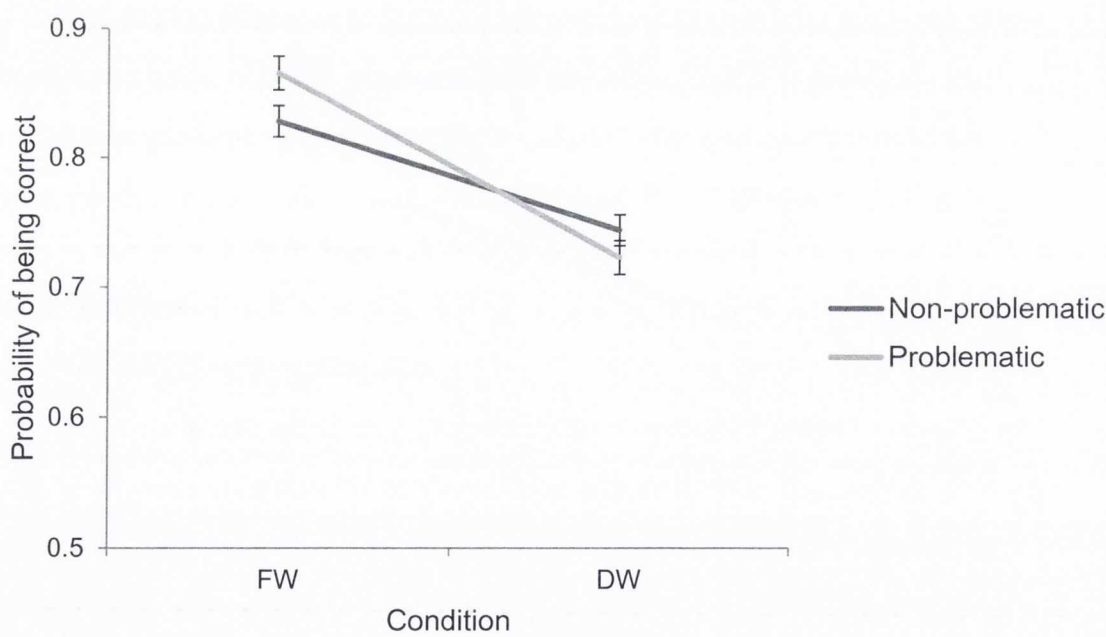


Figure 3.4. Average probability of being correct when responding for both driving groups in the FW and DW conditions.

Note. Bars represent standard error with Cousineau-Morey adjustments.

3.2.3.6 Relationships across tasks and questionnaires.

The variables in each of the computer tasks were correlated against each other and against participants' responses in the SSS and BIS. Table 3.2 details the relationships between participants' responses in the Stop-Signal Task and the Go/NoGo Task. There was a medium relationship between SSRT and reaction-time to go trials in the Go/NoGo Task, $r(56) = .44$, and between SSRT and reaction-time to commission errors, $r(56) = .51$. The only other significant relationship between the tasks was that between accuracy to go trials in the Stop-Signal Task and number of commission errors in the Go/NoGo Task.

Table 3.2. Correlations between the Stop-Signal Task and Go/NoGo Task variables

Stop-Signal Variables	Go/NoGo Variables			
	Go RT	Comm. Errors	Comm. Error RT	Om. Errors
SS Go	.23	-.04	.16	.21
SSRT	.46**	-.01	.51**	.17
Accuracy	.02	-.31*	.02	-.09
Prob. Inhibit	-.03	.05	-.08	.13

Note. ** $p < .001$, * $p < .05$

There were no significant relationships between the variables in the IST and those in either the Stop-Signal Task or the Go/NoGo Task. A number of the subscales of the SSS were correlated with some of the measures from the computer tasks. Correlations between all of the variables that had at least one significant correlation are listed in Table 3.3 below. For the Stop-Signal Task, SSRT was correlated with both the Boredom subscale, $r(56) = .28$, and with the total SSS score, $r = .29$. For the Go/NoGo Tasks, the Boredom subscale and total SSS scores were correlated with reaction-time to go trials ($r = .27$ and $r = .32$ respectively). These scales were also with commission error reaction-times ($r = .32$ and $r = .33$ respectively), and the Experience Seeking subscale was also correlated with this variable, $r = .28$. For the IST, there was a significant correlation between probability of being correct in the DW condition and both the Disinhibition subscale, $r = -.34$, and the total SSS, $r = -.28$.

Table 3.3. *Correlations between SSS scales and computer tasks.*

SSS Scales	<u>Stop-Signal</u>	<u>Go/NoGo</u>	<u>IST</u>	
	SSRT	Go RT	Comm. Error RT	Probability DW
Experience Seeking	.25	.28*	.23	-.05
Disinhibition	.13	.16	.2	-.34*
Boredom	.28*	.27*	.32*	-.21
Total SSS	.29*	.32*	.33*	-.28*

Note. * $p < .05$. Only variables with at least one significant correlation are listed.

There were very few statistically significant correlations between the BIS subscales and the variables in either the Stop-Signal Task or the Go/NoGo Task. Motor Impulsiveness was correlated with reaction-time to go trials in the Stop-Signal Task, $r(56) = .28$, and Attentional Impulsiveness was correlated with number of omission errors in the Go/NoGo Task, $r(56) = -.28$. There were a number of significant correlations between the BIS scales and measures on the IST and these are displayed in Table 3.4 below. A clear trend that emerges is that number of errors had a positive correlation with almost all of the BIS subscales while number of boxes opened and probability of being correct were negatively related to the BIS scales. Furthermore, the Motor Impulsiveness and Non-Planning scales were the only ones with statistically significant relationships with IST variables and all of these occurred in the DW condition.

Table 3.4. *Correlations between the BIS subscales and the IST measures.*

BIS Scales	<u>IST Variables</u>					
	Errors FW	Errors DW	Boxes FW	Boxes DW	Prob. FW	Prob. DW
Attentional Impulsiveness	-.01	.19	-.15	-.16	-.17	-.24
Motor Impulsiveness	.25	.3*	-.12	-.22	-.21	-.34**
Non-Planning	.15	.29*	-.02	-.24	-.13	-.35**

Note. ** $p < .01$, * $p < .05$

There were a number of significant correlations between the BIS subscales and the SSS ones. From the point of view of the BIS, there were slightly more correlations for the Motor-Impulsiveness and Non-Planning scales and these correlations tended to be higher compared with the Attentional Impulsiveness scale. For the SSS, the highest number of significant correlations was found in the Experience Seeking and Disinhibition scales along with the total SSS score.

Table 3.5. *Correlations between the BIS and SSS scales*

BIS Scales	Thrill and Adventure	Experience Seeking	Disinhibition	Boredom	Total SSS
Attentional Impulsiveness	.2	.28*	.27*	.1	.32*
Motor Impulsiveness	.03	.4**	.43**	.34**	.46**
Non-Planning	.03	.43**	.38**	.26*	.42**

Note. ** $p < .01$, * $p < .05$

3.2.4 Discussion

Though the results of the study were mixed with regard to the stated hypotheses, the overall trend was that the DSM was not supported in its application to dangerous driving among young people. The problematic driving group did score higher on a number of scales on the SSS and on all of the BIS scales. However, there was no difference between the driving groups on any of the measures in either the Go/NoGo Task or the Stop-Signal Task. The groups did display different behaviour as measured on the IST, though the implications of the specific differences are unclear. The results will be discussed according to the specific hypotheses proposed in section 3.2.1 .

3.2.4.1 Hypothesis 1.

The first hypothesis predicted that problematic drivers would score higher on the questionnaire measures of impulsivity. The problematic driving group indicated higher levels of impulsivity on all of the scales of the BIS. Though the partial eta squared indicated large effects for all three differences (according to Cohen’s rough criteria (J. Cohen, 1988)), those associated with Motor Impulsiveness and Non-Planning were higher

than that of Attentional Impulsiveness. This is particularly interesting since Motor Impulsivity and Non-Planning contain items that Steinberg et al. (2008) highlighted as being particularly relevant for cognitive control. Their reasoning for pointing to these scales in particular relates to the kinds of questions they contain. The Motor Impulsiveness scale relates to doing things without thinking and acting on the spur of the moment which does fit with the general description of cognitive control. A similar case can be made for Non-Planning Impulsiveness which contains statements relating to how careful and planned out a participant's thoughts and actions are. They excluded a number of items from the Attentional Impulsive scale from their own analysis and yet the present groups did differ on this scale. This scale does contain questions such as "[How often are you] restless at the theatre?" which are not easily associated with driving. However, other items belonging to this scale ask participants to rate the statements "I am a careful thinker" and "I concentrate easily" which, it is easy to imagine, would be relevant for drivers. However, it's not clear why issues of concentration might be related to deliberate violations (as opposed to lapses and errors); the variable that distinguishes the groups in this study. Accordingly, the significant differences between the groups on this scale neither fit with the DSM or with the idea of traffic violations in general. Nonetheless, there was still support for the hypothesis that problematic driving is related to psychometric measures of impulsivity.

3.2.4.2 Hypothesis 2.

Though some of the trends were in the right direction, the results of the Stop-Signal and Go/NoGo Tasks did not support the second hypothesis which stated that problematic drivers have poorer response inhibitory skills. On the Stop-Signal Task, the non-significant differences between the groups in terms of their accuracy was expected since this measure is not associated with impulsivity but rather is a measure of whether participants can associate the correct key with each stimulus. Furthermore, the groups were not expected to differ in average reaction-time since this is not associated with impulsivity but with the speed that they respond to each go stimulus. The task is designed so that participants should inhibit about 50% of the stop trials (32 in this case) and the groups as a whole were found not to differ significantly from this figure. This is in line with previous research using this task (Logan, 1994) and suggests that the participants did complete the task in line with the instructions. Again, the groups did not

differ on this measure nor would they be expected to given that it is a function of task design. SSRT is the main measure of inhibitory skill and while the non-problematic drivers did have a faster SSRT (indicative of good inhibitory skills), they did not differ significantly from problematic drivers. In the study that introduced the present version of the Stop-Signal Task (Logan et al., 1997), the low impulsivity group (as determined by a questionnaire measure) had an SSRT that was almost identical to the non-problematic drivers in this task. While their impulsive participants did have a slightly slower SSRT than the problematic drivers in this study, the trend is in the same direction. Furthermore, they found significant differences between their two groups with 136 participants compared with 58 in this study. Thus, the SSRT appears not to be a very sensitive cognitive measure, especially considering that the effect size between the groups in the present study was actually greater than that between the groups in Logan et al.'s.

For the Go/NoGo Task, not only were there no significant differences between the groups, but even the non-significant pattern in the main measure of inhibition (commission errors) was in the opposite direction to what the hypothesis predicted. Problematic drivers actually made, on average, one less error than the non-problematic drivers. As stated in the methods section, the present version of the Go/NoGo is closest in design to the one used by Roche et al. (2004) though theirs was slightly easier. The control participants in their study (i.e. those not suffering from traumatic brain injury) had an error rate of just under 40%, while the participants in this study made commission errors on 50% of the nogo trials. This suggests that the timing procedures in this task did make it more difficult. However, this also means that these results cannot be compared directly with any other studies since no studies used the exact same timing procedure as the present one. Differences were not expected, and were not found, between the groups in terms of reaction-time to go trials, reaction-time when committing errors and number of omission errors since these are not directly related to inhibition. Participants had significantly faster responses when committing commission errors (compared with go trials). This effect was no more prevalent in either group suggesting that both groups performed the task in a similar manner.

The last measure investigated in the Go/NoGo Task was the difference in number of trials preceding go and nogo trials. Eigsti et al. (2006) found that increasing the number of go trials before a nogo trial increased the chances of committing a commission error for both adolescents and adults in their study but that this effect was pronounced

for adolescents. They suggested that this indicated that as the number of trials increased, the task became exponentially more difficult for the adolescent group due to poorer inhibitory skills. The present study investigated this effect in a different manner by comparing the number of go trials preceding successful inhibitions and unsuccessful inhibitions. In line with the findings of Eigsti et al., the number of preceding trials did seem to increase task difficulty. However, there was no difference between the driving groups in this pattern suggesting problematic drivers were no more affected by long sequences of go trials than non-problematic participants.

3.2.4.3 Hypothesis 3.

While the results of the Go/NoGo and Stop-Signal Tasks were relatively clear in not supporting the DSM, the outcome of the IST was more ambiguous. Overall, participants completed the task in a manner that was in line with previous research – they opened more boxes, made fewer errors and had a higher probability of being correct in the FW condition (the condition where the number of boxes opened did not impact on the number of points awarded for a correct guess). There was no difference between the driving groups in terms of number of boxes that they opened and there was no interaction between driving group and condition for this variable. This suggests that neither group was more interested than the other in completing the task properly. A more complicated picture emerges when considering the impact of driving group on numbers of errors made and probability of being correct when responding. The groups did not differ overall in terms of their probability of being correct when responding. Within the FW conditions, problematic drivers had a higher probability of being correct when responding compared with non-problematic drivers and this effect was reversed in the DW. However, neither of these differences was large enough to achieve statistical significance and so the trend appears to be that not only did the groups perform the same in the overall task, but their responses were similar in each separate condition. However, the significant interaction between driving group and condition (FW vs. DW) suggests that the trend is slightly more complicated. While the participants in both groups had a lower probability of being correct in the DW condition than the FW one, this difference was greater for problematic drivers. As described above, it is not simply the case that they had a lower probability in the DW condition or a higher probability in the FW. It is a much more nuanced effect with the problematic group's difference between

the FW and DW condition being larger. A nearly identical trend was found for number of incorrect choices. The implications of these findings are far from clear. In Clark et al.'s (2006) study, they found differences between amphetamine users and controls in the FW condition only. This makes some sense since the DW condition has an incentive for being less reflective while the FW condition allows participants to collect as much information as they please. No research using the IST has found, as in the present study, one group to display a larger change from FW to DW condition. Whatever the cause of this effect, it is difficult to see how it could indicate less reflection in the problematic driving group – especially since this group displayed slightly better performance in the important FW condition.

The performance of the participants in this study did differ slightly from those in previous studies of the IST. For example, in the paper that introduced the task (Clark et al., 2006), control subjects opened 7.5 and 13.1 boxes in the FW and DW conditions respectively –in line with other IST research findings (e.g. Solowij et al., 2012). However, in the present study, the average number of boxes opened by participants was 9.8 and 15.4 suggesting that the participants in this study were more cautious in their responses. Problematic drivers, whom it was hypothesised would display less reflection, had an average probability of .86 of correctly responding which is much higher than the .72 average probability for amphetamine users in Clark et al.'s study. Overall, the results suggest that the third hypothesis was not supported.

3.2.4.4 Additional findings.

There were a number of interesting results that emerged which did not relate directly to any of the three hypotheses. Though these findings do not address the specific research questions sought out by the study, they are nonetheless interesting in the context of the entire study.

Sensation seeking and problematic driving Problematic drivers were found to have a higher total SSS score along with higher scores on all of the subscales. The differences between the groups were significant in all cases except for the Thrill and Adventure Seeking scale. In their study of changing sensation seeking over ages, Steinberg et al. (2008) used an earlier version of the SSS but suggested that many of the items seem to address inhibition. The questionnaire does contain a Disinhibition

subscale, and the participants in the present study were found to differ on this. However, the questions belonging to this scale are very different from the kinds of questions generally associated with impulsivity. For example, one of the questions in this scale asks participants to choose which of the two sentences applies more to them: "I like 'wild' uninhibited parties" or "I prefer quiet parties with good conversation". Despite the name of the scale, questions such as this do not address the kinds of impulsivity described in the DSM (i.e. being able to control impulses), and are more related to being "disinhibited" from societal expectations. For this reason, the responses on this questionnaire do not address the first hypothesis of this study (i.e. dangerous drivers score higher on questionnaire measures of impulsivity). The SSS is more likely to address the first system described in the DSM - the dopamine-related socio-emotional system that, as described in section 3.1.3, undergoes changes predominantly in early adolescence. Indeed, this is the very reason that the questionnaire was included in the study and the clear differences between the groups on many of the subscales may reveal an interesting aspect of the DSM and its application to dangerous driving.

This is not the first driving study to examine the relationship between sensation seeking and driving. In a review of 40 studies investigating the relationship between dangerous driving and sensation seeking, Jonah (1997) found a robust medium relationship between the variables regardless of the specific questionnaires used to measure each one. Interestingly, Jonah found the strongest relationship to be between dangerous driving and the Thrill and Adventure subscale of SSS. This was the only subscale of the SSS that was not found to be significant in the present study, though the overall difference in sensation seeking between the present groups had a large effect size which is in line with those studies described by Jonah. The largest difference between the groups in this study (excluding the total score) was on the Disinhibition subscale. Zuckerman (1994) describes those who score high on this scale as having reduced social constraints and cites research that suggests that they engage in more casual sex and are more likely to be gamblers. As mentioned previously, despite the name of this scale, its questions are not associated with impulsivity as defined in the present thesis (i.e. not being able to control oneself).

Relationship between impulsivity tasks While there were some correlations between the response inhibition tasks, they were largely between less important

variables. SSRT is the principal measure of inhibition in the Stop-Signal Task while number of commission errors is generally seen as the equivalent for the Go/NoGo Task. Despite this, neither of these measures was found to be correlated with the other. Reaction-time measures of the Go/NoGo Task were correlated with SSRT but not with reaction-time to go trials in the Stop-Signal Task. There is no particular reason why reaction-time in the Go/NoGo, which is not usually seen as a measure of inhibition in itself, would be related to the SSRT which is theorised by Logan et al. (1997) as being entirely separate from reaction-time; a suggestion supported by its lack of correlation with reaction-time measures in the Stop-Signal Task itself. While previous research has utilised versions of both the Go/NoGo and Stop-Signal Task together (e.g. Rubia et al., 2001), few of these studies have described the relationship between behavioural measures on the tasks. Rubia et al. (2001) found that, though they shared many neural underpinnings, the two tasks did elicit unique areas of activation and the results of this study do suggest that they may well tap into different forms of inhibition. In one of the few studies that did compare performance on the Go/NoGo and Stop-Signal Tasks, Reynolds, Ortengren, Richards, and de Wit (2006) did find a medium relationship between commission errors and SSRT. This finding, together with the present results, leads to an inconclusive view of the relationship between the predominant measures of impulsivity in each task. However, the relationship between SSRT and reaction-time in the Go/NoGo has not been described in any previous research and further study is required to determine what the real relationship between these variables is.

Relationship between questionnaire and behaviour measures On the basis of theory alone, the relationship between the response inhibition measures and the questionnaire measure of impulsivity is quite unexpected, since the BIS is one of the most commonly used measures of impulsivity and since response inhibition is typically seen as a key component of it (e.g. Clark et al., 2006). Very few correlations were found between the response inhibition measures and the BIS, and those relationships that were significant were for variables in the tasks that were not core to the concept of response inhibition (e.g. number of omission error in the Go/NoGo Task). Previous research in this area has received mixed results with Go/NoGo measures found to be related to questionnaire impulsivity in one study (Stadler & Janke, 2003) while very few relationships were found between behavioural tasks and questionnaire measures

(Enticott, Ogloff, & Bradshaw, 2006; Horn, Dolan, Elliott, Deakin, & Woodruff, 2003; Reynolds et al., 2006). Logan et al. (1997) found that SSRT was related to impulsivity scores on the Eysenck Personality Inventory. Nevertheless, the results of the present study, along with those of Horn et al., suggest that response inhibition may not be a component of impulsivity but instead could be an entirely separate concept. The results do suggest a relationship between Motor Impulsiveness and Non-Planning Impulsiveness and performance in the IST. However, this relationship existed only for the Decreasing Win condition while the Fixed Win condition is typically seen as the measure of reflection impulsivity. In the original study, Clark et al. (2006) found no relationship between the BIS and the IST, though they only looked at total BIS score rather than any of the individual scales.

Gender There were no differences between males and females on any of the behaviour tasks and there was no interaction between gender and driving group on any of the measures. There is no theoretical reason why an interaction should have been found between the two variables. It is not as if the influence of response inhibition would be expected to be different for each gender. However, as highlighted in the introduction, the developmental patterns of males and females, with regard to issues such as gross white and grey matter development have been found to differ. It is possible that these developmental contrasts could lead to differences in response inhibition and previous research has found some differences between males and females on the Go/NoGo Task (Liu et al., 2012). Unfortunately, the differences between males and females in that study were ambiguous as males had a faster reaction-time but did not make more commission errors – the latter of which is generally seen as the clearest measure of response inhibition. Due to the nature of sampling in the present study, the finding that males and females did not differ on any the tasks here does not necessary suggest that in the general population, males and females display similar response inhibition and reflection impulsivity.

Males and females were found to differ on one of the subscales of the SSS (Boredom scale) and one of the BIS subscales (Non-Planning). Previous research has found few differences between males and females on the SSS (e.g. Coventry & Hudson, 2001) and so it is uncertain whether these findings have implications for dangerous driving. In a review of the BIS, Stanford et al. (2009) found very few gender differences

on the subscales except on the Motor Impulsiveness scale – on which males and females did not differ in this study. Again, it is difficult to know if the increased scores of females on cognitive complexity is related to dangerous driving –especially since the driving groups did not differ on this scale. Overall, the results indicate that males and females, regardless of their driving group, do not tend to differ on these measures.

3.2.4.5 Implications.

There are a number of implications of the findings in this study, but the overarching outcome was that the DSM of risk-taking was not supported in its application to dangerous driving among young people. There are a number of logical explanations for this outcome with the most obvious one being that the DSM simply does not apply to dangerous driving. This could be due either to the DSM being an incorrect theory altogether, or to dangerous driving being a unique risk activity among young people which does not stem from the same factors that lead to other risk-taking behaviours. Another possible explanation is that the DSM is basically correct but that the behavioural tasks in the present study do not address cognitive factors that are relevant for the theory. A third explanation is that the DBQ was ineffectual in identifying problematic and non-problematic participants. Each of these explanations will be discussed briefly.

It is possible that the DSM is flawed in its description of the causes of risk-taking among this age group. The theory is described as “speculative” in the original paper (Steinberg, 2008) and while ample evidence does support the theory, the present study represents one of the few attempts to test it directly. While there are no obvious logical reasons for why the theory should not be correct, the proposal that risk-taking results from a lack of inhibitory control is a relatively atheoretical one. For example, the theory suggests that two neurological systems explain increased risk-taking in young people but does not explain why different adolescents engage in different types of risks (e.g. dangerous driving vs. unsafe sex) or why some adolescents do not seem to be particularly high risk-takers at all. One of the most troublesome aspects of the theory is the issue of the relationship between age and risk-taking. As described in the introduction, those in their early to mid-twenties are also found to engage in large amounts of binge drinking (Livingston & Room, 2009) and smoking (Cancer Research UK, 2012). The developmental changes discussed in this introduction have largely finished by the start of the twenties and so the DSM does not lend itself easily to explaining risk-taking in this age group.

Furthermore, while a relatively simple model of adolescent neurodevelopment has been presented so far, things are, unsurprisingly, a little more complicated than this. For example, Luna et al. (2001) also found changes in thalamic and striatal regions across late and early adulthood – areas that have not been found to play a particularly important role in impulsivity. Given this complex development, it may be too selective to simply focus on a small number of changes and then declare that these explain the complex phenomenon of interest. This kind of criticism can also be applied to the examination of those brain areas associated with dangerous driving. Section 3.1.4 describes those areas associated with driving behaviours such as speeding and focused on those that have also been found to be typically involved in impulsivity (e.g. the DLPFC and ACC). However, this is also an over-simplification with areas such as the orbitofrontal cortex (Calhoun et al., 2002) and the thalamus (Uchiyama et al., 2003) having been found to have a role in safe driving. None of this is to deny that frontal structures and ACC are associated with impulsivity, undergo changes during late adolescence and are related to dangerous driving, but is simply to highlight that these descriptions are somewhat selective and inevitably lead to an oversimplified view of the inter-relations between these different factors.

An alternative explanation is that the lack of differences between the groups stems from the tasks used in the present study rather than from deficiencies in the theory itself. Performance in the Go/NoGo and Stop-Signal Tasks has been found to be associated with those areas that are still developing into the early twenties (DLPFC and ACC); however, as described above, there are many areas that undergo change during late adolescence. Furthermore, these tasks have been associated with brain regions other than those developing during the relevant age periods. For example, Tamm et al. (2002) found performance in the Go/NoGo Task to be associated with a number of areas such as the left inferior frontal gyrus and left middle/superior frontal gyri. Furthermore, they did not find much association between inhibition and the DLPFC or ACC. Another issue relates to the impact of age on performance in the tasks. If these tasks do tap into developmental aspects of the DSM, then adolescents should have a poorer performance on them. As described in the introduction of this chapter, the different breakdowns of age groups in different studies make it difficult to determine the impact of age. For example, Rubia et al. (2006) found a difference between their two age groups of 10-17 and 20-43 in performance on a Go/NoGo Task. However, these are reasonably large age

ranges and their results do not necessarily indicate that Go/NoGo performance improves in late adolescence. Related to this point, much of the research that utilises these tasks is of a neuroimaging nature (e.g. Garavan et al., 2006). Researchers have typically not been interested in just the performance of participants on the tasks, but also the neural correlates of their performance. Steinberg (2008) cites a number of studies that have found that, while adolescents can often match the performance of adults in tasks of executive functioning, adults often display much more diffuse activation utilising a number of different brain regions at once. Conversely, adolescents have been found to rely on frontal lobe functioning to a much greater degree. Luna et al. (2001) found that adult behavioural performance in an anti-saccade task was reached in early adolescence but that as participants got older, they employed more brain areas when successfully inhibiting. Luna et al. suggest that young people could be over-taxing the inhibitory systems of the brain. This could suggest that younger people may be able to match adult inhibitory performance in a distraction-free lab environment. The same could be the case in the present study (i.e. the performance of problematic and non-problematic drivers may be similar for “laboratory inhibition” but they may be relying on different brain regions). Problematic drivers may be worse at inhibiting responses and impulses in real-world driving situations which are full of distractions and additional task demands. This is, of course, entirely speculative given that the present study relied entirely on behavioural measures without any neuroimaging information. It is worth noting that, though it was not significant, the direction of the difference between the driving groups on the Stop-Signal Task was in line with the DSM with the non-problematic drivers having a faster SSRT. The size of the effect associated with this difference was actually greater than that reported in original paper for this specific variant of the task (Logan et al., 1997). Logan et al. found a significant difference with 68 participants in each group. Had the groups in the present study involved this number, the difference between the groups for SSRT would have been significant; assuming that the difference remained roughly the same as at present.

Another possible explanation is that dangerous driving may differ in the first neurological system described by the DSM rather than the second. The DSM proposes that risk-taking increases during adolescence due to increased activation in a dopaminergic socio-emotional system. It could be the case that increases in impulse control (the second system) are uniform for all individuals and that it is differences in the

first system that influence behaviours such as dangerous driving. Participants' responses on the SSS do seem to support the idea that the sensation seeking aspect of the DSM may explain the variance in dangerous driving better. However, this is still just a paper-and-pen measure and so it suffers from the same issues as questionnaire-measures of impulsivity, namely, responses on a questionnaire such as the SSS could be indicative of lifestyle choices which can stem from multiple factors. Testing Steinberg's suggestion that there are changes in a socio-emotional system requires some kind of behavioural measure. Unlike impulsivity, there are much fewer agreed-upon tests of sensation seeking and so it is difficult to determine how differences between groups in this regard could be measured. Another important consideration is that it is extremely unlikely that neurologically related impulsivity changes are uniform across the population. As with all psychological research, there is huge variability found among participants in neurological and impulsivity studies. For example, in the present study six participants made 17 commission errors in the Go/NoGo while three participants made only three errors. If the DSM theory is correct in its assertion that impulse control does reduce risk-taking, then some relationship between an activity such as dangerous driving and inhibitory measures should exist.

A final explanation for the outcome of this study is that the method of classifying problematic and non-problematic drivers was flawed. The DBQ is one of the most commonly used questionnaires for driver behaviour but is not without its critics. In his book addressing potential flaws in driver behaviour research, af Wahlberg (2009) dismisses much questionnaire research as lacking validity and spends a great deal of time criticising the DBQ in particular. Questions of the utility of the DBQ, as with those for all questionnaires, centre on the reliability of its factor structure and on the relationship between participants' responses and their real-world behaviour. The DBQ does not take into account the amount of time an individual spends driving on the road which is important since people who seldom drive have much fewer opportunities to commit violations than those who are on the road almost every day. While this could be addressed by taking a measure such as "violations per 1000km driven", such a measure would assume that people give accurate estimations of their distance driven –adding even more uncertainty to their score. In the previous chapter, it was found that participants who had been involved in at least one accident had, on average, a higher score on the DBQ Violations subscale. This suggests that, at least for the present sample,

the questionnaire is not completely removed from reality. A more thorough discussion of these issues is provided in the next chapter.

3.2.4.6 Limitations.

There are a number of limitations in the present study. Participants were assigned to problematic and non-problematic groups on the basis of a questionnaire which, as mentioned above, may confound their classification. Given that a massive advantage of the present study is that it does not rely solely on questionnaire measures of impulsivity, the reliance on questionnaire measures of driving is made even more salient. As discussed in the previous chapter, the DBQ does not take into account the amount of time that participants spend driving and so those individuals who rarely drive could just have a low Violations score due to lack of opportunity rather than because they are inherently safer drivers. To overcome this issue, it was originally intended that only participants who had estimated driving at least 1,000km in the last year would be included in this study. However, due to difficulties in recruiting enough young drivers with this kind of experience, this requirement was dropped to 100km in the last year. This is quite a small distance and it is questionable whether such participants have really driven enough in order to be identified as problematic or non-problematic. Another potential issue is that assignment to groups in this study was on the basis of relative scores (i.e. the 60 participants in each gender with the highest and lowest Violations score were contacted for this study). This could lead to a situation where the problematic drivers have more Violations than non-problematic ones, but do still not have a particularly high number of Violations. This does not appear to be the case in this study as the scores for the participants in the problematic and non-problematic groups were higher and lower, respectively, than previous description of these scores for both males and females (e.g. Özkan & Lajunen, 2005). The number of participants in each sample may not have been sufficient enough to discover significant relationships between group membership and the inhibitory variables, particularly in the case of the SSRT (see section 3.2.4.2). An additional limitation relates to the source of the participants in this sample. Participants were all students from an urban university that agreed to take part in two pieces of research; the online questionnaire and the laboratory tasks. These participants may not be representative of young drivers across the country. In particular, attending a university at the centre of a city may restrict driving opportunities for these participants.

3.2.4.7 Further study.

Given the large influence that neuropsychological findings have had on the present study, an obvious idea for future research would be to carry out this research in a neuroimaging context. For example, research does suggest that adults and adolescents display different brain activation during these tasks and so it could potentially be the case that problematic and non-problematic drivers also display these differences. Another approach to the present work would be to see if the presence of peers would impact differently on the performance of problematic and non-problematic drivers. This is not an unwarranted suggestion given that in a behavioural measure of risk-taking, Gardner and Steinberg (2005) found that younger participants (aged 13-16 years) were more affected by the presence of peers. A behavioural measure of sensation seeking that is related to the first system described by the DSM could also be included in future research to examine the combined role of the two neurological systems in dangerous driving.

3.3 Conclusions

This study tested the application of the DSM in explaining dangerous driving among young people. The DSM proposes that risk-taking reduces during early adulthood due to increased cognitive control associated with frontal lobe development. The present study tested this claim by comparing dangerous drivers with safer drivers on a number of behavioural tasks of impulsivity. While the two groups of participants did differ on questionnaire measures of impulsivity (hypothesis one), there were no differences between the groups on a Go/NoGo or Stop-Signal Task (hypothesis two). There were differences between the groups on an IST, though the implications of the exact differences are unclear (hypothesis three). There are a number of reasons why the tasks may not have distinguished between the groups – the DSM could be incorrect, the tasks could be unrelated to what the DSM discusses or the participants could have been incorrectly classified due to shortcomings in the DBQ. The first two explanations are not easy to address in follow-up research but the next chapter addresses the third explanation – that the participants were incorrectly assigned to their respective driving groups.

Chapter 4: Impact of a More Valid Classification of Problematic Drivers on the Role of Inhibition and Reflection Impulsivity

4.1 Introduction

As discussed in chapter 2, the Driver Behaviour Questionnaire (DBQ) is one of the most commonly used questionnaires in the driving behaviour literature. de Winter and Dodou (2010) estimated that about 174 studies used the DBQ or a modified version of it and considering that this meta-analysis was published over two years ago, that number is probably now closer to 200. No other questionnaire in the driving behaviour literature has garnered close to this kind of popularity and this was precisely the justification for the use of this questionnaire as a tool for identifying problematic and non-problematic drivers for the study detailed in the previous chapter. In that study, the lack of differences between problematic and non-problematic drivers on the tasks has three possible explanations: developmental factors are not the underlying reason of dangerous driving in young people, the tasks used do not address the correct developmental factors or the method of identifying problematic and non-problematic drivers was not successful. The present discussion will focus on the latter explanation (i.e. that participants were not successfully categorised). What exactly does it mean to question the ability of the DBQ to identify problematic and non-problematic drivers? The two most pertinent issues are the ability of the DBQ to predict real life behaviour and the overall factor structure of the DBQ. While the issue of the factor structure certainly relates to the predictive capabilities of the questionnaire, this latter topic is also related to issues such as social desirability, memory for past behaviours and events and other general issues associated with questionnaires – particularly those addressing illegal or potentially immoral behaviour. The question of the DBQ's factor structure is particularly important in the present discussion given that, as will be discussed below, the DBQ has been applied and tested on predominantly adult populations. The present study will approach the issue of the suitability of the DBQ for young drivers through two entirely distinct studies.

Study 3 will present the results of a confirmatory factor analysis of the DBQ for young drivers using the same data discussed in study 1 in chapter 2. The study will also present the outcomes of a comparison between the fit of the three-factor solution of the DBQ (Lapses, Errors and Violations) for young and older drivers. Study 4 seeks to overcome another issue relating to the use of the DBQ – its ability to differentiate

between problematic and non-problematic drivers. The problematic driving group in this study were young Northern Irish drivers who had been apprehended by the police for speeding and who were attending an education course in lieu of a fine and points on their licence. Their responses on the same tasks as those described in the previous chapter were compared with some of the participants from study 2. Those participants in that study who had indicated no previous penalty points or accidents were used as the non-problematic group in study 4 in this chapter. While study 4 does not introduce any additional theoretical issues, an introduction to previous research relating to the factor structure and validity of the DBQ is necessary before study 3 can be described.

4.1.1 Predictive ability of the Driver Behaviour Questionnaire

The first version of the DBQ consisted of 50 items belonging to five main categories – Slips, Lapses, Mistakes, Unintended Violations and Deliberate Violations (Reason et al., 1990). A factor analysis of this original study found that the items conformed broadly to three factors which were labelled Lapses, Errors and Violations. Lapses were seen as those behaviours that typically resulted from loss of concentration (e.g. attempting to drive away from a stationary position at traffic lights in third gear). Errors referred to those behaviours that resulted from mistakes that were not deliberate and were not in breach of the law (e.g. backing into something you had not seen). Violations were behaviours in which the driver was seen as breaking the law or deliberately driving dangerously. The authors found that the Violations scale of the DBQ had a degree of validity as a) scores decreased with age, which was not observed for the other two measures, and b) men of all ages had higher scores than females. Parker, Reason, Manstead, and Stradling (1995) reduced the DBQ to a 24-item questionnaire that maintained the same factor structure. The Violations subscale was expanded and violations were divided into ordinary and aggressive violations by Parker, Lajunen, and Stradling (1998) which resulted in the 28-item DBQ – eight lapses, eight errors, six ordinary violations and six aggressive ones. This is the most commonly used DBQ (and is the one used in the present thesis). To complicate matters, some authors combine both Violations scales in their analyses (e.g. de Winter & Dodou, 2010) while others use the two separate scales (e.g. Constantinou et al., 2011). Another issue is that many researchers remove and alter questions across different studies.

These issues make it difficult to determine exactly how valid a measure of driving behaviour the DBQ actually is. However, even if a homogenous version of the DBQ was used across different studies, what does it mean to ask if it is a valid measure of driving behaviour? Although the questionnaire is purported to address all kinds of driving behaviour, most researchers are interested in the relationship between DBQ scores and crash risk. However, not all researchers are in agreement that crashes are the best measure by which the DBQ (or any driving questionnaire) should be judged. af Wahlberg (2009) suggests that we should only be interested in culpability in accidents rather than involvement in them. However, culpability can be an ambiguous issue – it is not always clear who caused an accident. And while there certainly may be cases where one driver played absolutely no role in a collision, it's not altogether clear how many crashes fall into this category. This is not to say that ignoring culpability and focusing purely on accident involvement frees us entirely from ambiguity. Should we measure accident involvement on the basis of self-report? Research suggests that drivers can have quite a poor memory for past driving accidents (see af Wahlberg, 2009). What about officially recorded statistics? Aside from the practical difficulties in accessing participants' official statistics of accident involvement (if indeed they are available at all), these recordings generally exist for only more serious accidents since most minor accidents (e.g. rear end shunts are not reported to the police or to either of the drivers' insurance companies). The DBQ was in no way specifically designed to predict only major accidents and so comparisons with officially recorded incidents may not reveal a lot about the validity of the questionnaire. The relationship between simulator crashes (and general performance) is another method of validating a driving questionnaire but there are obvious questions of external validity surrounding this methodology. While simulators have come a long way, it's not altogether clear that performance in simulator studies is representative of real-life driving. For example, Godley, Triggs, and Fildes (2002) found that participants drove slower in a simulator compared with an instrumented car. Given that participants are likely to monitor their speed quite closely in an instrumented car study, speed in a simulator is probably much slower compared with real world speeds. The discussion below will cover the relationship between the DBQ and these three approaches- self-reported accidents, official statistics and simulator studies before focusing on some of the general issues faced by driving questionnaires.

The most comprehensive summary of the relationship between the DBQ and crash involvement comes from a meta-analysis carried out by de Winter and Dodou (2010). They focused on the Errors, which they defined as being made up of Errors and Lapses, and Violations, which were made up of Ordinary and Aggressive Violations. They analysed 30 studies in which the direct relationship between Violations and self-reported accidents were investigated and for all of these studies they combined the two types of violations – aggressive and ordinary. They found that there was a weak positive relationship between Violations and self-reported accidents with an estimated 95% CI of $r = .12 - .14$. Note that while this effect size is quite small, the relatively large number of individuals who have never been involved in an accident is likely to reduce the strength of the correlation. A comparison in violation score between those who had been involved in an accident and those who had never may have yielded a higher effect size. Errors were also found to be associated with self-reported accident involvement but to a slightly smaller degree than Violations, $r = .09 - .11$ (95% CI). Constantinou et al. (2011) found that ordinary violations were related to past accident involvement while aggressive ones were not. Unfortunately, the version of the DBQ that they used was a non-standard one which was the amalgamation of a number of separate pre-existing driving questionnaires. Gras et al. (2006) used the 28-item DBQ and like Constantinou, they did not combine the Violations subscales. Again, they found that Ordinary Violations significantly distinguished between individuals who were accident-involved and those who were not, while Aggressive Violations did not. However, on the basis of their own factor analysis (discussed further in section 4.1.2), they only included 3 items in the Aggressive Violations category.

The above findings emphasise two very different points. Firstly, the DBQ, and particularly its Violations scale, has been found to have some relationship with self-reported accident involvement. This seems to be the case regardless of whether the scales are combined or separate – though the Ordinary Violations scale has had more success in the latter type of analysis. The second point that this brief summary demonstrates is the relative lack of continuity in the use of the DBQ. Constantinou et al. (2011) mixed and matched a number of different questionnaires and still referred to their analysis as involving the DBQ. Gras et al. (2006) moved the items in their questionnaire around according to a new factor analysis. Despite the relatively positive results of de Winter and Dodou (2010) meta-analysis, a look at the individual studies making up this

analysis suggest that the DBQ is more of a conceptual questionnaire than a standardised one.

Examining the relationship between DBQ scores and self-reported accidents is one way to approach the issue of the validity of the DBQ. However, as af Wahlberg (2009) points out, this is a far-from-perfect way to assess the validity of the questionnaire. For one thing, it assumes that drivers have a good memory for past accidents or that they will report them honestly. In a series of commentaries between af Wahlberg and the authors of the original meta-analysis (af Wahlberg, Dorn, Freeman, De Winter, & Dodou, 2012), af Wahlberg notes that in their own work with a bus company, drivers reported having fewer crashes than official records suggested. De Winter's reply to this finding was that official records themselves are not perfect and that issues such as duplication can lead to an over reporting of crashes and so this does not necessarily indicate that self-report measures are less valid. In their original meta-analysis, they examined three studies that investigated the link between recorded accidents and reported violations, finding no significant correlation between the two. They suggest that this may be more of a reflection of the small number of studies used and of the problems (such as duplication and under-reporting) of official records. However, af Wahlberg believes that the lack of significant correlation between the DBQ and official figures results from shortcomings in the questionnaire itself and that significant relationship between self-report measures and the DBQ are the result of *common method variance*. This is a broad term which describes how two variables measured with similar methods may display a false relationship. Questionnaire measures are particularly susceptible to this problem since participants may fill out answers across different questionnaires in a similar way, (e.g. participants may vary in their conceptualisation of what extreme scores on a Likert scale actually mean).

A number of studies have investigated the relationship between DBQ responses and performance on simulators – sometimes referred to as virtual environments. As discussed above, there are validity issues when it comes to simulator-research; however, they do avoid issues such as common method variance or insufficient records. One of the most interesting aspects of this kind of research is that the focus need not necessarily be accidents. While linking DBQ scores to accidents does make conceptual sense, the real test of the questionnaire is how accurately it describes people's general driving behaviour. Higher numbers of violations on the DBQ have been associated with higher

speeds in a simulator (Schwebel, Severson, Ball, & Rizzo, 2006) and less heavy braking (Stephens & Groeger, 2009), though the latter study found that violations were associated with just that one simulator measure and were not related to any other indicators of dangerous driving. Reimer, D'Ambrosio, Coughlin, Kafrissen, and Biederman (2006) did not use the DBQ itself, but did find that their survey measures did correlate with a number of simulator behaviours such as speeding and traffic weaving. These relationships between self-reported violations and simulator performance are all the more impressive given that participants are likely to drive much more cautiously in the presence of researchers and in a laboratory environment (Godley et al., 2002). However, the lack of any real consequences of crashing makes it difficult to know if driving violations in a simulator are the same as those in real life.

The above discussion arose from the question of whether the DBQ is an appropriate tool for identifying problematic drivers. As detailed above, the DBQ has had a mixed history in terms of its relationship with crash involvement and simulator behaviour. While researchers such as af Wahlberg view the DBQ as unreliable and effectively worthless, others have had some success in demonstrating its validity with real life behaviours. However, this is not the only question that is of relevance for the questionnaire. Another issue concerns the overall factor structure of the questionnaire. As will be detailed below, there have been many attempts to describe the factors that underlie DBQ responses and most of these studies have dealt with middle-aged participants. The question of factor structure is of great importance since a lack of consistency in the items belonging to any or all of the scales calls into question how the questionnaire is used.

4.1.2 Factor structure

A number of studies have expressly examined the factor structure of the DBQ using different statistical approaches and with different populations. A brief overview of these studies is necessary before the aims of the present studies can be understood. A number of studies of the factor structure of the DBQ will be looked at in terms of the analysis they used, the factor structure they found (in the case of exploratory work) or investigated (for confirmatory studies), and the age and nationality of their participants. The articles discussed below are those that used the extended 28-item DBQ (some with slight variations) with regular road users. Özkan and Lajunen (2005) attempted to add

positive driving questions to the DBQ and Özkan, Lajunen, and Summala (2006) focused on the stability of the factor structures over time and for these reasons neither are discussed below.

Mesken, Lajunen, and Summala (2002) collected data from over 1,000 Finnish regular drivers on the extended DBQ. Their sample had a mean age of 37.5 ($SD = 15.1$) years and they found, using principal axis factoring (PAF) that a four-factor solution was the best fit with items roughly falling into Ordinary Violations, Aggressive Violations, Errors and Lapses – though some items did not fall into their usual scale. This dataset has been used in a number of studies since. Lajunen et al. (2004) used the Finnish dataset alongside data from Great Britain and The Netherlands with participants of roughly similar mean ages. They removed an item on drink driving (as in the present study) and a principal components analysis (PCA) revealed the traditional four-factor structure held for the samples; though they only found three items to belong to the Aggressive Violations scale. They followed this with a second order factor analysis and found that Errors and Lapses could be grouped together as one scale and both Violations scales could also be combined. Özkan, Lajunen, Chliaoutakis, et al. (2006) added data from three more countries, Turkey, Greece and Iran, to that of Lajunen et al. and the average age for their overall sample was roughly 30 years. In what was the first confirmatory factor analysis (CFA) of the extended DBQ, they investigated the fit of the data to a three-factor model; Ordinary Violations, Aggressive Violations and Errors; they ignored Lapses, suggesting that this scale is largely irrelevant for accidents. They found what they termed a ‘partially satisfactory’ result for each of the countries and suggest that responses to the questionnaire are similar across different cultures.

Gras et al. (2006) collected data from about 350 Spanish drivers who had an average age of about 37 years ($SD = 9.4$). Using PCA, they once again found a good fit for the usual four factors but they found that many items loaded onto factors with which they were not generally associated, (e.g. the Error factor contained four Lapses items and one Aggressive Violations one). Bener, Özkan, and Lajunen (2008) found using PCA that in their samples of drivers from Qatar and UAE (mean age = 33.72 ($SD = 0.21$)) there was a good fit for a three-factor solution classified as Violations, Lapses and Errors.

Though there is slight divergence in the findings of the studies described above, it does appear that the general factors of the DBQ, Errors, Lapses and Violations, have been found for numerous samples. Both the three-factor solution and the four-factor one

(with Violations split into aggressive and ordinary) have been supported, though most studies focused on the latter. A shortcoming of many of the studies is that they employ PCA to determine if their factor structure is in line with the traditional conception of the DBQ. Matsunaga (2010) suggests that PCA should really only be used at the initial stage of scale development to reduce a large number of items to a small number of components and that common factor analysis (such as PAF) is more appropriate for follow-up studies (to which the above belong). However, whatever technical arguments can be made about the appropriateness of component analysis for exploratory work, it is questionable as to whether the analysis of DBQ structure should be exploratory at all. The scale is so established and the structures so defined that it would seem that a CFA is a much more appropriate approach. Özkan, Lajunen, Chliaoutakis, et al. (2006) provides one of the few examples of a CFA of the extended DBQ and declared the fittings only to be 'partially satisfactory'. Given these rather unimpressive results, more research of a confirmatory nature is needed for the DBQ.

Mattsson (2012) has produced the most comprehensive investigation of the suitability of the DBQ for use with a number of different groups. Specifically, Mattsson's analysis looks at both genders and multiple age groups and asks the basic question "is the fit of the DBQ the same for the groups?" In order to explain how he addressed this question, and since it is relevant for the present chapter, a brief description of *factorial invariance* is necessary. In a confirmatory factor analysis, a predefined factor structure is tested against collected data. The fit of each individual item is tested in a similar way to regression coefficients and a number of fit indices are provided to gauge the overall appropriateness of the model for the data at hand. At its most basic, factorial invariance involves the application of CFA to two groups simultaneously and a fit index is provided which can be compared with the overall fit to see if the scale is appropriate for both groups – a scale is said to have factorial invariance (as opposed to factorial noninvariance) for the groups if the underlying model fits both groups. Researchers are typically interested in factorial invariance across groups when they wish to compare scores from one group with the other (e.g. difference in number of Errors or Violations between young and old drivers). However, the matter is complicated by the fact that there are a number of different types of factorial invariance. Wu, Li, and Zumbo (2007) identify four main types of configural, weak, strong and strict invariance. Configural invariance is achieved when the factor structure is the same across groups. Weak invariance refers to

circumstances when not only are the factor structures the same, but the loadings across the groups are the same. Strong invariance refers equality in both the loadings and intercepts, while strong invariance has the additional criteria of equality in the residual variances.

In Mattsson's analysis of the DBQ he found that it did not achieve strong invariance across genders or across different age groups and concluded that the DBQ does not mean the same thing for different groups. In a response to Mattsson's study, de Winter (in press) suggested that Mattsson's study did not have a sufficient number of participants and that he went too far in requiring that strict invariance be researched in order for the groups to be considered comparable on the DBQ. Indeed, Rensvold and Cheung (1998) cite a number of sources that suggest that weak invariance is generally sufficient in order to consider groups similar in their patterns of responses to a measure.

4.2 Study 3

As explained above, the question of whether the DBQ can successfully identify problematic drivers is of huge importance to the present thesis given that the previous study relied on this questionnaire to assign participants to each of the two driving groups. Given that the previous study relied on a particular subscale of the DBQ, a central question is whether this scale does actually measure the factors that it purports to. If the questionnaire does not have clear subscales, then the utility of any of these individual scales would be called into question. As outlined above, there have been a number of investigations of the factor structure of the DBQ. The present study sets itself apart from these previous examinations on three counts: the factor structure investigated, the specific analytic technique used and the demographics of the participants.

Few studies have investigated a three-factor structure of the DBQ with many splitting violations into aggressive and ordinary violations (e.g. Lajunen et al., 2004). Most studies that investigated the structure of the questionnaire have used exploratory factor analysis. While this approach offers many advantages (see Field, 2009), it does not test whether a factor structure is present or not; its focus is instead on which items may belong together. Given that the scale is so well-established, a confirmatory approach (employed in the current study) is more appropriate. The final distinction in the present study is its focus on younger drivers. While most previous studies of the factor structure

of the DBQ have included young drivers in their sample, with the exception of Mattsson (2012), none of these studies has compared the fit of the DBQ for different age groups. And while Mattsson's study did compare different age groups, de Winter (in press) suggests that the sample sizes were insufficient. Factorial invariance is generally seen as an issue when a questionnaire is used with individuals from a different cultural background or when a measure has been translated into a different language. While young drivers are not from a different "culture" compared with older drivers, the evidence presented in chapter 1 does suggest clear driving differences between the groups. Despite these differences, it would be theoretically surprising if the groups did display wildly different interpretations of items relating to behaviours such as speeding or breaking red lights. Accordingly, the present study begins with the assumption that the questionnaire is factorially invariant across the age groups. Furthermore, the present study represents the first investigation of the DBQ with drivers in Ireland.

4.2.1 Hypotheses

The first hypothesis was that the three-factor solution is an appropriate one for young drivers in Ireland. The second hypothesis was that the three-factor solution of the DBQ is as appropriate for young drivers as it is for older ones.

4.2.2 Method

4.2.2.1 Design and participants.

The participants for this study were drawn from those who completed the online questionnaire described in chapter 2. This was the survey that was sent around a number of departments of Trinity College, Dublin. Links to the survey were also posted on car enthusiast forums in Ireland. However, the 671 participants who were removed from the analysis in chapter 2 made up the older driver group in this study. The mean age of this group was 31.1 years ($SD = 9$) and included 399 males. While some of the older drivers were recruited from college (alongside almost all the young drivers), most of these drivers were contacted through internet message boards and were not students of Trinity College, Dublin. The 624 young drivers in this study were the same as those analysed in chapter 2 and so their mean age was once again 19.1 years ($SD = 1.11$) and included 276 males. Although the participants originally completed a number of questionnaires, only their responses to the DBQ were used in this study.

4.2.2.2 *Model fit.*

The assessment of models in CFA is achieved through the use of fit indices though researchers are not in full agreement regarding the interpretation of these. While some of these indices involve significance-testing (e.g. Chi Square (χ^2), many simply present a statistic to the user which is to be interpreted using a number of rules of thumb). Kelloway (1998) divides indices into three different groups: absolute measures, comparative measures and parsimonious measures. The third group involves the comparison of different models on the same data to see which theory has the best fit. Since the present study is concerned with the testing of just one model, the three-factor structure of the DBQ, this group of indices will not be discussed further. 'Absolute measures' is a slightly misleading category name since these measures do result from the comparison of the proposed model with the just identified model (i.e. where all possible recursive paths are in the model). The most standard measure of absolute fit is the χ^2 . However, with large samples, the χ^2 will almost always be significant and so a ratio of χ^2 to degrees of freedom (*df*) is sometimes used where a result of between 2:1 and 5:1 is seen as indicative of a good model fit. However, Kelloway cautions that there is very little statistical basis for this rule and so it is best avoided. The root mean square residual (RMR) is a simple alternative fit measure that does take into account sample size and a score of .05 or lower is interpreted as indicating a good fit. The root mean squared error of approximation (RMSEA) is similar to the RMR and is perhaps one of the most common fit indices used. Steiger (1990) suggests that a score of less than .1 represents a good fit of the data to the model while a score of less than .05 suggests an excellent fit.

Comparative fit indices are ones in which the fit of the model is compared with a baseline model which is always a bad fit (e.g. the null model in which no relationships are hypothesised between the variables). The nonnormed fit index (NNFI) and the comparative fit index (CFI) are two commonly used measures of comparative fit and Kelloway (1998) suggests that a score of 0.9 or greater in either represent a good fit. It should be noted that there is disagreement in terms of what values represent a good fit. Mattsson (2012) cites sources that suggest that RMSEA scores should be lower than 0.05 and CFI scores higher than .95 in order for a good fit to be inferred. Matsunaga (2010) recommends that multiple measures of fit should be used and so in the present study χ^2 , RMR, RMSEA, NNFI and CFI will be reported. To test for factorial invariance, Cheung and

Rensvold (2002) recommend comparing the CFI on the unconstrained and constrained models. The unconstrained model is the one in which two groups (young and old drivers) are analysed at once with the only restriction being that the factor structure must be the same. A poor fit for this model indicates that for the separate groups, the same items do not load onto the same factors at all. In the constrained model, the groups are compared not only regarding whether the items load onto the same factors for each group, but also whether the factor loadings are the same. One set of fit indices is produced for both the unconstrained model and constrained model and Cheung and Rensvold suggest that if the difference in CFI for the two models is greater than 0.01, then this is an indication that the factor structure may not be factorially invariant.

4.2.2.3 Analysis.

All of the CFAs in this study were conducted using LISREL 8.54. The first CFA conducted was on the 'young' drivers in the dataset, those aged 21 and younger. This CFA aimed to test the three-factor model of the DBQ (see Özkan, Lajunen, Chliaoutakis, et al., 2006). This standard CFA was assessed using the indices described in section 4.2.2.2. The next stage of the analysis was the assessment of factorial invariance between the younger and older drivers. This was assessed using the steps suggested by Rensvold and Cheung (1998) in which the first stage involved a nested analysis in which a separate model was fitted to each group in an unconstrained manner (i.e. with the factor loadings free to vary (test of configural invariance)). This was followed by an additional CFA in which the model was fitted to each group in a constrained manner (i.e. the factor loadings were forced to be the same (test of weak invariance)). The unconstrained and constrained test results were compared against each other to assess the factorial invariance of the scale with respect to these different age groups of drivers. In all of the analyses, no attempt was made to improve the model using modification indices. As Mattsson (2012) points out, CFA is essentially a confirmatory approach and so the alteration of the model in response to the data defeats the purpose of the initial test and leads to a more exploratory approach.

4.2.3 Results

The fit of the data from the young drivers was tested against the model depicted in Figure 4.1 which also displays the factor loadings, factor covariance and item residuals.

The number for each item in the figure corresponds to the number for that item in the DBQ questionnaire which can be found in appendix 1. The model specified that each of the items loaded onto just one latent variable and all of the loadings were found to be statistically significant. As can be seen in the figure, the pattern of factor loadings is similar across the three variables. The items with the lowest loadings (DBQ1 and DBQ 14) both belong to the Lapses variable and both were 0.38. The Violations variable has some of the highest factor loadings with DBQ10, DBQ20, DBQ23, DBQ 24 and DBQ 27 all having loading > 0.65, which was the highest factor loading for a non-violations item. DBQ6, DBQ16 and DBQ24 were those items that are often placed in a separate Aggressive Violations scale (e.g. Lajunen et al., 2004; Özkan, Lajunen, Chliaoutakis, et al., 2006) and these items had loadings of 0.55, 0.45 and 0.68 respectively. Table 4.1 displays the fit indices for the young driver CFA described above. The χ^2 was statistically significant, $\chi^2(321) = 1299$, $p < .001$ and its ratio to df was just over 4:1. The RMSEA and RMR indices were less than 0.1 but were both greater than 0.05. The comparative indices, the NNFI and CFI, were both above 0.9 but neither was greater than 0.95.

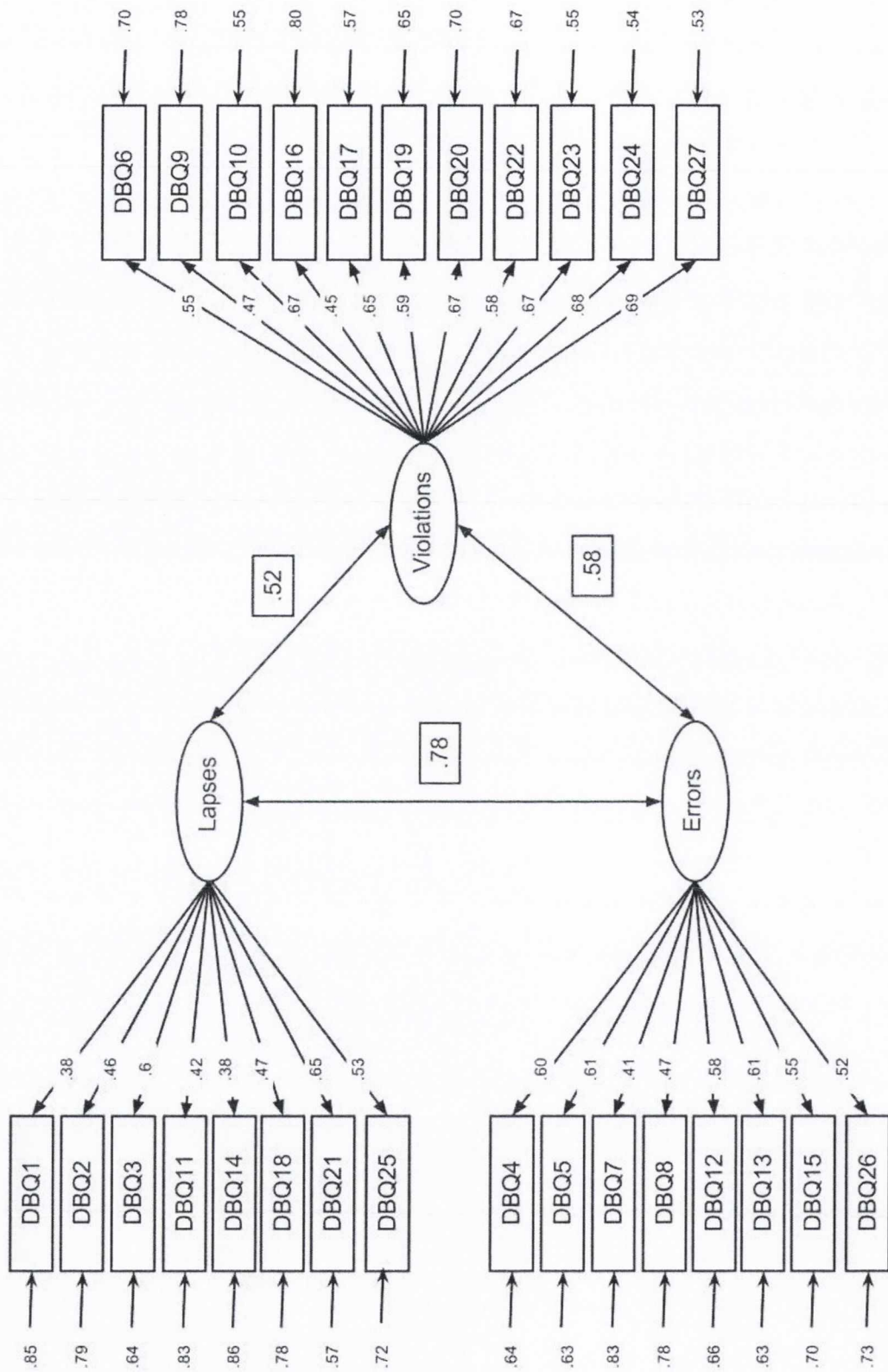


Figure 4.1. Three-factor DBQ structure for the young adult participants.

Table 4.1. Results of the CFA for young drivers, unconstrained nested model and constrained nested model.

	Young Drivers	Unconstrained Model	Constrained Model
N	624	1295	1295
χ^2 (df)	1299 (321)	2449 (642)	2493 (666)
RMSEA	0.08	0.07	0.07
RMR	0.06	0.06	0.07
NNFI	0.92	0.92	0.92
CFI	0.93	0.93	0.93

Table 4.1 also displays the fit indices for the unconstrained and constrained models comparing the younger and older drivers. Both of these models have very similar fits to the separate CFA of just the young drivers. Their χ^2 values are both statistically significant but their ratios of χ^2 to *df* are both less than 4:1. In going from the unconstrained model to constrained one, the only fit indices that change are the χ^2 , which increases slightly, and the RMR, which increases by 0.01. Cheung and Rensvold (2002) place the emphasis on changes in the CFI and as can be seen in the table, this fit index is the same for the two models.

Table 4.2. Comparisons between young and old drivers on the three scales of the DBQ.

	Lapses		Errors		Violations	
	Young	Old	Young	Old	Young	Old
Score ¹	14.7	14	11.7	11.1	19.5	21.3
	(4.2) ²	(3.8)	(3.3)	(3.1)	(7.3)	(6.4)
Cronbach's alpha	.71	.73	.75	.8	.86	.8

¹ The differences between the young and old drivers were significant at the $p < .001$ level for all three scales. ² Standard Deviations are shown in brackets.

Table 4.2 displays the scores obtained by each of the three scales of the DBQ and on the Cronbach's alpha for each group on these scales. Young drivers scored

significantly higher on the Lapses scale, $t(1294) = 3.52, p < .001, d = 0.19$, and on the Errors scale, $t(1294) = 3.55, p < .001, d = 0.2$. However, the older driver group scored higher on the Violations subscale, $t(1294) = , p < .001, d = 0.26$. Cronbach's alpha was above .7 for both age groups in all of the scales. For the Violations scale, Cronbach's alpha was above .8 for both age groups.

4.2.4 Discussion

The results of this study offer some support to the three-factor solution of the DBQ for young drivers. Furthermore, the results suggest that this solution is as appropriate for younger drivers as it is for older ones. While the findings suggest that the fit of the data to the three-factor solution is not perfect, it is in line with previous research on different populations. The implications of these results for the two hypotheses are discussed below.

4.2.4.1 Hypothesis 1.

As discussed in the introduction of this chapter, past research has addressed a number of different factor structures for the DBQ with many researchers dividing Violations into Ordinary and Aggressive Violations. While a number of researchers have investigated the three-factor solution, two of these used non-standard versions of the DBQ (Åberg & Rimmo, 1998; Westerman & Haigney, 2000) and the present study represents the first CFA of a three factor solution. In fact, Özkan, Lajunen, Chliaoutakis, et al. (2006) is the only study that has used CFA with the DBQ, and they did so on a version of the questionnaire that excluded Lapses and divided Violations into ordinary and aggressive ones. Nonetheless, their results were in line with those in the present study. They found that, for the six countries that they investigated, RMSEA varied between 0.05 and 0.09, the RMR between 0.06 and 0.08 and the CFI between 0.79 and 0.87 (they did not report the NNFI). Their χ^2 s were considerably lower at a range of 249 to 469; however, as described in the introduction to this chapter, chi square is influenced by sample size. The sample size in the present study was considerably higher than the 242 participants examined in each country that Ozkan et al. studied. The ratio of χ^2 to df in their study ranged from 1:1.7 to 1:3.1 which is more favourable than in the present study. Matsunaga (2010) advises that multiple fit indices should be utilised and, on this basis, the present results are in line with those recorded by Ozkan et al.

While these results do compare favourably with those of Özkan, Lajunen, Chliaoutakis, et al. (2006), this does not necessarily indicate that they are a good fit. Given the large sample size of the present study, the significant chi square statistic, which indicates a poor fit, is to be expected and so the results of the other indices, which are not as affected by large sample sizes, are of more interest. Steiger (1990) suggests that an RMR and RMSEA of less than .1 indicates a good fit suggesting that the three-factor solution is appropriate for the present data. However, Steiger's suggestion is at the more liberal end of the scale with Matsunaga (2010) stating that these two scores should ideally be below 0.05. A similar situation emerges when considering the comparative indices; the NNFI and CFI. Kelloway (1998) recommends that these scores should be above 0.9, which again suggests that the three-factor solution does fit for this sample. However, Mattsson (2012) expresses the view that the CFI should be 0.95 or greater. From these conservative statistical positions, the data do not represent a perfect fit for the model. Given that the indices do satisfy the more liberal tests of indices, these results appear to fit with Ozkan et al.'s conclusion of the DBQ factor structure being "...applicable but not firmly stable..." (p. 239).

4.2.4.2 Hypothesis 2.

The results of this study suggest that the three-factor solution is as good a fit for young drivers as it is for older drivers. In the unconstrained model, the same factor model was applied to the two driving groups and the fit indices indicate that, given this restriction, the overall fit was an acceptable one. This fit was similar to the overall fit of the three-factor DBQ solution for young drivers described in the previous section. An acceptable fit for the unconstrained model is referred to as evidence of configural invariance (Wu et al., 2007). In the constrained model, not only was the same factor structure applied to both groups, but the assumption that the factor loadings are identical was also enforced. The fit of this model was almost identical to the unconstrained model, which suggests that the relationships between the items and factors are the same for both driving groups. Wu et al. refer to this test as the test of weak invariance. They suggest that if weak invariance is found (as in the present study), then this is evidence that an individual's probability of obtaining a score is independent of their group membership. Cheung and Rensvold (2002) suggest an additional test of factorial invariance which is to compare the CFI of the constrained and unconstrained models.

They recommend that if the change in CFI is less than or equal to 0.01 (as in the present study), then the “null hypothesis of invariance should not be rejected” (p. 251). Based on these two types of tests; overall fit and change in CFI, the present data do seem to suggest that the three-factor DBQ model is as good for young drivers as it is for older drivers. While the present study tested configural and weak invariance, it is worth noting that other categories of invariance are sometimes used. Mattsson (2012) tested the DBQ across age groups for configural, weak and strong invariance. However, de Winter (in press) suggests that anything beyond weak invariance may be less important.

4.2.4.3 Additional findings.

The value of Cronbach’s alpha for the groups within each scale suggests that each one is unidimensional. This is particularly important for the Violations scale given that a number of researchers tend to split this scale into Ordinary and Aggressive Violations. The combinations of these scales into a single Violations scale (as endorsed by de Winter and Dodou (2010)) does appear to be justified since Cronbach’s alpha for each group exceeded even the conservative minimum mark of 0.8 (Field, 2009). In fact, the Violations scale had the highest Cronbach’s alpha for young drivers while, for the older driving group, it was equalled only by the alpha for the Errors scale.

The differences between the age groups on the driving scales were not in line with previous research. Westerman and Haigney (2000) describe a number of studies that found that Violations and Errors decreased with age while Lapses were not related. In their study of a previous version of the DBQ, Åberg and Rimmo (1998) also found a strong decrease in Violations as age increased. The present study did find a decline in Errors, but Violations were higher in the older driving group and Lapses were higher for the younger drivers. However, with such large sample sizes, even quite small differences will be found to be significant and the effect sizes for these differences all fell within Cohen’s range for small effects (J. Cohen, 1988). This difference may be due to how participants in each age group were recruited. While almost all of the young participants were current undergraduate students at a relatively prestigious Irish university, most of the older participants were recruited through internet car forums. Accordingly, the general decline in violations found in previous research may well be a robust finding, but other differences between the samples may have outweighed this effect.

As discussed above, the fit indices do indicate that the model has an acceptable fit for younger drivers. However, significant factor loadings for all of the items can often be just as important in examining model fit (R. Rensvold, personal communication, July 30, 2012). All of the items loaded significantly onto the factors for young drivers and, as displayed in Figure 4.1, the loadings of the items were all relatively high. For the Violations scale in particular, the lowest factor loading was .47 while some of the items had loadings approaching 0.7.

4.2.4.4 Limitations.

The goal of the present study was to examine the factor structure of the DBQ. However, the context in which participants completed the questionnaire was not consistent across the sample. Most of the younger drivers completed the questionnaire in response to an email sent around their college department by a member of administration. The email emphasised the prize that they could win by taking part. However, many of the older participants took part by responding to a link posted on a car forum where there was much less emphasis on the raffle aspect of the study. Given that these older drivers only discovered the study by visiting such a forum, it is probable that they were more interested in driving than the younger college students. A more accurate appraisal of the appropriateness of the three-factor structure of the DBQ could be obtained by sampling all of the participants in the same manner.

4.2.4.5 Further Study.

The purpose of this study was to demonstrate that the three-factor structure of the DBQ was appropriate for younger drivers since the questionnaire has typically relied on adult samples for validation. While the present study does offer support to this factor structure, and particularly the Violations scale, this is really only the minimum necessary to support the utility of this questionnaire for classification purposes. While a number of attempts have been made to link DBQ scores with accident involvement (see de Winter & Dodou, 2010) there is a severe lack of research into the accuracy of respondents' descriptions. Unless it is demonstrated that drivers are able (and willing) to accurately report instances of Errors and Violations, questionnaires such as the DBQ will always be open to criticism. There is no easy way to obtain this information. Simulator studies have been shown to have a degree of validity with real world behaviour (Godley et al., 2002).

However, if a participant indicates that they “sometimes” break the speed limit on a motorway, how long do they need to be in a driving simulator in order to decide if this description is accurate? Instrumented vehicles offer an opportunity to observe behaviour in a more real-life context. However, there are a number of behaviours on the DBQ that do not lend themselves to being easily measured (e.g. “[How often do you] Fail to check your rear-view mirror before pulling out, changing lanes, etc.” or “[How often do you] Overtake a slow driver on the inside”). Despite these shortcomings, useful studies could be devised using the above methodologies. A simulator design could be used to test drivers’ memories for their Violations, Errors and Lapses. Participants could complete the DBQ after a session (or a number of sessions) in the simulator or an instrumented car and their responses to suitable questions could be compared with their actual performance. Studies such as this could provide more concrete information on the reliability and validity of driving questionnaires. Until these properties have been established more clearly, studies that rely on these questionnaires, such as study 2 in the previous chapter, will always have a degree of doubt surrounding them.

4.3 Study 4

As described in the introduction to this chapter, study 4 is a replication of study 2 from the previous chapter. As described above, responses on the DBQ have been linked with variables such as accident involvement, which suggests that the questionnaire does have some correspondence with reality. However, this has not deterred researchers such as af Wahlberg (2003) from expressing scepticism as to the utility of such questionnaires. Driving questionnaires that ask participants about violations assume; a) that people are aware of how often they commit violations; and b) that even if they can accurately recall these event, they will report them honestly. Furthermore, the entire focus on the study in the previous chapter was the investigation of impulsivity without relying on psychometric measures. The reliance on questionnaires for the identification of problematic drivers prevented the study from truly being a non-self-report investigation of the relationship between driving and impulsivity. This study describes the outcomes of an attempt to identify dangerous drivers in a less subjective manner and test them on the same measures as were used in the study described in the previous chapter. Accordingly, the hypotheses from the present study follow directly from chapter 2.

4.3.1 Hypotheses

The first hypothesis was that problematic drivers have higher levels of impulsivity according to psychometric-measures. The second hypothesis was that problematic drivers display poorer response inhibition compared with safer drivers. The third hypothesis was that problematic drivers display reduced reflection when making decisions.

4.3.2 Method

4.3.2.1 Participants and design.

There were 75 participants (37 male) in this study. Participants were assigned to one of two groups – offenders and non-offenders. There were 45 non-offenders (22 males) and these were participants from study 2 who reported having never been involved in a traffic accident and never having received any penalty points. There were 30 participants in the offender group (15 males) and these were individuals who were attending a Young Driver Speeding (YDS) course in Belfast, Northern Ireland (a separate country from that which participants were recruited for the previous studies). This course is designed for individuals aged 17-25 who have been caught speeding either by a camera or at the side of the road by a police officer. In these situations the driver is given the option of a £60 fine and 3 penalty points, or they can choose to attend the YDS course. The course is a three hour interactive session in which the potential dangers of speeding are presented to the drivers. Participants in the course who are caught speeding within three years of taking it are not offered the course again as an alternative to the fine and the points. All participants were aged between 17 and 21 inclusive with a mean age of 19 years in each group. Participants all had a full driving licence and their average estimated distance driven in the last year was just under 8600kms. Participants completed a number of reaction-time tasks and questionnaires.

Participants completed the same reaction-time tasks and questionnaires as described in study 2. The variables of interest in the Stop-Signal Task were once again the average reaction-time, accuracy, probability of inhibiting and stop-signal response time (SSRT). In the Go/NoGo Task, groups were compared in their reaction-times to Go trials, number of omission errors, number of commission errors, speed of commission errors and difference in average number of trials preceding successful and unsuccessful

inhibitions. On the information sampling task (IST), the variables of interest were the number of boxes opened, the number of incorrect choices and probability of being correct. Participants in the non-offenders group completed the Barrett Impulsivity Scale (BIS), the DBQ and a short demographic/driving information questionnaire online while the non-offender group completed these tasks in the same sitting as the reaction-time tasks. All participants completed the Sensation Seeking Scale (SSS) and the Vocabulary test of the WAIS-R alongside the reaction-time tasks. Participants in the non-offender group were paid 10 euro for their participation while those in the offender group were paid 10 GBP. The consent form and debriefing sheet for this study can be found in appendix 3.

4.3.2.2 Materials.

The SSS was completed as a paper and pen questionnaire during the testing session for all participants. The Vocabulary test was administered using the standard WAIS-R vocabulary presentation sheet and participants' responses were collected using an audio recording. The computer tasks were presented either on a 17 inch monitor or on a 15 inch laptop screen. The computer used to deliver the tasks was a Dell Latitude 15 inch with a 1.8Ghz Intel Core 2 Duo processor and 2GB ram. The same programs were used to administer the tasks as in study 2.

4.3.3 Procedure

The tasks used were identical to those described in study 2 and the output was analysed in the same manner. Consequently, this information is not repeated and can be viewed in sections 3.2.2.3 and 3.2.2.4 , respectively.

4.3.4 Results

4.3.4.1 Demographics, driver characteristics and the WAIS-R.

There was no difference between the driving groups in their age, distance travelled last year or engine size of car. Non-offenders had a higher score on the WAIS-R vocabulary scale ($M = 50.74$, $SD = 7$) compared with offenders ($M = 40.4$, $SD = 7.3$), $F(1,69) = 36.46$, $p < .001$, $\eta_p^2 = .35$. Since all of the drivers in the offenders group had a full licence compared with about two thirds of the non-offender group, there was a significant difference with regard to type of licence held, $\chi^2 = 13.6$, $p < .001$. Males and

females were found not to differ in any of the above variables with the exception of age where the female participants ($M = 19.3, SD = 0.94$) were on average older than the males ($M = 18.8, SD = 1$), $F(1,70) = 4.97, p < .05, \eta_p^2 = .07$. A factorial ANOVA found that the groups did not differ on the Violations subscale of the DBQ, though the non-offenders did have a higher score that almost achieved statistical significance, $F(1, 71) = 3.7, p = .06, \eta_p^2 = .05$. There was no difference between males and females on this score and there was no interaction between these two fixed factors.

4.3.4.2 Questionnaires.

Tests of statistical assumptions. A Shapiro-Wilk test was carried out to assess the normality of the four subscales of the SSS (see Table 3.1) and for the total score. These tests were carried out for all four groups (male offenders, male non-offenders, female offenders and female non-offenders). The Thrill and Adventure Seeking subscale was not normally distributed for any of the groups and log or square root transformations could not correct this. The other scales were mostly normal though the Disinhibition subscale was not normal for female non-offenders and the Boredom subscale was not normal for female offenders. Levene’s test found that there was homogeneity of variance across all four groups.

Shapiro-Wilk tests were carried out for the three subscales of the Barratt Impulsiveness Scale (BIS; see Table 3.1) and it was found that there were normal distributions for the four groups for all of the scales except Attentional Impulsiveness which was not normal for the male offenders. Levene’s test for homogeneity of variance found that the variance within each group was the same across the three variables.

Table 4.3. *Subscales of the SSS and the BIS*

	Sensation Seeking Scale	Barratt Impulsiveness Scale
Subscales	Thrill and Adventure Seeking	Attention Impulsiveness
	Experience Seeking	Motor Impulsiveness
	Disinhibition	Non-Planning
	Boredom	

Main effects and interactions. There was a main effect of driving group for the Experience Seeking Subscale and for the overall SSS score, $F(1,71) = 8.9, p < .01, \eta_p^2 = .11$, and $F(1,71) = 6.1, p < .05, \eta_p^2 = .08$. As can be seen in Figure 4.2 both of these main effects were due to non-offenders scoring higher than offenders. There was a main effect of gender for the Boredom subscale with males scoring higher than females in both groups, $F(1,71) = 8.9, p < .01, \eta_p^2 = .11$. Due to the lack of normality for the Boredom subscale, non-parametric comparisons were carried out between males and females to see if the effect remained. A Mann-Whitney U test found that there was no difference between males and females for the Boredom subscale, $U = 526.5, z = 1.9, p = 0.06, r = .22$. There were no interaction effects between driving group and gender.

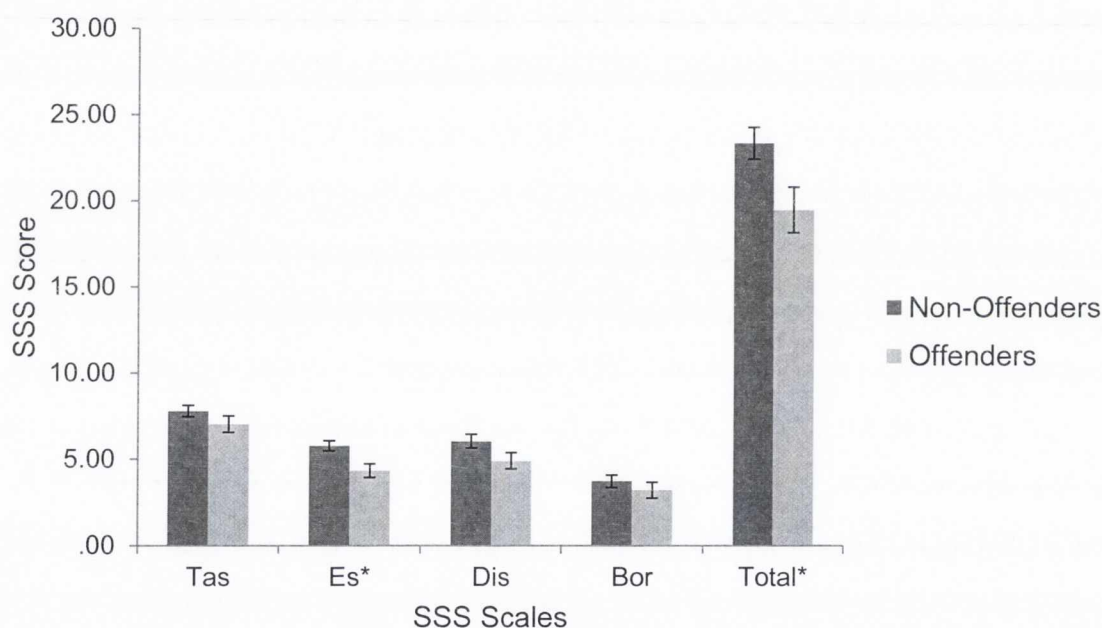


Figure 4.2. Comparison of offenders and non-offenders on all four subscales of the SSS and on the total score.

Note. * $p < .05$. Tas = Thrill and Adventure Seeking; Es = Experience Seeking; Dis = Disinhibition; Bor = Boredom). Bars represent standard errors.

There was a significant main effect of driving group for the Attentional Impulsiveness and for Non-Planning subscale, $F(1,71) = 5.87, p < .05, \eta_p^2 = .08$, and $F(1,71) = 6, p < .05, \eta_p^2 = .08$. In both cases, the offender group scored higher than the non-offender group. The differences between the driving groups on all of the subscales are

displayed in Figure 4.3. There were no main effects of gender and there were no interactions between gender and driving group.

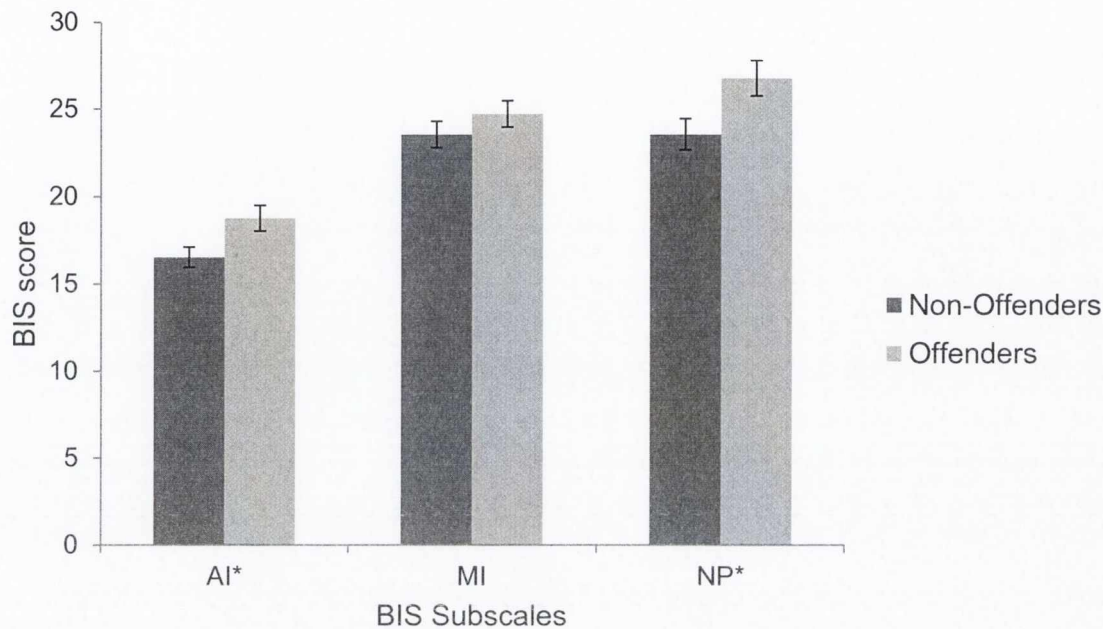


Figure 4.3. Comparison of offenders and non-offenders across the three BIS subscales. Note. * $p < .05$. AI = Attentional Impulsiveness; MI = Motor Impulsiveness; NP = Non-Planning. Bars represent standard errors.

4.3.4.3 Stop-Signal Task.

Tests of statistical assumptions. A Shapiro-Wilk test found that SSRT was normally distributed across all four groups. The reaction-time to go trials was not normally distributed for either of the female groups and the probability of inhibiting a stop-trial was not significant for either of the non-offender groups. Accuracy for go trials was found to be non-normal for all of the groups. Log and square root transformations failed to rectify any of these deviations from normality. The variance of the variables was homogenous across all groups with the exception of reaction-time to go trials, $F(3,71) = 3.2, p < .05$. Log transformations of reaction-time to go trials did lead to homogeneity of variance.

Main effects and interactions. There was no main effect of driving group or gender for any of the variables and there was no interaction effect between the two variables. A one sample t test found that, overall, participants did inhibit stop-trials with

an accuracy of .5, $t(74) = .87, p = .39, d = .1$. There was a significant correlation between probability of inhibiting and SSRT, $r(73) = .81, p < .001$ and probability of inhibiting and reaction-time to go trials, $r(73) = -.46, p < .001$.

4.3.4.4 Go/NoGo Task.

Tests of statistical assumptions. Shapiro-Wilk tests found that number of commission errors, reaction-time to go trials, number of preceding successful inhibition and number preceding unsuccessful inhibition were normally distributed for all groups. Reaction-time to commission errors was normally distributed for all groups except male non-offenders and number of omission errors was not normally distributed for any groups. Levene's test for homogeneity of variance found that reaction-time for commission errors, number of omission errors and number of trials preceding successful inhibition lacked homogeneity of variance across the groups. A log transformation of number of omission errors did bring about homogeneity of variance, while the remaining variables could not be corrected. Box's tests indicated that in the case of both the comparison of reaction-times for go trials and for commission errors and the comparison of number of trials before successful and before unsuccessful inhibition, there was not equality of the variance covariance matrices between the groups.

Main effects and interactions. There was a significant main effect of driving group for a number of the variables. As displayed in Figure 4.4, offender drivers were found to commit more commission errors than non-offenders, $F(1,71) = 14.38, p < .001, \eta_p^2 = .17$. Offender drivers also had a faster reaction-time for commission errors, $F(1,71) = 7.2, p < .01, \eta_p^2 = .1$, and for regular go trials, $F(1,71) = 15.28, p < .001, \eta_p^2 = .18$. Participants had faster reaction-times when making commission error compared with regular go trials, $F(1,71) = 85.9, p < .001, \eta_p^2 = .55$. There was no interaction between this pattern and driving group or gender. There were more trials on average preceding commission errors compared with successful inhibitions, $F(1,68) = 7.08, p < .05, \eta_p^2 = .32$. Again, there was no interaction between this pattern and driving group or gender. There were a number of significant correlations between the variables with reaction-time to go trials correlating with both number of commission errors, $r(73) = -.51, p < .001$, and with average reaction-time for commission errors, $r(73) = .86, p < .001$. Number of commission errors was also

found to be negatively correlated with average reaction-time for errors, $r(73) = -.39, p < .001$.



Figure 4.4. Mean number of commission errors for males and females in both driver groups.

Note. Bars represent standard error.

4.3.4.5 Information Sampling Task.

Tests of statistical assumptions. Shapiro-Wilk tests were carried out on the three pairs of variables for all four groups. Number of boxes opened and probability of being correct when responding were normally distributed for all groups except for male non-offenders. Number of errors committed was not normally distributed for most of the groups. There was equality of variance across all groups for all of the variables and Box's were non-significant for all pairs of variables.

Main effects and interactions. Participants opened more boxes in the Fixed Win (FW) condition compared with the Decreasing Win (DW), $F(1,71) = 33.01, p < .001, \eta_p^2 = .32$. There were no main effects for either of the independent variables on number of boxes opened and there were no interactions between any of the variables. Participants also made more errors in the DW condition $F(1,71) = 89.8, p < .001, \eta_p^2 = .56$. Again, there were no main effects for driving group or gender and there were no significant

interactions. Participants had a higher probability of being correct when they responded in the FW condition, $F(1,71) = 80.9, p < .001, \eta_p^2 = .53$. There was no significant main effect of driving group or gender on this variable and there were no interactions.

4.3.4.6 Relationship across tasks and questionnaires.

There were a number of correlations between the variables in the Stop-Signal and the Go/NoGo Tasks as can be seen in Table 4.4. The SSRT was correlated with the two reaction-time measures of the Go/NoGo – reaction-time to go trials ($r(73) = .34$) and commission error reaction-time ($r = .34$). Reaction-time to go trials in the Stop-Signal Task was correlated with reaction-time to go trials in the Go/NoGo ($r = .23$) and the former was also related to number of omission errors in the Go/NoGo ($r = .28$). While number of commission errors in the Go/NoGo was significantly related to accuracy to go trials in the Stop-Signal ($r = -.3$), it was not related to probability of inhibiting.

Table 4.4. Correlations between Stop-Signal and Go/NoGo measures

Stop-Signal Measures	Go RT	Commission Errors	Commission Error RT	Omission Errors
SS Go	.23*	.01	.18	.28*
SSRT	.34**	.12	.34**	.14
Accuracy	.04	-.3*	.02	-.1
Prob. Inhibit	.01	-.01	.01	.13

Note. ** $p < .01$, * $p < .05$

No variables in the Stop-Signal Task or in the Go/NoGo Task were found to be related to any of the variables in the IST. While variables in the SSS were correlated with a number of measures in the Go/NoGo Task, there were no correlations between the subscales of this questionnaire and the measures of the Stop-Signal Task and there was only one correlation with the measures in the IST. For the Go/NoGo Task the correlations between its measures and the scales of the SSS are presented in Table 4.5. The Experience seeking subscale of the SSS was correlated with more measures of the Go/NoGo than any other scale with omission errors being the only measure to which it was not significantly related ($r = -.11$). Both of the reaction-time measures of the

Go/NoGo Task were found to correlate with many of the SSS scales. Number of commission errors was found to correlate only with the Experience Seeking scale ($r = -.26$). For the IST, number of erroneous responses in the FW condition was negatively correlated with the Thrill and Adventure Seeking subscale of the SSS, $r = -.24$, $p < .05$.

Table 4.5. *Correlations between the measures of the Go/NoGo Task and the SSS*

Go/NoGo Measures	SSS Scales				
	Thrill and Adventure Seeking	Experience Seeking	Disinhibition	Boredom	Total
Go RT	.21	.34**	.18	.29*	.35**
Commission Errors	-.17	-.26*	-.06	-.05	-.18
Commission Error RT	.24*	.3*	.2	.4**	.4**
Omission Errors	.01	-.11	-.05	-.07	-.08

Note. ** $p < .01$, * $p < .05$

The subscales of the BIS were found not to correlate with any of the measures on the Go/NoGo, the IST or the Stop-Signal Task. Comparisons between the BIS and the SSS revealed a number of significant correlations and these are displayed in Table 4.6. The Motor Impulsiveness and Non-Planning scales had higher correlations with the scales of the SSS than the Attentional Impulsiveness scale. For the SSS subscales, the highest correlations with the BIS scales were found for the Disinhibition and Boredom scales and there were no significant correlations between the BIS scales and the Thrill and Adventure seeking scale.

Table 4.6. *Correlations between the BIS and SSS subscales*

BIS Scales	Thrill and Adventure	Experience Seeking	Disinhibition	Boredom	SSS Total
A.I.	.01	.18	.34**	.17	.25*
M.I.	-.01	.29*	.37**	.38**	.37**
NP.I.	-.05	.24*	.36**	.34**	.32**

Note. ** $p < .01$, * $p < .05$

4.3.5 Discussion

The performance of the participants on two of the BIS subscales and on one of the tasks, the Go/NoGo, lends some support to the Dual Systems Model (DSM) of adolescent risk-taking (Steinberg, 2008). However, no differences were found between the groups on the Stop-Signal Task or the IST and the non-offenders were actually found to have higher scores on a number of the scales in the SSS. Those results in the present study that are in line with the results of study 2 in chapter 3 will not be discussed in as much detail given that no new theoretical issues arise from such findings.

4.3.5.1 Hypothesis 1.

The first hypothesis stated that problematic drivers are more impulsive according to psychometric measures of impulsivity. The results are generally supportive of this hypothesis with offenders reporting higher levels of Attentional and Non-Planning Impulsiveness. On the basis of past research, the lack of differences between the groups on the Motor Impulsiveness scale is unexpected. This was the scale that Constantinou et al. (2011) found to have the highest correlation with both Ordinary and Aggressive Violations. Furthermore, the items belonging to the Motor Impulsiveness scale have greater face validity with regard to the Steinberg's description of cognitive control (Steinberg, 2008). It should be noted that the difference between the groups was in the hypothesised direction with offenders reporting higher levels. In their investigation of differences in impulsivity across age groups, Steinberg et al. (2008) did not include questions from the Attentional Impulsiveness scale of the BIS since they believed these not to be relevant to the age-related changes that the DSM focuses on. Yet this was one of the scales on which the groups were found to differ in the present study. The items in this scale relate to issues such as being able to maintain focus during a lecture. It's not

altogether clear why this would be related to driving violations since the latter are associated with deliberate behaviours. Constantinou et al. (2011) found that Attentional Impulsiveness had a smaller relationship than Motor and Non-Planning Impulsiveness with all of the DBQ scales and that it was only significantly related to the Errors scale. Since the offenders scored higher on all three scales, though significance was achieved for only two, it is not unreasonable to suggest that this offers support to the hypothesis that problematic drivers display higher levels of psychometric impulsivity. There was a slight contrast between the present study and the results of study 2. The problematic groups in both studies scored higher on the Attentional Impulsiveness scale. However, in contrast to Study 2, the offender group did not score significantly higher on the Motor Impulsiveness scale. Also in contrast with study 2, the offender group scored higher on the Non-Planning Impulsiveness scale compared with the non-offenders. The direction of the difference between the groups was the same for both studies with problematic drivers in both studies indicating higher levels of impulsivity. In a review of the BIS, Stanford et al. (2009) investigated the scores of “normal” participants. The scores of the non-offenders were much more in line with these normal scores which suggests that the significant differences between the groups are due more to the offender group scoring higher than the population rather than the non-offenders scoring lower.

4.3.5.2 Hypothesis 2.

The results of the response inhibition tasks provided conflicting evidence for the appropriateness of the DSM in explaining dangerous driving. A clear distinction was found between the groups on the Go/NoGo Task while there was no difference between the groups on the Stop-Signal Task. The null findings of the Stop-Signal are not in line with what would be predicted by the DSM. The task was designed so that participants should, on average, inhibit 50% of the nogo trials and this was found to be the case. However, within the task there was a strong relationship between SSRT and probability of inhibiting. SSRT is the main variable of interest in the task and is thought to be a measure of how quickly a participant can inhibit an already committed response (Logan et al., 1997). However, the probability of inhibiting variable is an artificial one that should not be related to a core variable such as SSRT. As described above, the task is designed in such a way that participants should inhibit 50% of the responses. Regardless of whether participants are good at inhibiting responses or find it difficult, they should have the same

number of incorrect trials (i.e. 50%). The results of the present study suggest that the number of trials a participant successfully inhibits plays a huge role ($r = .81$) in determining their SSRT. However, variations from 50% are not supposed to be indicative of poor response inhibition on the part of the participant and so their relationship with SSRT casts doubt on the interpretability of this variable.

The groups did differ on their responses on the Go/NoGo Task though it is not entirely clear if this is indicative of poorer response inhibition. The primary variable of interest in the Go/NoGo Task is the number of commission errors committed by a participant (i.e. the number of nogo trials they incorrectly responded on; see Horn et al., 2003). The offending drivers committed more of these than the non-offenders and this was found for both males and females. However, the offenders also responded much faster to go trials than non-offenders and this variable was found to be strongly related to the number of commission errors. This correlation does make sense given that faster average reaction-times should make inhibition more difficult. On the basis of commission errors alone, it would seem reasonable to simply conclude that the offenders displayed poorer response inhibition compared with the non-offenders. However, given the difference in average reaction-times between the groups, a more accurate, though not necessarily incompatible, conclusion would be that offenders traded speed for accuracy. It is worth noting that, unlike in the Stop-Signal Task, participants were not told to respond as quickly as possible to the stimuli. Instead, they were instructed to try to respond while the stimulus was still on screen.

This is not the first study to find two groups differing due to a speed-accuracy trade-off on the Go/NoGo. Rubia et al. (2006), in their study of response inhibition and age, found that adolescents committed more errors and responded to tasks faster than adults did. Since the focus of their study was on neurological correlates to response inhibition, the researchers did not discuss whether they believe this outcome to be indicative of poorer response inhibition in the younger participants. Roche et al. (2004) found a similar trade-off for patients with traumatic brain injury concluding that fast reaction-times are indicative of poor top-down control. However, had the offenders displayed more errors with similar reaction-times, then the results would have more clearly pointed towards some kind of inhibitory deficit. Instead, the present results suggest a kind of inability to modulate behaviour to account for errors or task difficulty. This does raise questions as to what the Go/NoGo task does actually measure. While this

question is beyond the scope of the present thesis, its implications of this for the DSM are quite important. It is important to recall that the initial impetus for using the Go/NoGo was due to developmental trends in performance on it and its association with those neurological areas that are among the last to develop (e.g. the dorsolateral prefrontal cortex; see the Introduction of Chapter 3 for a more detailed description). However, Steinberg's theory does not focus on response inhibition but instead describes those in late adolescence as lacking "cognitive control". While the results of the present study do not offer clear support for the groups differing in response inhibition, the offenders do display Go/NoGo responses that are indicative of having less of an ability to modulate response to reduce errors. Since Steinberg (2008) offers no concrete description of what cognitive control actually is, the results of study 4 can thus be interpreted as broad support for the DSM.

The performance of the participants on the response inhibition tasks was in contrast to study 2. The most obvious difference is that the offender group in this study showed differential performance on the Go/NoGo Task while there was no difference between the problematic and non-problematic group on this task in study 2. For the Stop-Signal Task, the problematic drivers in study 2 displayed poorer inhibitory abilities though this difference was not significant. However, in the present study, the two driving groups were much more similar in their SSRT as indicated by the much smaller effect size in the present study. Comparison between these groups and the general population on these the Go/NoGo is not possible since normalised scores are not available for the exact version of the task used in this study. However, the Stop-Signal Task used in this study was identical to Logan et al.'s (1997) task. The results in the present study are in line with those of Logan et al. in terms of SSRT and accuracy. The participants in both groups appeared to be slightly faster than those in Logan et al.'s study.

4.3.5.3 Hypothesis 3.

The third hypothesis stated that problematic drivers display less reflection. There was little ambiguity in the results of this task with offenders displaying just as much reflection as non-offenders. Overall, participants opened more boxes, made fewer errors and had a higher probability of being correct when responding in the FW condition compared with the DW which is in line with previous research (e.g. Clark et al., 2006). Clark describes the FW conditions as being more indicative of reflection impulsivity since

in the DW conditions, participants have an incentive for guessing before sufficient information is provided. This contrasts with the FW conditions in which participants have no logical reason for responding before they have collected enough information to have a high chance of being correct. In the present study, participants' responses were in line with the control participants in Clark et al.'s study. Not only was there no difference between the driving groups on their scores in the FW conditions, but the differences in responses between the FW and DW conditions were the same across groups. Collectively, the evidence suggests that the participants did complete the task in the manner intended but there was no difference between offenders and non-offenders in the amount of reflection they engaged in before responding. The findings of this study are much less ambiguous compared with those in study 2. For study 2, problematic drivers displayed greater differences in their probability of being correct when responding between the FW and DW conditions. This relatively ambiguous outcome was absent from the present study with neither of the groups displaying any differences on this task.

4.3.5.4 Additional findings.

The non-offenders scored higher than the offenders on the Violations scale of the DBQ though the difference did not quite achieve statistical significance. This may initially seem at odds with the research discussed in the introduction of this chapter, some of which has found the DBQ to have a correlation with number of driving instances involving the police (see de Winter & Dodou, 2010). However, a simple explanation underlies this counter-intuitive finding. The participants in the non-offender group were selected from those who took part in the study 2. These participants were selected for that study on the basis of having particularly high and particularly low DBQ scores. However, their inclusion in the present study was dependent only on them having no penalty points and reporting no past accident involvement. Their DBQ score was deliberately ignored when considering their inclusion in this study and so the Violations score of this group is heavily influenced by the sampling method from the first study.

In contrast to a number of previous studies, including study 2 in the previous chapter, the offender driving group actually scored lower on all of the measures of sensation seeking compared with the non-offender group. However, only the difference on the Experience Seeking scale was found to be significant. It is difficult to compare these results with other research given that researchers have either used different

sensation seeking questionnaires (e.g. Dahlen et al., 2005) or they only described the results of some of the scales of the SSS (e.g. Constantinou et al., 2011; Schwebel et al., 2006). Dahlen et al.'s study used the Arnett Inventory of Sensation Seeking and did find it to be positively related to driving violations. In one of the few driving studies to look at the relationship between all of the SSS subscales and driving behaviours, Jonah, Thiessen, and Au-Yeung (2001) found the Experience Seeking scale to correlate only with alcohol-related driving offences. Schwebel et al., who did not look at the Experience Seeking Scales found the Disinhibition and Boredom scales of the SSS to be quite strongly correlated with the Violations scale of the DBQ. However, these positive results were all found for self-reported speeding. Given that this is the first study to compare offending and non-offending drivers on sensation seeking scores, it could be the case that previous findings are due to common method variance (see af Wahlberg, 2009). However, positive relationships between self-reported dangerous driving and sensation seeking have emerged from studies that have used quite different questionnaires (e.g. forced choice (Jonah et al., 2001) vs. Likert scale (Schwebel et al., 2006) questions). Such patterns are generally indications that common method variance is not driving the relationship. No other explanation is immediately apparent for the present results regarding sensation seeking.

There were a number of correlations between the two response inhibition tasks. However, these correlations were not between the variables of most interest in the tasks. For example, there was a small correlation between SSRT and reaction-time in the Go/NoGo Task. This is an unexpected relationship given that SSRT is supposed to be a measure that takes into account participants' reaction-times and that it was not related to go reaction-time in the Stop-Signal Task itself. The key variable in the Go/NoGo Task, number of commission errors, was found only to be associated with accuracy. The negative relationship indicates that those who were successful at inhibiting responses during the Go/NoGo Task were more accurate in their responses in the Stop-Signal. However, accurate responses in the Stop-Signal Task do not require any kind of inhibition – they merely require participants to press the correct key in response to one of two stimuli. Accordingly, this relationship is also quite unexpected. The relationships between the variables in the different response inhibition tasks were in line with study 2 suggesting that this lack of association is a relatively robust finding.

4.3.5.5 Implications.

It is not surprising that the IST results are different from those of the Go/NoGo given that the tasks purport to measure quite different constructs. However, the Go/NoGo and Stop-Signal both purport to measure response inhibition and yet they diverge in this study. The obvious explanation is that the tasks do not measure exactly the same thing. There are three sources of evidence that suggest that this may well be the case. Firstly, on the basis of description alone, there are differences between the tasks. While the Go/NoGo requires participants to break out of a pattern of responding, no such pattern is present in the Stop-Signal Task. Instead, the Stop-Signal requires participants to terminate a response that they have chosen more consciously. Furthermore, the Stop-Signal Task requests that the participant respond as fast as possible while also trying to inhibit nogo trials. There is a conflict in these requests as the participants do not realise that the task difficulty is automatically adjusted to account for the response speed. Accordingly, participants may be responding quickly while believing that if they were to slow down then they would be able to inhibit successfully on more trials. This conflict is not present in the Go/NoGo Task where participants are only instructed to respond while the stimulus is still on screen. The second source of evidence which suggests that the tasks are different comes from research that has compared performance on the two. The SSRT is the main measure of inhibitory ability in the Stop-Signal Task (Logan et al., 1997) while number of commission errors is the equivalent for the Go/NoGo Task (Garavan et al., 2002). Yet in studies 2 and 4, there were no correlations between these measures. These results were in line with the only previous study that compared the two (Stuart J. Johnstone et al., 2007), though this was with a much young sample of 7-12 year-olds. The final piece of evidence for divergence between the tasks comes from another finding in Johnstone et al.'s study. In their EEG analysis, they found that "...the morphology and topography of the ERPs for the Nogo and Stop stimuli are strikingly different..." (p. 32). They suggest that this difference may be due to Stop stimuli occurring after a response has been selected, while Nogo stimuli present themselves much earlier in the stages of response activation. On the basis of these differences, it is reasonable to conclude that they involve different cognitive processes.

The differences between the groups in this study were not in line with those in Study 2. Had the differences between the groups been the same in both studies, this

would have suggested that identifying problematic drivers on the basis of police apprehension offers no advantages over the use of questionnaire responses. Problematic drivers displayed poorer inhibitory abilities on the Stop-Signal Task in study 2 while there was very little difference between the groups in this study. However, the results in study 2 did not achieve statistical significance; a p value of about .2 means that the apparent difference had a one in five chance of occurring due to random error (if the groups do not actually differ). Accordingly, the simplest explanation for the reduced difference between the groups in study 4 is that the results of study 2 were due to chance. The finding that the groups differed significant for the Go/NoGo Task in only study 4 does lend support to the suggestion that at least some of the null findings of study 2 were due to the identification of problematic drivers in that study. Drivers who are students at an urban university may not be representative sample of the rest of the young driver population. The results of study 4 suggest that either the DBQ is not a particularly good measure of dangerous driving, since the groups in study 2 did differ on this measure, or that problematic driving behaviours of college students are due to factors other than those described by the DSM.

4.3.5.6 Limitations.

This study attempted to investigate differences on a number of tasks between non-offenders and offenders. The study focused on identifying the latter group through a method other than questionnaire responses for reasons explained at the end of the previous chapter and at the beginning of this one. However, the present method of identification of problematic drivers is not without its own limitations. The drivers in the offender group were young people who had only been caught speeding once by the police in Northern Ireland. Any drivers who are caught again within 3 years are not eligible to attend the course and must take the penalty points instead. Accordingly, the “offenders” in this study could not have been people who had frequently run into problems with the law over their driving behaviour. The classification of these drivers is based on the assumptions that those drivers who are indeed more problematic have a greater chance of being caught speeding while those drivers who have never been caught speeding have a greater chance of being non-problematic drivers. There is no direct evidence to support this assumption.

The groups may not have been entirely comparable given that they came from different countries with different legal systems and cultures. In both countries, the receipt of 12 penalty points within 3 years will lead to a disqualification of an individual's licence. However, in Northern Ireland, speeders are typically given 3 penalty points for speeding compared with 2 in the Republic of Ireland. Accordingly, speeding is punished more severely in Northern Ireland where the problematic participants were recruited. While this supports the classification of these participants, it is still the case that driving culture and/or enforcement of the law may differ between the two jurisdictions. The problematic and non-problematic drivers in study 2 were tested in homogenous environments while the offending participants in this study were tested at the centre where they were attending the course. Their testing environment was still a quiet one, but they did take part after having attended a 2 ½ hour course. Accordingly, they may have been more fatigued while taking part compared with the non-offender group.

Another limitation in this study is its focus on just one of the systems described in the DSM. While the SSS is used to gain a brief measure of sensation seeking, which roughly corresponds to the first system described by Steinberg (2008), the entire focus of this study, along with study 2, was the investigation of the DSM through non-self-report measures. Problematic driving among young people could be the result of an interaction of the two systems that Steinberg and others (e.g. Casey et al., 2008) have described rather than just a simpler explanation of "low impulse control leads to dangerous driving".

4.3.5.7 Further study.

Researchers have used behaviourally-based measures of the Balloon Analogue Risk Task (Upton et al., 2011) and the Stop Light Task (Gardner & Steinberg, 2005) to investigate risk-taking from a sensation seeking point of view (since these tasks do not require impulse control). However, despite their use as behavioural measures of sensation seeking, it's not altogether clear that this is what they actually measure. Sensation seeking is typically defined as a tendency for an individual to pursue stimulation (Ames, Zogg, & Stacy, 2002). It seems unlikely that a relatively boring computer-based task offers any reasonable kind of assessment of the kinds of sensation seeking processes that might be elicited by speeding down a roadway at night with friends while listening to music. A focus for future study in the broad area of risk-taking would be to design a task

that does actually measure the kinds of sensation seeking processes that lead people to engage in risk in the first place.

A (theoretically) simple follow-up to this research would be to identify dangerous drivers in a manner that leaves less ambiguity than the present study's method. Ideally, researchers could recruit individuals who have lost their licence due to repeat offences or who are known by local police to be frequently involved in driving-related offences. However, such designs require infrastructural and legal frameworks that may not be in place to facilitate this. Research with those who have been arrested for driving under the influence of alcohol has utilised this methodology frequently (e.g. Cavaiola, Strohmetz, Wolf, & Lavender, 2003). Elliott and Thomson (2010) recruited participants for their postal-questionnaire study through contacts with the UK police who aided them in contacting individuals who had received penalty points for speeding in the last four months. Such participants are similar to those in the present study and so the same limitations do apply. However, it does suggest that contact with more serious, repeat offenders may be possible through law enforcement agencies.

The findings of this study do suggest that poor performance on a response inhibition task may be related to dangerous driving. However, the non-experimental nature of this study negates any possible causal claims. An alternative way to test the impact of cognitive control on dangerous driving could be to train participants to exercise greater control and see if this impacted their future driving behaviour. This is not an entirely unprecedented approach since Isler, Starkey, and Sheppard (2011) have had some success in influencing speed choice by teaching higher order cognitive skills to young drivers. However, the skills they taught to these drivers were directly related to driving. The DSM suggests that the teaching of lower-level cognitive skills, which are not directly associated with driving, may have a positive influence on risk-taking behaviour while driving.

4.4 Conclusion

The results of the first study in this chapter (study 3) suggest that the three-factor solution for the DBQ is an appropriate one for young drivers (study 3; hypothesis one) and that is as appropriate for young drivers in comparison with older ones (study 3; hypothesis two). However, the relatively low Violations score for the young drivers in this

study suggests that they may not be a representative driving group. This is not altogether surprising given the limited sampling method in obtaining these participants. The second study of this chapter was a replication of study 2 comparing offending and non-offending drivers. There were differences between the driving groups on psychometric measures of impulsivity (study 4; hypothesis one) and on the Go/NoGo Task (study 4; hypothesis two). However, these differences do not clearly indicate poorer inhibitory skills among the offenders and instead it appears that these drivers seemed to respond fast while sacrificing accuracy. This result does call into question what the Go/NoGo Task actually measures but does still offer support for the DSM given that the higher risk drivers performed worse at a task that has been associated with late neurological development. There were no differences between the driving groups on the IST (study 4; hypothesis three).

Chapter 5: The Role of Risk Perception and Attitude Accessibility in Problematic Driving

5.1 Introduction

As described in the introduction, the different theories of adolescent risk-taking vary in their assumptions regarding the role that risk attitudes and risk perception play. Rational models (e.g. the Theory of Planned Behaviour) suggest that if people perceive the risks of a behaviour to be too high, then they will not engage in it. If rational models can explain typical risk-taking behaviours, then adolescent risk-taking must be the result of some kind of distortion of risk perception. As discussed in the Introduction of this thesis, this view is quite prevalent among the general public with a typical explanation of dangerous driving among young people being “they think they’re invulnerable”. While it is probably the case that many of these commentators do not literally believe this, the overall implication is that risk-taking during adolescence results from some lack of knowledge or understanding about the risks. Steinberg is quite direct in opposing this view of adolescent risk-taking when proposing the Dual Systems Model (DSM) (2008). In fact, he states that “...the factors that lead adolescents to engage in risky activity are social and emotional, not cognitive...” (p. 81). This chapter presents an investigation of risk attitudes among young people. This topic is not as directly related to the DSM as the questions of cognitive control discussed over the previous chapters and the role of risk attitudes is an issue that has quite broad implications for dangerous driving among young people. However, given that the DSM was formulated with direct reference to this issue, the topic does have relevance for the theory.

There are a number of different ways to test the assumption that adolescents do not understand risk as well as adults do. Adolescents’ perceptions of risks can be compared against those of adults. Furthermore, adolescents’ perception of risks relative to their peers can be compared with adults’ perception of relative risk. A third approach is to compare high and low risk adolescents to see if they differ in their risk perceptions. In keeping with the general direction of the present thesis, this third approach will be the focus of the present chapter. However, given its relevance, the outcomes of comparisons between adolescents and adults for risk perception, both absolute and comparative, will first be described.

5.1.1 Risk perception

Absolute risk can be assessed in two ways. Firstly, people can be asked to simply indicate how much they believe themselves to be at risk of a particular outcome. For example, Murphy, Rotheram-Borus, and Reid (1998) asked adolescents questions such as “Based on your behaviour over the past month, how much do you think you are at risk for getting the virus that causes AIDS?” Another approach is to ask people how risky a particular event is and compare this against some kind of official estimate (e.g. “What is the likelihood of being in a car accident?”). Evidence from studies such as these does not support the suggestion that young people have a lack of understanding of risk. For example, Millstein and Halpern-Felsher (2002) asked adolescents (aged 9-15 years of age) and adults (20 to 30 years) to estimate the probability of a negative outcome in a specific situation (e.g. the probability of being in a car accident due to alcohol, or the probability of dying in a lightning storm). They found that, in all cases, adults rated the probability of a negative outcome occurring for them as being lower than any of the younger groups. This trend remained for almost all of the outcomes even when accounting for numeracy ability and experience. Where possible, this study also compared participants’ risk-estimates against official statistics. Though they found that all participants over-estimated their risk of dying in a hurricane or an earthquake, the younger participants over-estimated these risks by a larger amount.

Another measure of risk is how people think of their own risk in comparison to others; either their peers or other age groups. Comparisons between different age groups have been made in this regard as well. Quadrel et al. (1993) asked adults and their accompanying teenage children to indicate the probability of a negative outcome occurring for them in comparison to others. The adolescents were just as likely as the adults were to rate them (the adolescents) as being more at risk than others. Furthermore, for some of the outcomes, adults were more likely than teenagers to rate themselves as being at less risk compared with others. Quadrel et al. defined absolute invulnerability as being the belief that there is no chance at all of a negative event occurring for oneself. They found that teenagers indicated absolute invulnerability less often than their parents did with Millstein and Halpern-Felsher (2002) finding similar results.

While the evidence so far does support the views of those researchers who believe adolescents to understand risk just as much as adults do (e.g. Reyna & Farley,

2006), the focus of this chapter is on a different approach to this issue. If rational models are correct, then high-risk adolescents (e.g. problematic drivers) should rate themselves as being less at-risk than their lower-risk peers. The evidence relating to this approach is split between those studies that have found high risk individuals to have a lower perception of risk, as predicted by rational models, and those studies that have found high risk individuals to perceive risk as being higher. Gerrard et al. (1996) measured levels of dangerous driving over a three year period and found that increases in levels of this behaviour were associated with increases in feelings of vulnerability to being in an accident. These increases in vulnerability were found both for comparative and absolute measures of accident risk. Cohn, Macfarlane, Yanez, and Imai (1995) found that those adolescents who engaged in a range of health-risk behaviours (e.g. drug taking) were less optimistic about avoiding the harms associated with these activities. Murphy et al. (1998) found a similar trend for risk of contracting HIV with high-risk young people giving higher estimates for their risk of contracting the virus.

These relationships between risk perception and risk behaviour are contrary to what would be expected based on rational models of health behaviour. However, the results of a number of studies have supported rational models by showing the exact opposite relationship between risk behaviour and perception. Benthin, Slovic, and Severson (1993) asked participants (aged 14-18 years) about their engagement in a number of "problem behaviours" and asked the following question about each behaviour: "If you did this activity, to what extent do you believe that you would be personally at risk of getting hurt or getting sick?" They found that, for almost all of the behaviours, those who engaged in them gave lower risk estimates on this question compared with non-engaging young people. Chassin, Presson, Rose, and Sherman (2001) found that smokers gave higher ratings in response to the statement "If I smoke cigarettes, I will live a healthy life". In another smoking study, Brynin (1999) found that current young smokers were less likely to agree with statements such as "Smoking is extremely dangerous".

These results seem to offer contradictory evidence with some studies suggesting high-risk adolescents are more aware of the dangers while other studies report the exact opposite. These variations may be due, in part, to differences in the nature of questions used in the studies. Those studies that found a positive relationship between risk perception and risk behaviours asked participants about the likelihood of a particular outcome happening to them. For example, Gerrard et al. (1996) asked participants how

likely it was that their driving would lead to an accident and Cohn et al. (1995) asked participants questions such as "...how much will you harm yourself if you [smoke]" Both of these kinds of questions focus on the risk of a negative outcome resulting from the behaviour. This is contrasted with the Brynin's study (1999) which asked participants to respond to the statement "Smoking is extremely dangerous". Notice that in this instance, the question is about the riskiness of a behaviour rather the risk of a particular outcome. Benthin et al. (1993) and Chassin et al. (2001) also found risk perception to be negatively related to risk behaviour but did so using questions that, at first, seem to address outcomes. However, in both of their studies, they asked questions that took the form of "if you engaged in this risk behaviour, how likely is it that this outcome would occur?" However, the "if" in questions such as these requires the participants to imagine engaging in the behaviour, perhaps over a long period of time. Consequently, such questions, despite mentioning specific outcomes, are really questions about the riskiness of the behaviour.

This explanation for the contradictory outcomes of the above studies is supported by research that has asked both behaviour and outcome focused risk questions. Johnson et al. (2002) asked adolescents and young adults about their involvement in a number of risky behaviours. They then asked participants to indicate the risks of a negative outcome occurring for them and to indicate how risky they thought the behaviour to be. They found that risk-takers rated their risks as higher in the outcome-type questions and this occurred for both absolute and comparative questions. However, the results were reversed for the behaviour focused questions though the difference between the groups did not reach statistical significance. A similar pattern was found for dangerous driving with Machin and Sankey (2008) finding a positive relationship between speeding and estimates of the likelihood of being in an accident and a negative relationship between speeding and a measure of the riskiness of certain driving behaviours.

While these studies do support the suggestion that the nature of the question (outcome vs. behaviour focused) impacts on the relationship between self-reported risk perception and risk behaviour, they do not explain why this might be the case. A possible explanation may be offered by Mills et al. (2008) who appeal to *Fuzzy Trace Theory* (Reyna & Brainerd, 1995). This theory was briefly mentioned in chapter 1 as part of the discussion of Dual Processing explanations of adolescent risk behaviour. Fuzzy Trace Theory emerged from research that found that children were able to perform well on

memory-based reasoning tasks despite having a poor recall of the individual elements of the task (Brainerd & Kingma, 1984). The original researchers sought to develop a theory for how reasoning could occur in the absence of explicit memory for a task. Reyna and Farley (2006) explain that the basic idea of the theory is that people encode multiple mental representations of experiences in memory and these representations range from precise verbatim ones to fuzzy gists, which incorporate only the broad features. Reyna and Farley support the view that young people are not risk-takers because of lack of knowledge. Indeed, Steinberg (2008) cites their 2006 review as evidence of the need for the DSM of adolescent risk-taking. Reyna and Farley suggest that the problem for young people is their over-reliance on verbatim representations and a subsequent weighting of the pros and cons. Instead, they suggest that mature risk-avoidance results from a gradual change towards gist-based reasoning. They suggest that individuals who think about a risk behaviour as simply being “bad” will be more likely to avoid that risk behaviour than somebody who thinks through the possible outcomes of a behaviour and makes a decision on what they believe is the most likely outcome.

Mills et al. (2008) point out that both positive and negative relationships between risk behaviours and attitudes make independent sense. Those individuals who engage in risky behaviour frequently may realise that they are at risk (positive relationship). However, those who do not identify a behaviour as risky may engage in that behaviour more often (negative relationship). Mills et al. suggest that the risk-perception questions that focus on outcomes (as in Gerrard et al., 1996) are by their nature much more specific than risk-questions that focus on the behaviour. Consequently, outcome focused questions encourage a verbatim approach in which individuals think over their actions and realise that they have exposed themselves to some risk. However, behaviour focused questions are more vague (e.g. “Is speeding dangerous”) and thus people answer them using gist-based reasoning. However, despite Mills et al.’s appeal to Fuzzy Trace Theory to explain the conflicting results, the explanation is not entirely satisfactory. For instance, in their study, Mills et al. asked adolescents about their risky sex behaviours and their perceptions of the risks. In line with previous research, responses to behaviour focused questions were negatively correlated with risk perception while outcome focused questions were positively correlated. However, the Fuzzy Trace Theory suggests that young people take more risks because they do not use gist-based reasoning. The study by Mills et al. suggests that the gist representations of high-risk young people categorise the

behaviour as not being very risky. Consequently, if these young people were to use their gist representations for decision making, it appears that they would still be involved in risks. In fact, the simplest explanation for Mills et al.'s findings is that gist-representations do determine risk involvement but that the problem for young people is not that they do not use this kind of reasoning, but that their gist representations do not characterise the behaviour as being particularly risky. Mills et al. attempt to address this issue by stating that "Adolescents who think about risk in gist terms...are more likely than others to perceive the gist of risk as high and to avoid risk". However, no research has backed this up since there is currently no method to test whether an individual reasons in gist terms or not.

5.1.2 Risks and benefits

The description of risk-taking so far has excluded a very important aspect of risk behaviours; risks can pay off and result in benefits to the individual. It's easy to imagine how this is the case for risk behaviours such as gambling; if you win at roulette, then you'll get a financial reward. If there were no benefits associated with a risk, then individuals would not be expected to engage in them and this applies to the kinds of recreational risks discussed above. Allen and Brown (2008) describe a number of studies that, unsurprisingly, suggest that peer acceptance and popularity play an important role in the driving behaviour of some young people. Furthermore, the authors point out that such concerns among young people are not trivial as evidence suggests that social isolation is associated with depression, anxiety and a number of other mental health issues. In fact, House, Landis, and Umberson (1988) found in a meta-analysis that social isolation predicted future mortality rates almost as much as smoking did; though they acknowledge that the mechanism through which smoking lead to death are much less ambiguous.

Given that most recreational risks present the opportunity for some kind of benefit, either of a hedonistic or social nature, the question of youth risk-taking must take into account not just risk perception, but also benefit perception. Figner and Weber (2011) describe how, for an individual, any instance of risk-taking involves a) the perception of the risks involved, b) the perception of the benefits, and c) the amount of risk that that individual is willing to put up with for the potential benefits. Figner and Weber suggest that the perception of risks and benefits differs for an individual

depending on the context (e.g. a financial risk vs. a recreational one). Their research suggests that many of the differences in risk-taking between men and women are the result of differences in the perceived risks and benefits of the situation. Interestingly, they have not found males and females to differ in the ratio of risks to benefits that they are willing to accept. Ben-Zur and Reshef-Kfir (2003) investigated the relationship between risk behaviour and both risk perception and benefit perception among adolescents. Their questions focused on the risk behaviours themselves (including dangerous driving) and they found that perception of benefits was positively related to risk involvement while there was no relationship between risk perception and risk behaviours. Despite results such as these, researchers typically focus only on the perception of risks in their explanations of youth risk-taking.

The methodologies of the above studies are relatively unsophisticated. Much of this research consists of asking participants to rate on a Likert scale how risky a particular behaviour is or what the chances are of something negative happening to them while engaging in this behaviour. While these questions have revealed a number of interesting results, they may be limited in what they can tell us about the reasoning of a participant in a real-life risk-taking scenario. Even aside from the issue of whether people answer these questions truthfully, or whether they interpret the Likert scale points in the same way, this approach assumes that people view risks under lab conditions in the same way that they view them when they are in real life situations. This has led to the notion of *hot* and *cold* reasoning (see Loewenstein, Weber, Hsee, & Welch, 2001); the former refers to the kind of reasoning associated with emotional situations where there may be competing demands while cold reasoning is the kind of reasoning that takes place in calm setting. The key problem with testing this concept is that hot reasoning, almost by definition, takes place in settings that are not conducive to careful psychological testing. Figner et al. (2009) use the Columbia Card Task to attempt to induce an emotional state in participants. While they have demonstrated interesting differences between adolescent and adult thinking, it is questionable whether these induced emotional conditions in the lab offer any kind of correspondence with real life risk-taking.

5.1.3 Attitudes

A number of methods do exist that may allow for the testing of risk and benefit perception in a more nuanced manner than simple questionnaire measures. However,

before discussing these particular methods, the case will be made that the perceptions of risks and benefits can, in many instances, be conceptualised as attitudes. While numerous definitions of attitudes have been proposed (see Fraser & Burchell, 2001), the present discussion will use the definition articulated by Fazio, Chen, McDonel, and Sherman (1982). Their description comes from a cognitive perspective with attitudes defined as a link between an attitude object and an evaluative category. While this definition may seem to be recursive given that it uses the word “attitude”, the use of the phrase “attitude object” really conveys that the things that people can have an attitude towards are quite diverse (e.g. food, particular behaviours, art and even abstract concepts). The evaluative aspect of the definition is also quite broad and can incorporate both cognitive evaluations, such as “useful”, and emotional evaluations like “good” (Fazio, Sanbonmatsu, Powell, & Kardes, 1986). This description portrays attitudes as being no different from any other associations in semantic memory (e.g. Collins & Loftus, 1975). Collins and Loftus, among others, propose that semantic memory is made up of concepts that are connected in a *semantic network*. Furthermore, Collins and Loftus propose that when a concept is *activated*, those concepts that are strongly connected with the original concept will also be activated (e.g. when the concept “ant” is activated, the concepts “insect” and “small” might also be activated). Within a framework such as this, Fazio et al. (1982) suggest that attitudes should be viewed as the connection between any attitude object (e.g. “ant”) and an evaluative category (e.g. “pleasant”) as opposed to a descriptive category (e.g. “insect”). An advantage of this conception of attitudes is that the definition makes no assumptions about the relationship between attitudes and behaviour.

An important extension of this view of attitudes is that attitudes are seen as varying in strength (Fazio et al., 1982). Two individuals can both hold the attitude that blood donation is a good thing, but the strength of the relationship might differ for the two. The strength of an attitude is seen as the likelihood that the evaluative statement will be activated when the attitude object is encountered (Fazio, 2007). Fazio describes this strength as varying along a continuum with *no attitude* at one end and *consistently activated attitude* at the other. A simplistic starting point is that stronger attitudes are more likely to be activated and are, thus, more likely to influence behaviour. To test this initial theory, Fazio and Williams (1986) assessed the latency of participants’ responses to questions about their attitudes towards Ronald Reagan and Walter Mondale in the run-up

to the 1984 US presidential election. Faster responses were thought to indicate stronger attitudes; a concept referred to as attitude accessibility which will be discussed in greater detail in section 5.1.5 . They found that those with stronger attitudes towards their respective candidate of choice were more likely to view that candidate as having performed well in a debate and were, ultimately, more likely to vote for that candidate.

5.1.4 MODE model

Attitude strength refers to the degree that an attitude will be automatically activated in association with the attitude object (Fazio, 2007). However, the activation of an attitude does not influence behaviour in a deterministic fashion. The MODE model (Motivation and Opportunity as DEterminants of the attitude-behaviour relation) was developed to describe precisely those situations in which attitudes are likely to have a significant impact on behaviour (Olson & Fazio, 2009). This model suggests that people will act on the basis of automatically activated attitudes unless they have both the opportunity to and motivation to deliberate. Olson and Fazio point to a number of reasons why an individual might be motivated to resist an attitude including the desire to be correct when responding (in a test scenario), the desire to avoid socially unacceptable behaviour (particularly with regard to racist attitudes) or the desire to avoid an injurious outcome. However, these motivations will not have an impact on behaviour if the opportunity to deliberate is not available. Olson and Fazio list a number of issues that limit opportunity, the most obvious of which is time. If a decision must be made quickly, then the MODE model predicts that attitudes will have a strong influence on behaviour. However, there are other potential factors that can limit opportunity such as fatigue and distraction which may reduce the cognitive resources needed to fully consider motivational factors.

Figure 5.1 is based on figures presented by Olson and Fazio (2009). It presents a graphical representation of the MODE model where there are two processes that influence behaviour in a situation – automatically activated attitudes and motivational factors. Opportunity is presented as a kind of gate as in the absence of opportunity, the presence of motivational factors is irrelevant. The diagram on the left of Figure 5.1 represents a situation in which both attitudes and motivational factors are competing to influence behaviour but it is the attitudes that ultimately win in this instance since the lack of opportunity prevents motivational factors. The diagram on the right of this same

figure represents a situation in which both opportunity and motivation are present and so the role of attitudes is minimised.

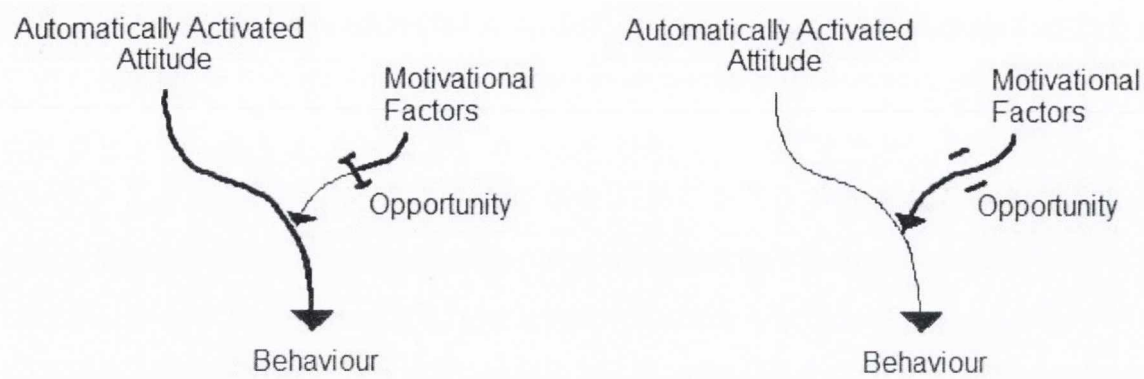


Figure 5.1. Representation of the MODE model based on figures used by Olson and Fazio (2009).

Before discussing the evidence to support this model, the relationship between this view of attitudes and more recent measures of implicit attitudes requires a brief description. Fazio (2007) suggests that traditional pen-and-paper methods of obtaining attitudes represent a situation in which a respondent has plenty of opportunity to counter their attitudes if they have motivation to do so. However, implicit measures of attitudes, such as the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998), do not allow individuals the opportunity to influence their responses even if they wish to do so. Discrepancies between explicit and implicit measures of attitudes have lead some researchers to propose models of attitudes in which people can simultaneous hold different attitudes towards the same attitude object (Wilson, Lindsey, & Schooler, 2000). However, Olson and Fazio (2009) point to a number of studies that suggest that as opportunity and motivation to deliberate on explicit measures are reduced, responses to these measures correspond to a higher degree with implicit measures. Accordingly, they propose that implicit and explicit should be conceptualised as referring to the method rather than the attitude. There are other interpretations of what exactly implicit measures such as the IAT measure (e.g. Greenwald, Nosek, Banaji, & Klauer, 2005), but this debate is not particularly relevant to the present work. In a review of behaviours and implicit measure of attitudes towards those behaviours, Frieze, Hofmann, and Schmitt (2009) found that the greatest correspondence existed when conditions facilitated the

impact of automatic attitudes. They found that both motivation and opportunity were two of the variables that determined the degree to which a situation facilitated such attitudes.

5.1.5 Attitude accessibility

Thus far, the discussion of attitudes has been almost entirely theoretical focusing specifically on the perspectives of Fazio and his colleagues. However, very little has been said about the concept of attitude strength, particularly how it might be measured. Recall that Fazio's concept of an attitude is that it is simply a link in memory between an attitude object and an evaluative category. In accordance with theories of semantic networks (e.g. Collins & Loftus, 1975), when a concept (such as an attitude object) is activated, those concepts that are semantically related will also be activated. Fazio et al. (1982) suggest that the speed of the activation of an evaluative concept following activation of an attitude object indicates the accessibility of an attitude which is synonymous with the strength of an attitude. Accordingly, attitude accessibility is typically measured by observing the response latencies to attitudinal questions.

As described above, Fazio and Williams (1986) investigated the relationship between attitude strength and voting behaviour in the 1984 US presidential election. They measured participants' responses to questions about the suitability of each candidate for the position. They also measured how long it took participants to respond to the questions and found that those participants who had accessible attitudes (i.e. fast reaction-times) were more likely to vote for the candidate for whom they had originally indicated a preference. A number of other studies have investigated the links between attitude accessibility and behaviour. DeMarree, Petty, and Strunk (2010) found that the accessibility of self-esteem, which they conceptualise as the speed with which people can access an attitude towards themselves, predicted the degree to which self-esteem was resistant to change. That is, people with more accessible attitudes towards themselves were more resistant to attempts to temporarily influence their self-esteem. Furthermore, they found that the degree to which self-esteem influenced judgements and predictions increased as accessibility increased. A. B. Cohen, Shariff, and Hill (2008) found that the accessibility of religious beliefs predicted church attendance. In support of Fazio's (2007) conception of the differences between implicit and explicit measures, Lebel (2010) found that those individuals who responded faster on explicit measures of self-esteem had a

higher correspondence between these scores and their results on implicit measures of self-esteem.

While the above findings do offer support for Fazio's description of attitudes, they do not explain why exactly attitudes might influence behaviour. Firstly, Fazio (2007) suggests that attitudes are shortcuts, much like the heuristics and biases described by Tversky and Kahneman (1974). As in the MODE model, people rely on attitudes when they either do not have the opportunity or the motivation to go against them. Attitudes remove the necessity to construct opinions about objects each time we encounter them. This is why implicitly measured attitudes correspond best with behaviours that take place under circumstances where opportunity and/or motivation are lacking (see Frieze et al., 2009). Fazio and Williams (1986) suggest that the mechanism by which attitudes influence our behaviour is through their subsequent biasing of the interpretation of information once they have been activated. In their own study, they found that accessibility of attitudes towards candidates predicted both voting behaviour and judgement of debate performance. They explained this result by suggesting that highly accessible attitudes are more likely to be activated when an individual is presented with information regarding a candidate (e.g. at a debate). The activated attitude has an influence on the way people interpret subsequent information presented to them (e.g. whether they view a candidate's smile as an expression of politeness or as an unfriendly smirk). The information can then strengthen the attitude, or at least prevent it from being eliminated, leading people to be more likely to vote in a consistent manner. DeMarree et al. (2010) provide a similar explanation for their findings regarding the accessibility of self-esteem. They propose that individuals with low accessibility to their attitudes towards themselves (i.e. self-esteem), are more likely to be influenced by environmental factors (e.g. mood). Accordingly, methods that attempt to alter participants' attitudes towards themselves are more effective if the participant does not have readily available access to a self-evaluation.

5.1.6 Attitude accessibility and risk

The overarching concept behind the discussion of attitude accessibility is that while an attitude may be available to an individual, it may not be highly accessible. This has relevance for risk given the nature of risk perception questions. Questions relating to outcomes (e.g. "What are your chances of being in a car accident") are not examples of

attitudes. They do not involve an association between an attitude object and an evaluation. Instead, they require individuals to engage in some kind of mental calculation, either consciously or automatically. However, while outcome focused questions are not examples of attitudinal questions, behaviour focused questions can be. Asking participants how much they agree with a statement such as “Smoking is dangerous” is an example of an attitude since “Smoking” is an attitude object while “dangerous” is an evaluative label of a cognitive nature. Consequently, statements about the risks of a behaviour are really questions assessing negative attitudes towards that behaviour. Conversely, questions relating to perceived benefits of a behaviour are examples of questions assessing positive attitudes.

Rhodes and Ewoldsen (2009) investigated the relationship between participants’ accessibility of attitudes towards smoking by asking participants to respond with “like” or “dislike” to a number of objects (e.g. “cockroaches”) and behaviours (e.g. “watching TV”), one of which was “smoking cigarettes”. That found that attitude accessibility accounted for smoking behaviour even after traditional paper-and-pen measures of smoking attitudes had been accounted for. While no direct tests of response latency to perception of risks or benefits of dangerous driving have been conducted, a number of studies do suggest that accessibility may be relevant for this issue. In a series of interviews with problematic young male drivers, Falk and Montgomery (2007) found that the drivers were well able to identify risk factors in dangerous driving. However, they found that these drivers did not seem to think about the extremely serious possible outcomes (e.g. death) unless they were prompted and the authors remark that ‘...traffic accidents seemed to “end” with the moment that the accident happens...’ Once participants were prompted to describe the possible consequences of a crash, they had no difficulty listing serious injury or death suggesting that this information was available for them. However, their reluctance to spontaneously describe this information suggests that it may not be highly accessible. In a quantitative equivalent to this study, Gormley and Fuller (2008) found that young and older drivers listed negative outcomes of driving dangerously with the same frequency, but the younger drivers (17-19) were more much less likely to list death near the beginning of their list.

As described above, many implicit measures of attitudes can be seen as assessments that deny participants the opportunity to deliberate in their responses. Hatfield, Fernandes, Faunce, and Job (2008) found there to be a good correspondence

between an IAT measure of speeding and self-report dangerous driving. However, the IAT requires there to be two mutually exclusive categories for respondents to assign stimuli to. Hatfield et al. found that participants were faster to pair “speed” related words with “bad” words and “safe” related words with “good” words. The problem with this design is that the IAT effect could be due to participants believing safety to be a good thing, but not necessarily believing speeding to be a bad thing. Furthermore, while the words belonging to the speed category are all pretty closely related to driving behaviour (e.g. “speed”, “race”), many of the words in the safe category were less related to driving (e.g. “careful”, “sensible”).

5.2 Study 5

As described in the introduction to this chapter, the relationship between risk behaviour and risk perception varies depending on the nature of the risk questions. Questions that are behaviour focused often find that high risk-takers view the behaviour as less risky. Questions that focus on the potential negative outcomes of the behaviour typically find that risk-takers rate their own risks as being higher. This phenomenon has been demonstrated for attitudes to unsafe sex (Mills et al., 2008) and attitudes towards smoking (Johnson et al., 2002). Machin and Sankey (2008) have also found this relationship for driving behaviour and the present study represents an expansion of their approach. They collated participants’ risk-perceptions towards a number of driving behaviours such as running a red light or doing an illegal U-turn. The present study focuses purely on attitudes towards the riskiness of speeding given the important role that this single behaviour plays in fatal car accidents. For outcome focused questions, Machin and Sankey only asked participants what their chances of being in an accident were in the next 12 months. Falk and Montgomery (2007) suggest that problematic young drivers may not think much beyond the crash itself. Accordingly, this study expands Machin and Sankey’s by asking participants not just about their chances of being in an accident, but also about their chances of hurting somebody or damaging their car. Furthermore, Machin and Sankey did not distinguish between comparative and absolute questions in their approach.

A conclusion of the previous chapter was that the identification of problematic drivers through self-report measures may not always be ideal and that less biased

measures may hold more validity. Nonetheless, the present study once again relies on self-report measures to classify drivers. Study 4, described in the previous chapter, recruited participants from a training course for young people who had been apprehended by the police for speeding. Study 4 sought to investigate contributing factors to dangerous driving that would not be expected to be affected by attending a training course (e.g. impulsivity). The present study is concerned with attitudes towards dangerous driving which, unlike impulsivity, could well be affected by the process of being caught speeding and attending a driver education course. In the present study, identification of problematic drivers was not done through the use of the driver behaviour questionnaires (DBQ) and this was for two reasons. Firstly, as described in the discussion section of chapter 4, the null findings of chapter 3 may relate to an inability on the part of the DBQ to tap into the essence of what dangerous driving among young people consists of. After obtaining null findings with the DBQ followed by significant differences using police identification, to return to the DBQ would represent a step backwards. The second reason is that previous attitudinal research with young drivers has revealed interesting findings using much more blunt approaches, such as asking people “how often do you drive dangerously” (e.g. Gerrard et al., 1996).

5.2.1 Hypotheses

The first hypothesis is that problematic drivers perceive their risk as higher when responding to outcome focused risk questions while perceiving dangerous driving as being less risky for behaviour focused questions. The second hypothesis of this study is that both problematic and non-problematic drivers display optimistic biases in that they see themselves as less likely to be involved in an accident compared with others.

5.2.2 Method

5.2.2.1 Participants.

Participants were 17-21 year old males and females recruited from universities and Institutes of Technology (ITs) across Ireland. Departments in a number of ITs were asked to send an email to their students (appendix 4). Students were informed that they would be entered into a raffle for a music player if they took part in the study. The online questionnaire (appendix 4) was completed by 434 participants. A number of participants were excluded from the analysis for reasons outlined in Table 5.1. The most common

reason for exclusion was that a participant indicated that they did not drive very often. These were participants who stated that they had driven less than 1000km in the last six months or who chose the option “I don’t drive very often” in question 9 on the questionnaire. Nine participants were removed for providing unreliable information such as very high numbers of years driving or very high numbers of penalty points. The remaining 215 participants had a mean age of 19.8 years and included 146 males.

Participants were identified as problematic and non-problematic drivers on the basis of their responses to questions 12 and 14 on the questionnaire (see section 5.2.2.3). Participants who indicated that they had driven recklessly or dangerously “a few times” or more (i.e. responses 3, 4 or 5 on question 12) or that they had driven at speeds much faster than the speed limit “a few times” or more (i.e. responses 3, 4 or 5 on question 14) were identified as problematic. There were 94 problematic drivers and 121 non-problematic drivers

Table 5.1. *Criteria for Removal from Questionnaire Analysis and Number of Participants Removed*

Removal Criteria	Number of participants removed
Were not 17-21 years of age or did not say	43
Did not indicate gender	3
Did not drive very often	144
Were missing an answer in the questionnaire	18
Gave unreliable information	11
Total Removed	219

5.2.2.2 Measures and procedure.

Participants were instructed to click a link contained in the email that had been sent around their department. This link brought them to the online questionnaire (appendix 4) which first asked participants a number of demographic and driving questions. The next part of the questionnaire contained three questions (questions 12 to 14) regarding participants’ past driving behaviour; in the last three months, *how often have you driven recklessly?, how often have you driven at speeds slightly higher than the*

speed limit?, and *how often have you driven at speeds much higher than the speed limit?* These questions were all answered on a five-point Likert scale: 1 (*Never*); 2 (*Once or Twice*); 3 (*A few times*); 4 (*More than a few times*); 5 (*Regularly*). Participants were then asked nine questions about how at-risk they saw themselves as drivers. The first four questions asked participants on a seven-point Likert scale how “at risk” they were of different events (e.g. being in a car accident; see appendix 4 for exact questions). The next four questions were the same as the previous four, but these asked participants to rate their risk relative to people their own age on a seven-point scale with “1” representing “much less likely than others and “7” representing “much more likely than others”. The last risk question asked participants how risky they thought driving at very fast speeds is with their answers given on a seven-point Likert scale ranging from “Not at all risky” to “Extremely risky”. The consent form for this study can be found in appendix 4.

5.2.2.3 Analysis.

The focus of the analysis of the online questionnaire was the impact of driver group (problematic or non-problematic) and gender on participants’ responses to the risk perception questions (Questions 15 – 23). The risk questions were divided into three sections: absolute risk, comparative risk and global risk. Each participant’s mean absolute risk score was the average of the four absolute risk questions (Questions 15 – 18). A mean comparative risk score was given on the basis of participants’ responses to questions 19 – 22. Participants’ global risk score was based solely on their responses to question 23. An independent groups factorial ANOVA was conducted for each of these three dependent variables with gender and driving group as the fixed factors. Furthermore, a series of one sample *t* tests were conducted to see if the participants in each of the groups saw their risk of being involved in an accident as greater than that of other drivers. Questions 15 and 16 asked participants what their chances were of being in an accident in the next 6 months and before they were 25 respectively. Those participants who indicated that they had “no chance” to both of these were classified as seeing themselves as relatively invulnerable similar to Millstein & Halpern-Felsher’s (2002) classification procedure. A chi square analysis was conducted to determine if the distribution of “invulnerable” individuals was even across the two driving groups and a separate analysis investigated the distribution of these individuals among the genders.

5.2.3 Results

5.2.3.1 Driving information.

Table 5.2 and Table 5.3 below present summaries of the driving characteristics of the sample and of each group. Both tables also contain inferential statistics relating to the differences between the problematic and non-problematic groups on each variable. Table 5.2 presents a summary of the scale variables while Table 5.3 presents a summary of the nominal variables. The average age of the drivers was just under 20 and their average time since they first started driving was under three years. The two groups did not differ on these two variables but problematic drivers did have a significantly higher number of penalty points, $U = 5103$, $p < .05$, $r^7 = 0.14$. However, as can be seen in Table 5.2, numbers of penalty points were still very low in the groups. In fact, 179 out of the 215 participants did not have any points on their licence.

Table 5.2. Summary of Measurement-Type Driver Information

	Average	Problematic	Non- Problematic	t-score / U score	p
Age ^a	19.8	19.7	19.9	U = 5355	.44
Time driving ^b	31.9	31.6	31.9	t = 0.03	.98
Distance ^c	10005	11019.15	9218	U = 4976	.12
Points ^d	0.41	.6	.28	U = 5103	.047

Note. All figures are averages. Problematic and non-problematic drivers were compared using a Mann-Whitney U when data were non-normal or heterogeneously varied. Variables measured in: ^a years, ^b months since first started driving, ^c kilometres, ^d number of penalty points

A higher proportion of the participants were males and only 12 participants were learner drivers. The groups did differ on these two variables with the problematic group having a greater proportion of males but a smaller proportion of learner drivers. Very few participants had ever been involved in an accident and the groups did not differ in the

⁷ Field (2009) recommends the use of r as a measure of effect size for the Mann-Whitney test.

number of participants in each who had. There were proportionately more males in the problematic driving group, $\chi^2 = (1, N = 215) = 8.97, p < .01$.

Table 5.3. *Summary of Frequency-Type Driver Information*

	Group	Problematic	Non-Problematic	Chi-square ¹	p
Gender	Males	74	72	8.97	.003
	Females	20	49		
Licence	Full	86	99	4.1	.04
	Learner	8	22		
Accidents	Not Involved	15	13	2	.37
	Involved	79	107		

Note. ¹ In each of the tests of independence, there were no expected cell frequencies below 5.

5.2.3.2 Risk questions.

Three independent groups factorial ANOVAs were conducted for absolute risk, comparative risk and global risk with gender and driving group as the fixed factors.

Tests of statistical assumptions. The normality of the three variables across all combinations of gender and driving groups was assessed with a Shapiro-Wilk test. Nine of the 12 tests were statistically significant indicating that the distributions were mostly non-normal. These departures in normality were largely resistant to log and square root transformations. A Levene’s test for homogeneity of variance was not significant for absolute risk or comparative risk. However, this same test found significant differences in variance between the groups for global risk, $F(3, 211) = 9.25, p < .001$. This heterogeneity of variance could not be corrected with log or square root transformations. For all of the chi-square analyses below, the expected count was greater than 5.

Main effects and interactions. For absolute risk, there was a significant main effect of driving group, $F(1, 211) = 18.5, p < .001, \eta_p^2 = .08$, with problematic drivers estimating their risk of a negative car incident as being higher than non-problematic drivers did. There was no main effect of gender and no interaction between gender and

driving group. There was also a significant main effect of driving group on comparative risk, $F(1, 211) = 10.5, p < .001, \eta_p^2 = .05$ with problematic drivers seeing their risk of a negative car incident as being higher. There was no main effect of gender and no interaction between driving group and gender.

For global risk, there was a significant main effect of driving group with non-problematic drivers rating the global risk of speeding as being higher, $F(1,211) = 14.8, p < .001, \eta_p^2 = .07$. There was also a main effect of gender with females rating the global risk as being higher, $F(1, 211) = 18.5, p < .001, \eta_p^2 = .08$. There was also a significant interaction between gender and group, $F(1,211) = 5.6, p < .05, \eta_p^2 = .03$. This interaction was due to the fact that there was a larger difference between problematic and non-problematic participants among males, $U = 1432, p < .001, r = .41$, than there was among females, $U = 344.5, p < .05, r = .27$; though non-problematic drivers gave a higher risk estimate for both groups (Non-parametric tests were used as the data were not normally distributed and there was conflict between the results of the these tests and parametric equivalents). The effects of driving group for each of the three risk variables are illustrated in Figure 5.2.

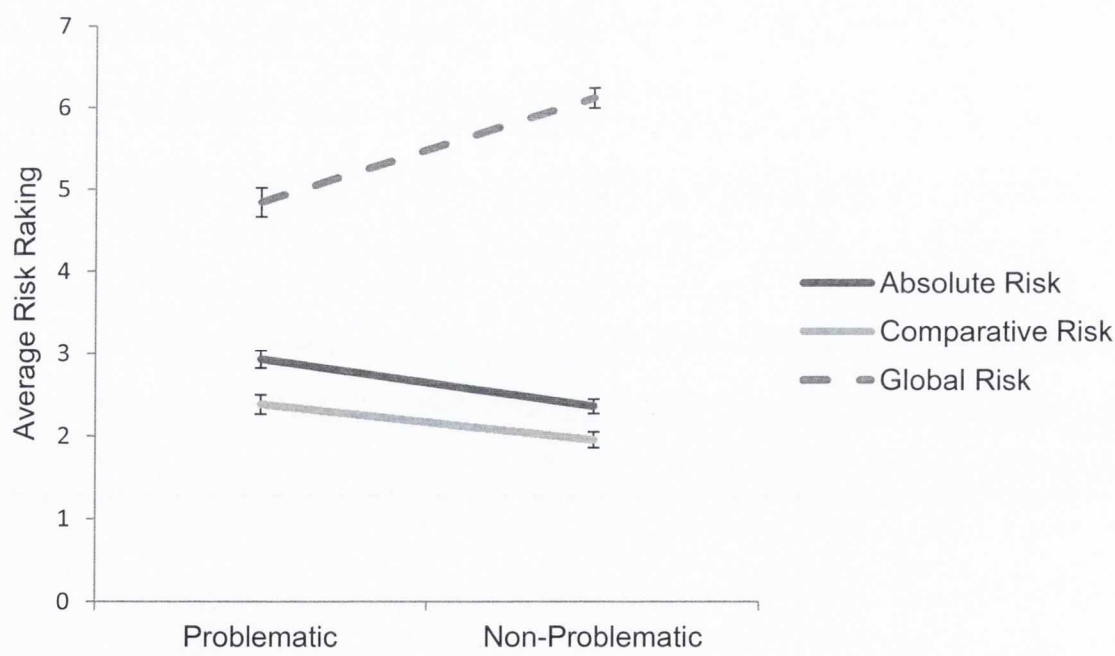


Figure 5.2. Comparison between problematic and non-problematic drivers on average risk ratings for 3 types of risk.

Note. Error bars represent standard errors.

Figure 5.3 portrays the mean comparative rating score for each group. A score of 4 (the midpoint) indicates the perception of being at neither more nor less risk than others while scores of less than 4 indicate the perception of being at less risk than others. The average score was significantly different from 4 for males and females in both problematic and non-problematic groups. The rating by the non-problematic group was much further from 4, $t(120) = 21.8, p < .001, d = 3.98$, than the average rating of the problematic group, $t(93) = 14.1, p < .001, d = 2.93$.

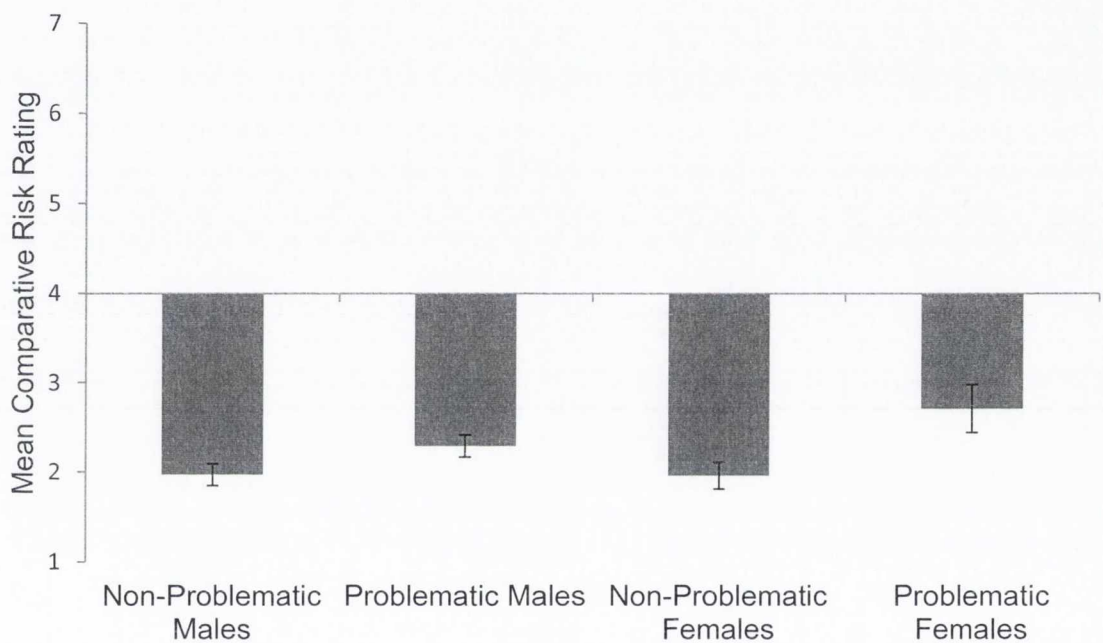


Figure 5.3. Mean comparative risk ratings for each group.

There were a total of 37 participants who were classified as viewing themselves as invulnerable based on their responses to questions 15 and 16 which both asked about the chance of being in an accident while driving. When divided between the driving groups, 28 of these belonged to the non-problematic driving group while only 9 were in the problematic group. This means that almost 25% of non-problematic participants believed that they had absolutely no chance of being in an accident in the next 6 months and/or before they were 25 years of age. This compares with fewer than 10% in the problematic group. This difference was found to be statistically significant, $\chi^2 = (1, N = 215) = 6.83, p < .01$. The distribution of individuals viewing themselves as invulnerable was the same for males and females, $\chi^2 = (1, N = 215) = 1.46, p = .23$.

5.2.4 Discussion

This study's two hypotheses were supported by the results. Problematic drivers gave higher estimates of their risks of being involved in a negative driving incident while, at the same time, they rated speeding as being less risky than non-problematic drivers did. Both groups displayed an optimistic bias when comparing their chances of being involved in an accident with those of other people their age. The two hypotheses will be discussed separately followed by a discussion of those interesting results that were not directly related to the hypotheses.

5.2.4.1 Hypothesis 1.

The first hypothesis was that problematic drivers see the risks of dangerous driving as lower than non-problematic drivers but that they see their own risks of being involved in a negative driving incident as higher. Problematic drivers had a significantly higher absolute risk score and comparative risk score than non-problematic drivers. It did not matter whether they were giving a standalone rating or comparing themselves to other drivers, problematic drivers thought that they had a higher likelihood of being in a crash. On the basis of the partial eta squared statistics, the differences between the groups were of a medium effect size. For the global risk question, problematic drivers indicated that they believed driving at fast speeds to be less risky than non-problematic drivers did and this was, again, with a medium effect size. These differences were in line with previous findings. Johnson et al. (2002) found this same trend for both smoking and risky sex although in their study significant differences were only found for the outcome focused question. Johnson et al. offers no real explanation for the effect of question type on risk rating.

Mills et al. (2008) found similar results in their investigation of risky sexual behaviours among high school students. However, they did not describe their questions as differing in their focus on behaviours and outcomes. Instead, they describe the outcome questions as being more explicit which leads participants to think carefully about the behaviour. Conversely, they suggest that less direct questions, such as those that do not mention outcomes, encourage more gist type reasoning on the part of participants. This reference to gist reasoning attempts to link their findings with fuzzy trace theory (Reyna & Farley, 2006). As discussed in the introduction, this theory, as applied to risk-taking among young people, suggests that young people do not think

about risk in gist terms and are more likely to weigh up pros and cons of risky behaviour. However, results such as those in the present study tell us nothing about how young people reason in risky scenarios. Indeed, the results of studies such as the present one suggest that either young risk-takers are already using gist based reasoning or that, if they were to utilise it more, their risk-taking would only become worse.

It is worth noting that the responses of the driving groups are not necessarily inconsistent. Indeed, for the non-problematic group, the results are easily interpretable. They see dangerous driving as risky and so they do not engage in it. This lack of engagement leads them to see themselves as not being at risk of being in a road collision. The results of this study do not directly allow for such a causal conclusion. This description is simply meant to illustrate that quite plausible explanations can be made for the responses of the non-problematic drivers. However, for problematic drivers, such a line of reasoning is not so easily made. If problematic drivers rate themselves as being more at risk due to their risky behaviours, then, logically, doesn't this indicate that they recognise dangerous driving as being risky? Or if causality runs the other way, if they do not believe dangerous driving is particularly risky, then why do they see themselves as being more at risk than safer drivers? A possible explanation for the distinction may also be that the global behaviour question asked only about speeding, while the outcome focused questions did not mention any particular behaviours. It could be that problematic drivers believe that an aspect of their driving other than speeding is what leads them to be slightly more at risk than others.

5.2.4.2 Hypothesis 2.

The second hypothesis proposed was that both problematic and non-problematic drivers have an optimistic bias for negative outcomes while driving. This hypothesis was supported by the findings with both groups giving comparative risk ratings that were far below 4 on a scale in which 4 represented that they had the same chance as anybody else their age of being in a crash. The average score for both groups differed from 4 with a very large effect size. In fact, for the entire sample, only eight participants gave an average comparative risk rating that was above 4. Out of a sample of 215, it is highly unlikely that only 8 have a higher probability of being in a crash compared with all others in their age group. Reyna and Farley (2006) point to a number of studies that found this same optimistic bias among young people in a number of different areas. While results

such as these may suggest that problematic driving among young people is a result of such a bias, Cohn et al. (1995) found that the optimistic bias is greater in adults than in younger people. Interestingly, the non-problematic group had a much larger optimism bias than the problematic group. This is the same result as was described with regard to hypothesis 1 (i.e. that problematic drivers have higher ratings of comparative risk than non-problematic drivers).

Another interesting finding relates to feelings of invulnerability (Millstein & Halpern-Felsher, 2002). Non-problematic drivers were much more likely to indicate feelings of invulnerability by suggesting that they had “no chance” of being in an accident in the next six months and/or before they reach 25. What is particularly interesting about the optimism bias in this instance is that the questions only asked participants about their chances of being involved in an accident while they are driving. The questions did not state anything about whether they were to blame or not for such a hypothetical accident. From a logical point of view, even the safest drivers should realise that, through no fault of their own, they could be involved in an accident. A popular statement regarding dangerous driving among young people is that they believe they are invulnerable (Lovley, 2009). However, the present findings suggest that safe young drivers are actually more likely to believe this compared with dangerous drivers. The present results also go against the idea that the problem for young drivers is that they are overly-optimistic. Quadrel et al. (1993) suggest that the optimistic bias, which they found among adults and adolescents, results from cognitive factors. A source of a potential cognitive bias may come from the amount of times drivers see themselves successfully complete a journey without incident. However, they are most likely to notice other drivers when those drivers are engaging in risky behaviour. This may lead to an inflated sense of one’s own safety.

5.2.4.3 Additional findings.

Much less research has focused on differences between males and females compared with the body of literature examining high and low risk individuals. The results of this study offer some suggestion for the differences in incidences of dangerous driving typically found between males and females (Özkan & Lajunen, 2006). The finding that males gave lower risk estimates for the behaviour focused global risk question is not particularly surprising given that this group contained more problematic drivers.

However, males had a lower risk estimate in both driving groups. Furthermore, the partial eta squared statistics indicate that the effect of gender exceeds even that of driving group, .081 and .065 respectively. Figner and Weber (2011) describe their research as suggesting that women view the risks associated with recreation risk behaviours as being greater than males do. The responses to the global risk question support this view. However, the responses to the outcome focused questions did not show females as being different from males. For example, the non-problematic females had similar driving behaviours to the non-problematic males but rated dangerous driving as being more risky than those males. However, in spite of this, they gave the same estimates for their own risks. This suggests that both males and females may use past behaviour in similar ways to assess their own risk. The difference in responses to the global question could then indicate a number of different things. Perhaps behaviour focused questions are too abstract to be related to real world behaviour (i.e. what does it actually mean to say that driving at fast speeds is "quite risky"?). While this explanation might fit with the gender findings of this study, it does not fit with the overall differences between problematic and non-problematic drivers which suggest that there is some kind of relationship between real world behaviour and responses to behaviour focused questions.

An alternative interpretation of the differences between the genders on only the behaviour focused questions is that males and females differ in what leads them to drive safely. The interaction between gender and driving group on this variable suggests that global risk perception plays a greater role for males than it does for females since male problematic and non-problematic groups displayed a much greater difference in their responses to the behaviour focused question. That global risk perception should play a greater role in determining male driving behaviour is an entirely speculative idea. There seems to be no logical reason why male problematic driving should result from lower risk estimates while female problematic driving does not. Özkan and Lajunen (2006) emphasise the cultural and social aspects of driving and how these may relate to gender. They found that increased levels of femininity led to a decrease in risk-taking among participants. While it amounts to a somewhat vague conclusion, perhaps these social and cultural factors explain why risk perception may be more important for male risk-taking than for females.

5.2.4.4 Limitations.

There were a number of limitations in the present study. Participants were not asked about their attitudes towards the benefits of speeding. Ben-Zur and Reshef-Kfir (2003) found that benefits were actually a better predictor of risk-taking behaviour than risks were. The lack of these questions was largely due to difficulty in generating a benefit question that was the opposite of "How risky do you think it is to drive at fast speeds?" The reverse question of "How beneficial do you think it is to drive at fast speeds?" is much more ambiguous than its risk counterpart. Very little research has asked participants about the benefits of recreational risk and so there is little to base potential questions on. Another shortcoming of this study is that participants were classified as problematic on the basis of questions that addressed general risky driving while the behaviour focused risk question asked only about the risks of speeding. Furthermore, in this study, participants were described as indicating "invulnerability" if they indicated that they believed there was no chance that they would be involved in an accident while driving. However, participants were not asked how much they expected to drive in the next six months. It could be the case that more people in the non-problematic group planned not to drive at all in this period. However, non-problematic drivers did not report less distance driven in the last year, and so it seems reasonable to suppose that their distance driven in the next six months would not be very different.

The participants of this study were spread out across the country with some attending more rural colleges than others. Nonetheless, since they were all college students, the current sample is a relatively homogenous group. For example, only about 20% of participants had ever received a penalty point. However, this is not actually too far off the national average with estimates by the Road Safety Authority in Ireland that, as of the end of September 2012, almost 480,000 licensed drivers had received penalty points (RSA, n.d.) and with the Central Statistics Office estimating there to be about 2.9 million licensed drivers in Ireland in 2008 (CSO, 2009). Given the lack of supervision during the questionnaire and the fact that a reward was offered for taking part, a number of people completed the study in a less than honest manner. Eleven participants were removed for providing clearly incorrect information and it is doubtless that some of the remaining participants gave less than accurate answers throughout. While this is a problem for any questionnaire research, the feeling of anonymity associated with internet use may exacerbate the problem for studies such as this.

5.2.4.5 Further study.

A clear assessment of both the perception of risks and benefits of dangerous driving could aid our understanding of the role of attitudes in risky behaviour. Furthermore, much of the work on the impact of outcome and behaviour focused questions has been conducted with young participants. The extent to which these effects change with age could also have implications for how we understand the link between attitudes and risky behaviour. Another interesting approach would be to investigate the impact of different focused questions on risk rating for much more controlled laboratory tasks. Laboratory tasks, such as gambling studies like the Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994), would allow researchers to manipulate risks and benefits and observe how participants' responses changed for both outcome and behaviour focused questions. Such an approach may be able to elucidate the causal roles that responses to these different risk questions play.

5.3 Study 6a

This study differs from the other studies in the chapter in that its primary focus is to provide stimuli for another task – the endorsement task described in study 6b of this chapter. The title “6a” is given since it predominantly serves this functional purpose. This study outlines a procedure in which participants provided a number of positive and negative words to complete the sentences used in study 6b. The words were then selected on the basis of their frequency in the English language (based on Leech, Rayson, and Wilson (2001)), the number of syllables and letters in them and their qualitative suitability for the future tasks. In section 5.1.6 the case was made that perceptions of risks and benefits associated with a behaviour are really examples of negative and positive attitudes towards that behaviour, respectively. The only prediction of the present study is that the good and bad words that participants will be asked to supply will relate to benefits and risks regarding dangerous driving.

5.3.1 Method

5.3.1.1 Participants.

There were 101 participants in the study who were all undergraduate psychology students at Trinity College, Dublin and were all recruited by email. An error in the online

questionnaire resulted in basic demographic information being lost. Seven participants did not fully complete the study. Participants were entered into a raffle for a music store voucher in return for their participation.

5.3.1.2 Measures and procedure.

The study was completed as an online questionnaire. Participants were asked to choose between the numbers 1 and 2 at the beginning of the questionnaire. Those participants who chose “1” were asked to supply five *positive* words to complete the sentence “driving at fast speeds is...” and five positive words to complete the sentence “driving at fast speeds would make me feel...” Words supplied to the first sentence are referred to as “cognitive” ones while those supplied in response to the second sentence are referred to as “emotional” words. Those participants who chose “2” at the beginning were asked to complete these two sentences with negative words. Accordingly, there were four sentence types altogether: “Driving at fast speeds is [positive]”, “Driving at fast speeds is [negative]”, “Driving at fast speeds would make me feel [positive]”, and “Driving at fast speeds would make me feel [negative]”. The exact materials relating to this study can be found in appendix 5.

5.3.1.3 Analysis.

Participants were not asked to supply words in any particular order, and so this aspect of responses was not taken into account in the analysis. Participants’ responses were mixed together and were ordered according to frequency. Four words from each of the four categories, positive cognitive, positive emotional, negative cognitive and negative emotional, were selected on the basis of a number of criteria which are described below.

5.3.2 Results and selection

The ten most frequently supplied words for the four sentences are displayed in Table 5.4. The four most frequent words from each category were selected. However, a number of words were not used, despite their frequency, within all categories except positive emotional. In the positive cognitive group, *Exhilarating* was not selected due to its high syllable count and relative infrequency of use in the English language.

Irresponsible was excluded from the negative cognitive group for the same reason while

Bad was not used as the sentence “Driving at fast speeds is *Bad*” was judged to have too much of a moral undertone to it. A larger number of words were excluded from the negative emotional category. *Anxious* was excluded due to its relative low frequency in English and due to the fact that the three other “top-four” words were all related to fear. *Frightened* was excluded for this latter reason as well. *Unsafe* was deemed to be potentially confusing given its negative prefix. *Sick* was excluded since the sentences were intended to refer to psychological constructs and *Dangerous* was excluded as it was deemed to be unsuitable as an emotional word.

Table 5.4. *The ten most frequent words supplied by participants with the words in each category appearing in decreasing frequency.*

Positive Cognitive	Positive Emotional	Negative Cognitive	Negative Emotional
<u>Fun</u> ¹	<u>Confident</u>	<u>Dangerous</u>	<u>Nervous</u>
<u>Exciting</u>	<u>Excited</u>	<u>Stupid</u>	<u>Scared</u>
<u>Thrilling</u>	<u>Powerful</u>	Bad*	Anxious*
Exhilarating*	<u>Alive</u>	<u>Reckless</u>	<u>Worried</u>
<u>Enjoyable</u>	Cool	Irresponsible*	Unsafe*
Cool	Good	<u>Risky</u>	Sick*
Efficient	Brave	Selfish	Dangerous*
Good	Great	Inconsiderate	Frightened*
Great	Invigorated	Scary	<u>Reckless</u>
Fantastic	Alert	Foolish	Uncomfortable

¹Those words underlined were selected for use in study 6b. *Indicates words that were not selected for reasons explained in the text.

5.3.3 Discussion

The words underlined in Table 5.4 will be utilised in study 6b of the present chapter. Many of the words that were rejected were done so on the basis of a qualitative judgement on the part of the researcher. While this does introduce the possibility of a bias in the design, all changes were made to facilitate the reaction-time task in study 6b. As predicted the negative words all related to some level of risk associated with speeding. For example, the negative cognitive words included “dangerous” and “reckless” instead of

non-risk-related negative words such as “boring” or “tedious”. Participants seemed to focus predominantly on the risk aspects of driving when generating these negative words. The positive words all related to the immediate benefits that might result from driving at fast speeds. For example, the positive cognitive words included “exciting” and “thrilling” rather than less exhilarating possible words such as “nice” or “pleasant”. These outcomes support the assertion in the present thesis that perceptions of risks and benefits associated with a behaviour can be conceptualised as attitudes towards that behaviour meaning that they are essentially evaluative statements about the behaviour.

5.4 Study 6b

This study presents the results of the behavioural task that participants completed after finishing the questionnaire described in study 5. The behavioural task was based on the work of McCusker (2001) and is similar to previous investigations of attitude accessibility (e.g. Lebel, 2010). While study 5 addressed risk attitudes using traditional questionnaire methods, the focus of this study was on the accessibility of those attitudes. The task attempted to reduce participants’ opportunity to deliberate by presenting a large number of attitude trials and asking them to respond as fast as possible. While it was still possible for participants to deliberate, their performance on the driving-related trials can be compared to the control trials to see if the “respond fast” instruction was followed equally across trials. Verplanken, Hofstee, and Janssen (1998) found that participants were faster to respond to emotional attitudes (i.e. how they felt) compared with cognitive attitudes (i.e. what they thought). Both types of statements were incorporated in the present study.

As will be described below, the reaction-time task asks participants whether they agree or disagree with a number of positive (e.g. “Driving at fast speeds is fun”) and negative (e.g. “Driving at fast speeds is dangerous”) speeding statements. A participant who agrees with a positive driving statement is endorsing a benefit associated with speeding. Agreeing with a negative statement is equivalent to endorsing a risk associated with speeding (see study 6a for details of these arguments). However, disagreeing with a positive statement is not the same as agreeing with a negative one. For example, a participant who thinks that speeding is **not** fun is not necessarily saying that speeding is dangerous—they could just find it boring. Conversely, disagreeing with a negative

statement is not the same as agreeing with a positive one. A person may think that dangerous driving is **not** risky, but they might also think that it is not fun or exciting. This logic holds for the reverse; endorsing a positive statement is not the same as rejecting a negative one. This study approaches attitudes from the point of view that they can be positive or negative. There is not just one attitude, such as “Speeding is risky”, that people either have or do not have. Rather, there are two potential, and separate, attitudes: “Speeding is risky” and “Speeding is not risky”. The same is the case for positive speeding statements, with “speeding is good” and “speeding is not good” being two separate attitudes.

As described in the introduction, the MODE model (Fazio & Towles-Schwen, 1999) proposes that the accessibility of attitudes plays an important role in determining the link between these same attitudes and subsequent behaviour. Specifically, in those circumstances where there is no motivation to go against immediate attitudes, or where opportunity to do so is lacking, automatically activated attitudes are predicted to have a stronger impact on behaviour. As described in the Introduction chapter, much risk-taking behaviour occurs in the presence of peers (e.g. Preusser et al., 1998). Such situations may lead young people to be less motivated to avoid risky behaviours. For driving in particular, decisions are often made on a split-second basis (e.g. whether to slow down for an upcoming bend or not). Thus, drivers may also be lacking the opportunity to assess their immediately activated attitudes and re-evaluate their situation.

5.4.1 Hypotheses

The first hypothesis is that those who engage in more problematic driving endorse more positive statements about speeding, while they also endorse fewer negative statements. This hypothesis is based on those studies that have found a negative relationship between risk behaviour and risk perception when the risk questions are behaviour focused (e.g. Johnson et al., 2002). This hypothesis was also assessed in study 5 and so is not the main focus of this study. The second hypothesis is that even though problematic drivers endorse more positive statements and less negative ones, they do not endorse all positive and reject all negative. And conversely, non-problematic drivers do endorse some positive and reject some negative statements about speeding. The third hypothesis is dependent on the second being supported. This hypothesis states that problematic and non-problematic drivers differ in their accessibility of driving attitudes.

Specifically, the third hypothesis suggests that, while problematic drivers may agree with some positive statements about speeding and disagree with others, they will have faster accessibility to those benefits with which they agree (e.g. agreeing with “Driving at fast speeds is fun”) compared to those with which they do not agree (e.g. disagreeing with “Driving at fast speeds is exciting”). The reverse is the case for negative attitudes with problematic drivers having quicker access to those negative attitudes they disagree with (e.g. disagreeing with “Driving at fast speeds is dangerous”). The reverse is predicted to be the case for non-problematic drivers.

5.4.2 Method

5.4.2.1 Participants.

Studies 5 and 6b were completed at the same time and so the same participants took part in this study as in the previous one. However, a number of additional participants were removed from the analysis of this study with the numbers and reasons provided in Table 5.5. As described in section 5.2.2.2, participants were required to enter details to connect their questionnaire and reaction-time results. Of the 227 participants who completed the online questionnaire, 101 did not complete the reaction-time task or did not provide consistent information and so their results could not be matched. Furthermore, after completion of the task, participants were asked if they experienced any technical difficulties with the task and whether they were able to do the task without interruption. Participants who experienced technical difficulties or reported being interrupted were also excluded. One of the participants completed the reaction-time task by pressing the same key for all 32 trials while another participant responded to more than half the trials with reaction-times that were noticeably faster than all other participants (some were less than 20ms). These two participants were also removed from the analysis. The remaining 100 participants had a mean age of 19.9 years and there were 65 males and 35 females. There were 44 problematic drivers and 56 non-problematic ones based on the same criteria as detailed in study 5.

Table 5.5. *Criteria for Removal from Reaction-Time Task Analysis and Number of Participants Removed*

Removal Criteria	Number of participant removed
Did not complete the online task	101
Were not fluent in English or did not respond to this questions	2
Had a reading difficulty or did not respond to this questions	13
Had to stop while completing the reaction–time task	2
Had technical problems with the reaction-time task	6
Had unusual response times in the task	2
Total removed	126

5.4.2.2 Measures and procedure.

When participants had completed the questionnaire (described in study 5) they were told that they would be completing another task. A Java applet was presented in the middle of the webpage and measured 800px X 500px in size (width and height respectively). The applet consisted of white text presented against a black background. Participants used the space bar to continue through a number of screens explaining the task. The exact instructions given to participants can be found in appendix 4. The instructions were presented in font size 28 and in font type Tahoma.

The main task consisted of 32 trials each of which was made up of two parts. In the first part, an unfinished sentence with three full stops would be presented (e.g. “Driving at fast speeds is...”). This sentence would remain on the screen for 3000ms and would be followed by a blank screen for 1000ms. The sentence would then be completed by a single word (e.g. “fun”). Participants were told to press “s” on their keyboard if they agreed with the full sentence and “k if they disagreed. To remind participants what responses were associated with each key, “Agree” remained in the top left of the applet screen for the duration of the task while “Disagree” was in the top-right (since “s” and “k” are on the left and right of a keyboard respectively). The words remained on screen until a response was given and there was a 1000ms blank screen before the next sentence was presented. The font type was Tahoma for all of the words and sentences. Participants

were given four practice trials to familiarise themselves with the task. The sentences in these trials were not related to driving and were not included in any analyses.

The font size for the words “Agree” and “Disagree” was 28 while the sentences and words themselves were presented in 38. The 32 trials in the main task consisted of 16 sentences beginning with “Driving at fast speeds...” and 16 sentences beginning with “Swimming in the sea...”. Within both of these categories, there were eight emotionally based sentences (“Driving at fast speeds would make me feel...” and “Swimming in the sea would make me feel...”) and eight cognitive sentences (“Driving at fast speeds is...” and “Swimming in the sea is...”). For these four sentence types, there were four trials in each. The same words were used for both the driving and swimming sentences. Table 5.6 lists the exact words used in both the driving and swimming sentences which are based on the results of study 6a. At the end of the task, participants were given the option of entering a raffle for a music player by supplying their email address.

Table 5.6. *Stimuli used to complete the sentences for both driving and swimming sentences*

Cognitive Positive	Cognitive Negative	Emotional Positive	Emotional Negative
Fun	Dangerous	Confident	Nervous
Exciting	Stupid	Excited	Scared
Thrilling	Reckless	Powerful	Worried
Enjoyable	Risky	Alive	Reckless

5.4.2.3 Analysis.

Endorsement task. The endorsement task was analysed in a mixed-factorial ANOVA with number of endorsements as the dependent variable. Driving group (problematic vs. non-problematic) served as the between groups fixed factor while condition (driving vs. swimming), nature (cognitive vs. emotional) and valence (positive vs. negative) were the three repeated measures independent variables. To reduce unnecessary analysis only the highest level interaction was analysed further. For example, if there was a three-way interaction and a number of two-way interactions, only the three-way interaction was investigated further. The justification for this focus is that the presence of a high level interaction renders lower level ones much less interesting

with regard to the hypotheses. Furthermore, only interactions involving the driving group variable were focused on for further investigations.

Reaction-time task. The reaction-time analysis was not conducted in the same manner as the endorsements for a number of reasons. Firstly, reaction-time responses often display non-normal distributions (Fazio, 1990) and so individual responses were adjusted to address this (described below). Secondly, while number of endorsements could just be entered straight into an ANOVA model with condition, nature and valence as the within subjects factor, this could not be done with reaction-times. If reaction-times were directly entered into a model such as this, it would not take into account whether the time was in response to a participant agreeing or disagreeing with the sentence – two very different behaviours.

Whelan (2008) suggests that cut-off times can be an effective way to address the typically positive skews observed in reaction-time data (i.e. remove those reaction-times that are unusually fast or slow) but cautions that there are no reliable guidelines as to where the cut-off points should be. In the first presentation of the IAT, a task not entirely dissimilar to the present study, Greenwald, McGhee, & Schwartz (Greenwald et al., 1998) used 3000ms as the upper cut-off and 300ms as the lower. Any individual responses that were above or below these scores, respectively, were changed to the cut-off (e.g. a response of 3200ms would be changed to 3000ms). This approach has the benefit of addressing outliers without incurring too much missing data. Fazio recommended that reaction-time data be reciprocally transformed as the distribution of reciprocals is typically more normal than the raw data. Both techniques were applied in the present study. Firstly, individual responses that were less than 250ms or greater than 3000ms were changed to 250ms and 3000ms respectively. The lower bound of 250ms is 50ms shorter than that used by Greenwald et al. (1998) since the IAT is a more cognitively demanding task than the current endorsement task. The reaction-times were then reciprocally transformed according to the following formula: $1 / (RT + 1)$, where RT was reaction-time represented in seconds. Fazio recommends adding 1 second to the reaction-time if any of the times are less than one second – of which a number were in the present study. While these transformed scores were used for all of the analysis, the reaction-times reported in graphs and discussed in the text are untransformed times.

As stated above, the reaction-times could not be entered straight into the model as this would not take into account whether a participant was agreeing or disagreeing with the statement. The analyses by other researchers do not offer much help for a number of reasons. A number of previous endorsement task studies used a design that consisted of multiple control trials and a single test trial (e.g. Fazio & Williams, 1986; Smith & Terry, 2003). This design allows for a very simple analysis as participants either agree or disagree with the statement and they have a single reaction-time indicating their accessibility of this attitude. However, cognitive tasks rarely rely on single trials with typical IATs involving 160 trials (e.g. Rothermund & Wentura, 2004). Due to the online nature of the present study, only 16 experimental trials were incorporated. With this number of trials, analysis of individual trials was not a realistic option. Another approach is to ignore the choice that participants make on each trial (e.g. agree vs. disagree) and simply focus on average reaction-time to all experimental stimuli. Fazio and Powell (1997) utilised this approach in a study that investigated whether having accessible attitudes towards general likes and dislikes can predict student well-being. In this instance, the researchers were not interested in what participants liked, just how accessible these likes were and so an analysis that focused only on reaction-times was appropriate. However, as per the hypotheses of this study, a participant who quickly agrees with the statement "driving at fast speeds is fun" cannot be treated exactly the same as a participant who can quickly disagree with this statement.

One possibility is to divide participants' responses into those that are agreements and disagreements. This division could then be used as a repeated measures variable in addition to condition (driving vs. swimming), nature (cognitive vs. emotional) and valence (positive vs. negative). However, cases are always removed from a repeated measures ANOVA in a listwise fashion and so by including this additional independent variable only participants who have at least one response in all 16 cells (e.g. driving-cognitive-positive-agree, driving-cognitive-positive-disagree, etc.) would be included in the analysis. In the present study, no participants had responses in all 16 cells and so the above approach was not possible. However, this shortcoming can be somewhat overcome by combining reaction-times to cognitive and emotional statements. Unfortunately, this means that no distinction is made between these types of statements in the reaction-time analysis.

Resulting from this choice, the main analysis conducted on the reaction-time results was a mixed-factorial ANOVA with driving group (non-problematic vs. problematic

drivers) as the independent fixed factor and condition (swimming vs. driving), valence (positive vs. negative) and agreement (agree vs. disagree) as the three repeated measures factors. Reaction-time was the dependent variable in this ANOVA. As with the analysis protocols described for the endorsement task, the highest level of interaction was investigated and only those interactions concerning the driving group variable were analysed further. This study did not include gender as an additional independent variable for reasons of participant numbers. As described above, repeated measures ANOVAs exclude cases listwise. There were simply not enough participants to divide the sample based on two grouping variables (driving group and gender) and conduct a coherent analysis.

5.4.3 Results

5.4.3.1 Endorsements.

A mixed-factorial ANOVA was carried out to compare the number of statements endorsed by the driving groups in the different categories. The between groups variable was driving group (problematic vs. non-problematic) while the three repeated measures IVs were condition (driving vs. non-driving statements), nature (emotional vs. cognitive statements) and valence (positive vs. negative statements). The number of endorsements that participants made within each category ranged from 0-4.

Tests of Statistical Assumptions. The normality of the distribution of endorsements for the 8 conditions for both groups was assessed with a Shapiro-Wilk test. All 16 of the tests were significant indicating that the distributions were non-normal. A Levene’s test found that the variance of the distributions for the two groups was the same for all conditions except for driving-emotional-positive and driving-cognitive-positive. Due to the repeated measures design of the analysis, all transformations must be carried out on all of the between subjects variables. Neither log nor square root transformations could bring about normality across the eight variables for the two groups. A Box’s test found the variance-covariance matrices to be equal for the two driving groups, $F(36, 28707) = 1.04, p = .411$.

Table 5.7. *List of Effects Investigated by mixed-factorial ANOVA of Number of Endorsements*

Main Effects	Interactions
Group	Condition X Group*
Condition**	Nature X Group
Nature**	Valence X Group**
Valence	Condition X Nature
	Condition X Nature X Group
	Condition X Valence**
	Condition X Valence X Group**
	Nature X Valence
	Nature X Valence X Group
	Condition X Nature X Valence**
	Condition X Nature X Valence X Group

Note. * $p < .05$, ** $p < .001$

Main Effects and Interactions. A number of main effects and interactions were found in the ANOVA analysis. Table 5.7 lists all of the effects within the ANOVA and those that were significant. There were two main effects, three two-way interactions and two three-way interactions. The driving groups did not differ in the number of statements they endorsed and positive statements were, overall, no more likely to be endorsed than negative ones. There was a significant main effect of nature with participants endorsing more cognitive statements ($M = 8.8, SD = 2.1$) than emotional ones ($M = 6.6, SD = 2.4$), $F(1, 98) = 79.2, p < 0.001, \eta_p^2 = 0.45$. There was also a significant main effect of condition with participants endorsing more swimming statements ($M = 6.9, SD = 2.6$) than driving ones ($M = 8.5, SD = 2.8$), $F(1, 98) = 19.9, p < .001, \eta_p^2 = .17$. As per the analysis protocols outlined in section 5.4.2.3 only the three-way interaction involving the driving group variable was investigated further. This interaction was a mixed interaction between driving group, condition and valence, $F(1,98) = 20.6, p < .001, \eta_p^2 = .18$.

Sources of three-way interaction. In order to understand the source of the interaction a separate repeated measures ANOVA was conducted for each of the two

driving groups. These ANOVAs were two-way factorial ones with condition and valence as the fixed factors and number of endorsements as the dependent measure. Table 5.8 shows the effects investigated in these ANOVAs and identifies those that were statistically significant. The interaction effects are the only ones discussed in order to elucidate the source of the original three-way interaction.

Table 5.8. *Results of the Repeated Measures ANOVAs for Driving and Swimming Statements*

	Main Effects	Interactions
Driving	Group* Valence**	Group X Valence**
Swimming	Group Valence**	Group X Valence

* $p < .05$, ** $p < .001$

Figure 5.4 depicts the interaction between group and valence for just driving statements. The interaction was found to be significant, $F(1, 98) = 38.5, p < .001, \eta_p^2 = .28$, and Figure 5.4 suggests that, for driving statements, problematic drivers endorsed more positive statements and fewer negative statements than non-problematic drivers. These differences were found to be statistically significant, $t(98) = 5.9, p < .001, d = 1.18$, and $t(98) = 3.84, p < .001, d = 0.43$, respectively. Furthermore, while non-problematic drivers endorsed more negative statements about driving than positive ones, $t(55) = 9.89, p < .001, d = 2.7$, problematic drivers endorsed the same number of negative statements as they did positive ones, $t(43) = .04, p = .97, d = 0.01$. For swimming statements, there was no interaction between group and valence and there was no main effect of group. Valence was found to have a significant effect on number of swimming statements endorsed with participants agreeing with more positive statements.

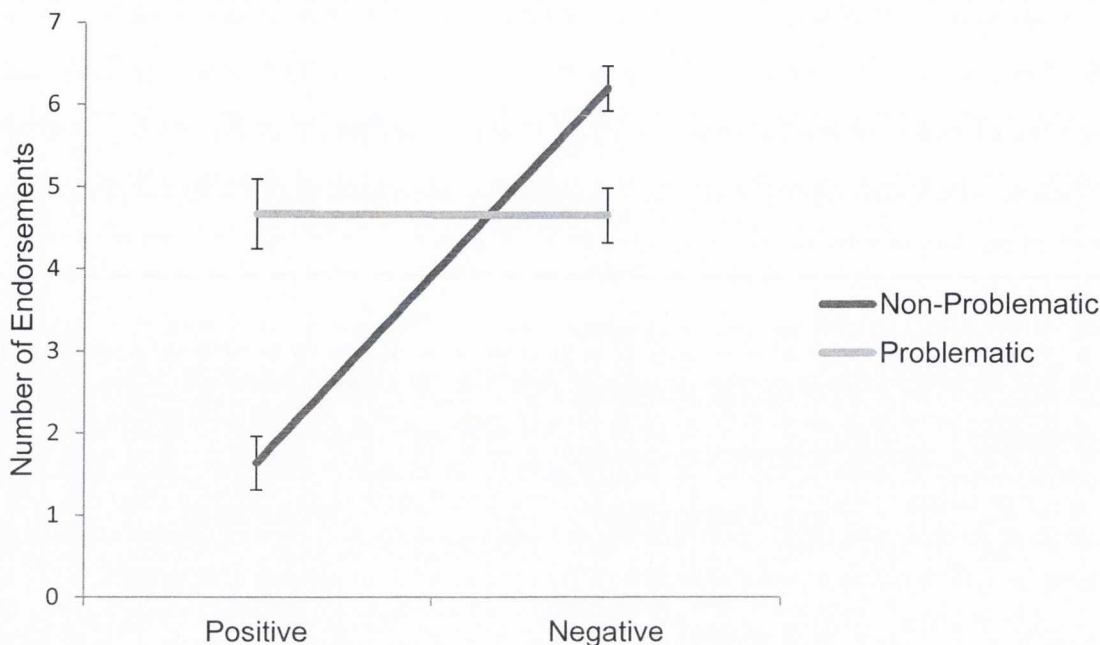


Figure 5.4. Number of negative and positive driving statements endorsed by problematic and non-problematic drivers⁸

Although the problematic group did endorse more positive speeding statements and fewer negative than the non-problematic group, the former group were far from endorsing all of the positive statements, $t(43) = 7.84, p < .001, d = 2.4$, or none of the negative statements, $t(43) = 14.94, p < .001, d = 4.6$.

Relationship with Questionnaire Results. The relationship between the risk ratings that participants gave on the questionnaire (described in study 5) and the numbers of positive and negative driving statements endorsed are presented in Table 5.9. The number of negative driving statements that participants endorsed was not related to either absolute or comparative risk but was positively related to ratings of global risk with a large correlation, $r(99) = .561, p < .001$ (i.e. participants who endorsed more negative statements were more likely to describe driving at fast speeds as being risky). The inverse relationship was found for endorsement of positive driving statements with those participants who endorsed more positive statements being more likely to give smaller global risk ratings. The number of positive driving statements did have a medium positive relationship with absolute and global risk.

⁸ Error bars were adjusted for repeated measures design in line with Cousineau (2005) and Morey's (2008) recommendations.

Table 5.9. *Relationship between ratings of risk and number of driving statements endorsed.*

	1.	2.	3.	4.	5.
1. Absolute Risk	-				
2. Comparative Risk	.715**	-			
3. Global Risk	-.102	.032	-		
4. No. of Negative Driving Endorsements	-.115	-.104	.561**	-	
5. No. of Positive Driving Endorsements	.398**	.272*	-.584**	-.442**	-

Note. Scores are Pearson’s Correlation Coefficients. * $p < .05$, ** $p < .001$

5.4.3.2 *Reaction-times.*

Tests of statistical assumptions. Roughly 3.2% of responses were outliers and were treated in accordance with the description given in section 5.4.2.3. The normality of the distribution of each individual variable for both groups was assessed using a Shapiro-Wilk test. All variables were found to be normally distributed. A Levene’s test for homogeneity of variance found that there was equal variance across the two groups for all but one of the variables; reaction-time for agreeing with negative swimming statements, $F(1,31) = 13.05, p < .01$. A Box’s test found that the driving groups had equal variance covariance matrices $F(36, 3206) = 1.5, p = .5$.

Relationship between reaction-times and number of endorsements. There were a number of correlations within each condition (swimming and driving) between number of endorsements and reaction-times. Table 5.10 demonstrates that the greater the number of positive driving statements that participants agreed with, the slower participants were when they disagreed with positive driving statements, $r(92) = -.56, p < .001$. While agreeing with positive driving statements was associated with faster reaction-time to those positive statements, this relationship was not significant. The more negative driving statements that participants endorsed, the quicker they were to endorse negative statements, $r(97) = -.34, p < .01$. The number of negative driving statements endorsed was actually positively related to reaction-time for disagreeing with any negative statements, but this relationship was not significant.

Table 5.10. *Relationships between reaction-time to driving statements and number of driving statements endorsed.*

Driving Statements	No. of Positive Endorsements	No. of Negative Endorsements
Agree with positive RT	.18	-.15
Disagree with positive RT	-.56**	.33**
Agree with negative RT	-.23*	.34**
Disagree with negative RT	-.17	.1

Note. * $p < .05$, ** $p < .01$

The correlations between number of swimming statements endorsed and reaction-times were different compared with those for driving statements. As depicted in Table 5.11, the same negative relationship between number of positive statements endorsed and reaction-time when disagreeing with positive statements was found, $r(84) = -.29, p < .01$. However, for these trials, there was a significant positive relationship between number of positive trials endorsed and reaction-time when agreeing with positive trials, $r(87) = .22, p < .05$. For negative swimming trials, there was no relationship between number of negative trials endorsed and reaction-time when agreeing with negative trials. Unlike for driving trials, there was a significant negative relationship between number of negative swimming trials endorsed and reaction-time when disagreeing with negative trials.

Table 5.11. *Relationships between reaction-time to swimming statements and number of swimming statements endorsed.*

Swimming Statements	No. of Positive Endorsements	No. of Negative Endorsements
Agree with positive RT	.22*	-.22
Disagree with positive RT	-.29**	.02
Agree with negative RT	-.15	-.01
Disagree with negative RT	-.02	-.23*

Note. * $p < .05$, ** $p < .001$

The overall trend of these correlations is that for either valence of trial (positive or negative), those participants who agreed with more of those types of trials had a faster reaction-time when endorsing them and a slower reaction-time when disagreeing with them. However, with the exception of the relationship between number of positive trials endorsed and reaction-time when disagreeing with these trials, the patterns were different for driving and swimming statements.

Main effects and interactions. A mixed-factorial ANOVA was conducted for the reaction-time to statements with condition (driving vs. swimming), agreement (agree vs. disagree) and valence (positive vs. negative) as the repeated measures variables and driving group (problematic vs. non-problematic) as the independent groups variable. The comparisons made and the outcomes of these are displayed in Table 5.12. It’s worth noting that since repeated measures ANOVAs always remove participants listwise, the number of participants and, consequently, degrees of freedom, is different across the analyses in this results section.

Table 5.12. *List of Effects Investigated by mixed-factorial ANOVA of reaction-times of positive and negative attitudes*

Main Effects	Interactions
Group	Condition X Group
Condition	Agreement X Group
Agreement	Valence X Group
Valence	Condition X Agreement
	Condition X Agreement X Group*
	Condition X Valence*
	Condition X Valence X Group
	Agreement X Valence*
	Agreement X Valence X Group*
	Condition X Agreement X Valence
	Condition X Agreement X Valence X Group*

Note. * $p < .05$

There was found to be no significant main effect of any of the individual variables. Participants in both groups had the same overall reaction-times and, as an entire group, the driving groups did not differ for driving and swimming statements when agreeing and disagreeing or for expressing positive or negative attitudes. There were two significant two-way interactions; one between condition and valence, $F(1,31) = 13.2, p < .01, \eta_p^2 = .3$, and one between agreement and valence $F(1,31) = 7.54, p < .05, \eta_p^2 = .2$. There were two significant three-way interactions: one for condition, agreement and driving group, $F(1,31) = 4.6, p < .05, \eta_p^2 = .13$, and another for agreement, valence and driving group, $F(1,31) = 6.8, p < .05, \eta_p^2 = .18$. The four-way interaction is the only one that will be investigated for a number of reasons. All of the variables contribute to this effect and it relates directly to the hypothesis of the study. Furthermore, as will be seen below, the investigation of a four-way interaction requires a substantial amount of analysis. The investigation of all of the interactions would lead to an overly-cluttered results section.

Source of four-way interaction. Before describing the analysis of the four-way interaction, it is worth noting that such effects can be broken down in a large number of ways. The swimming sentences were included as control trials and so it was predicted that the groups would not differ on these. Accordingly, the first step in this breakdown was to conduct a separate analysis for the driving and swimming conditions. A three-way mixed-factorial ANOVA was carried out for each condition with reaction-time as the dependent variable, agreement and valence as the repeated measures variables and driving group at the independent groups fixed factor. The original four-way interaction appears to be due to a significant three-way among the three variables in the driving condition, $F(1,50) = 22.8, p < .001, \eta_p^2 = .32$, which is not present in the swimming condition, $F(1,59) = 2.3, p = .13, \eta_p^2 = .04$.

Table 5.13. Results of ANOVAs investigating reaction-time for driving and swimming statements.

	Main Effects	Interactions
Driving	Agreement	Agreement X Group*
	Valence*	Valence X Group
	Group	Agreement X Valence
		Agreement X Valence X Group**
Swimming	Agreement	Agreement X Group
	Valence*	Valence X Group*
	Group	Agreement X Valence*
		Agreement X Valence X Group

Note. * $p < .05$, ** $p < .001$

Source of three-way interactions The three-way interaction among agreement, valence and group for reaction-time to driving statements was investigated by conducting two separate mixed-factorial ANCOVAs for driving statements (see Table 5.13). The first ANCOVA focused only on reaction-times to positive driving statements with agreement (agree vs. disagree) as the repeated measures variable and driving group (problematic vs. non-problematic drivers) as the independent groups variable. These analyses were ANCOVAs since, as described above, there were significant relationships between number of endorsements and reaction-time within a number of categories. Accordingly, in this analysis, number of positive driving statements endorsed was entered as a covariate. This variable was not entered into any of the previous ANOVAs given that it would have had an impact on variables that are not theoretically linked with it (e.g. reaction-time to negative driving statements). The second ANCOVA contained the same independent variables but with reaction-times to negative driving statements as the dependent variable. Number of negative driving statements endorsed was entered as a covariate for this analysis. The results of these ANCOVAs are presented in Table 5.14.

Table 5.14. Results of ANCOVAs investigating differences between the groups in their reaction-times to positive and negative statements

	Main Effects	Interactions
Positive Statements	Agreement* Group	Agreement X Group*
Negative Statements	Agreement Group	Agreement X Group

Note. * $p < .05$

As can be seen in Table 5.14, for positive statements there was a significant interaction between agreement and driving group, $F(1,57) = 6.7, p < .05, \eta_p^2 = .11$. This interaction was not significant for negative driving statements, $F(1,75) = 0.18, p = .67, \eta_p^2 = .002$. Reaction-times to positive statements are depicted in Figure 5.5. Non-problematic drivers were faster at disagreeing with positive statements than they were at agreeing with them $t(29) = 2.148, p < .05, d = 0.4$. This trend was reversed for problematic drivers who were quicker when agreeing with positive statements, $t(29) = 5.48, p < .001, d = 1.003$. Furthermore, problematic drivers were quicker at agreeing with positive statements compared with non-problematic drivers, $t(66) = 2.04, p < .05, d = 0.5$, while non-problematic drivers were quicker at disagreeing compared with problematic drivers, $t(90) = 3.44, p < .01, d = 0.73$.

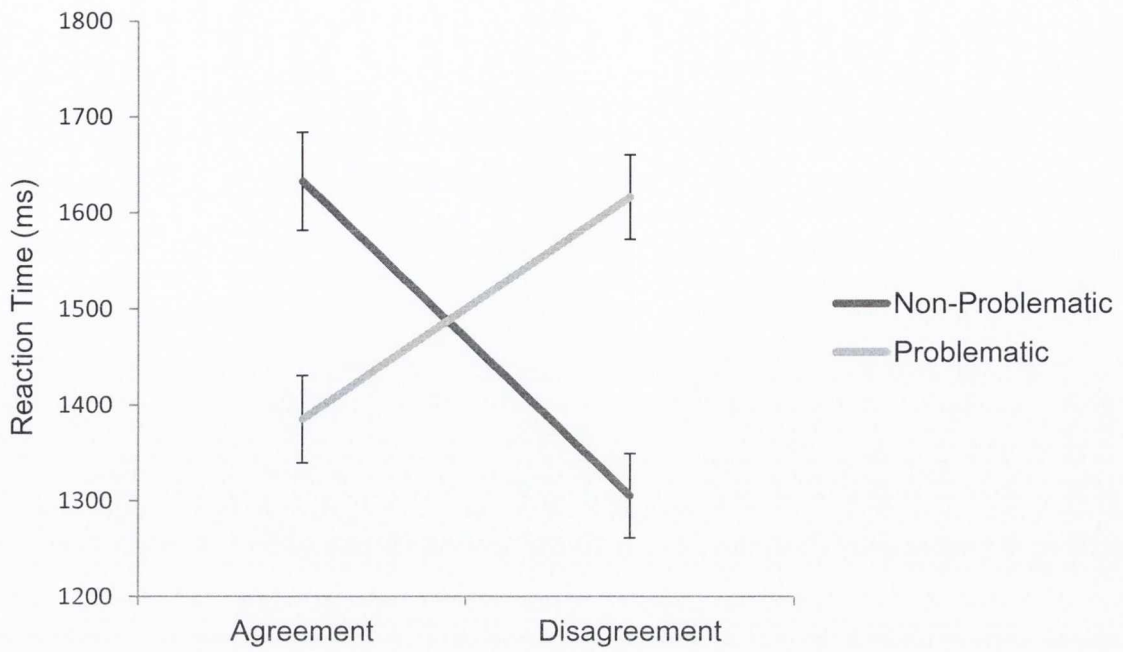


Figure 5.5. Reaction-times for agreement and disagreement with **positive** driving statements for both driving groups.

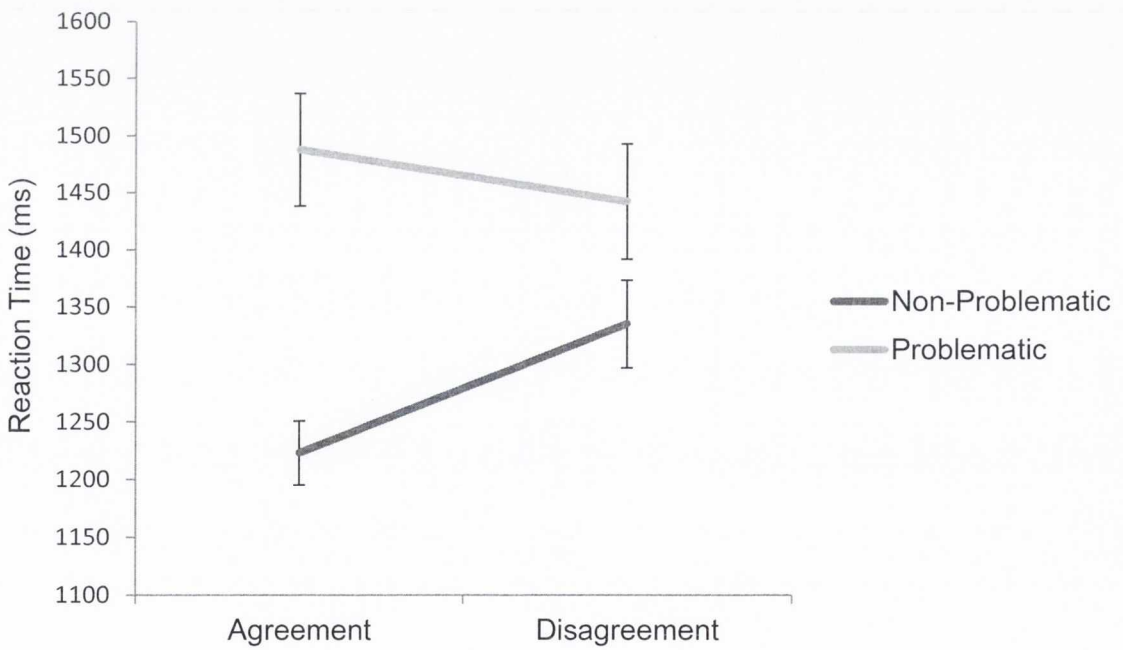


Figure 5.6. Reaction-times for agreement and disagreement with **negative** driving statements for both driving groups.

The results depicted in Figure 5.5 relate only to positive driving statements as the ANCOVA for negative driving statements did not find a significant interaction between agreement and driving group (see Figure 5.6). However, a comparison between the

groups on endorsement times for positive and negative statements reveals an interesting trend which is shown in Figure 5.7. Problematic drivers were faster at endorsing positive driving statements than they were at endorsing negative ones, $t(30) = 2.8, p < .01, d = 0.57$. This was not the case for non-problematic drivers who were faster at endorsing negative statements compared with positive ones, $t(33) = 2.2, p < .05, d = 0.38$. These reversed patterns did produce a significant interaction between the variables with both number of positive and negative statements endorsed serving as covariates, $F(1,61) = 5.98, p < .05, \eta_p^2 = .11$. However, this interaction only occurred when comparing reaction-times for agreeing with statements. There was no significant interaction between the groups when comparing reaction-times for disagreeing with positive and negative statements.

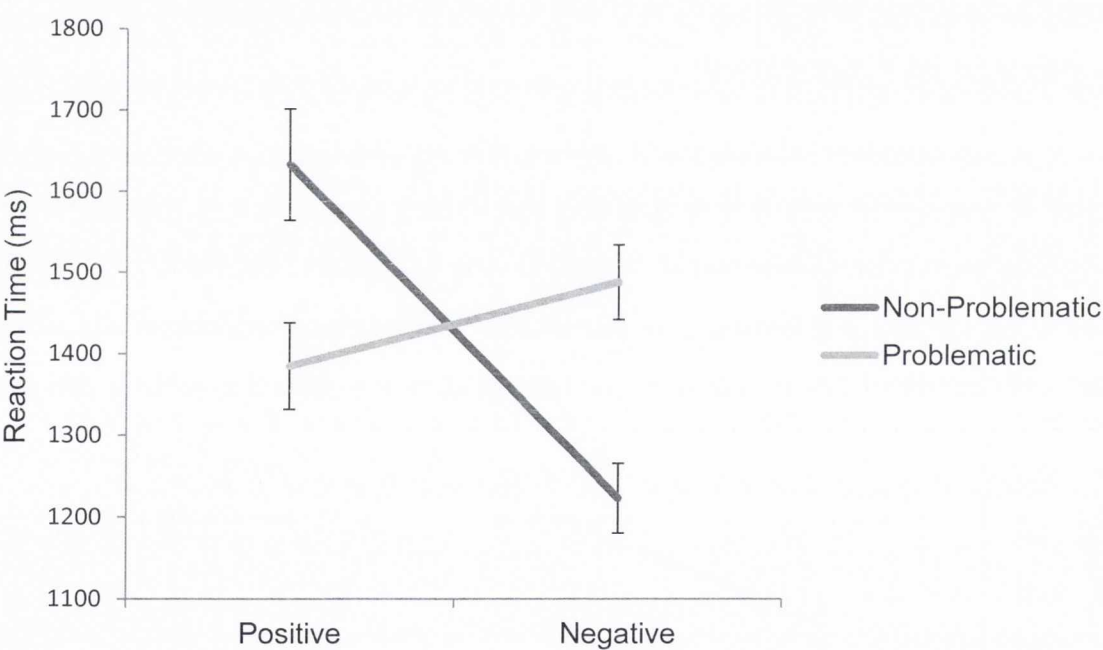


Figure 5.7. Reaction-times to positive and negative driving statements for both driving groups.

5.4.4 Discussion

There was a degree of support for the hypotheses in this study. Problematic drivers were once again found to perceive risk as being lower for behaviour focused questions. Furthermore, this study found that problematic drivers perceived the benefits of dangerous driving as being greater than non-problematic drivers did. Despite this, problematic drivers were far from endorsing all of the positive statements or not

endorsing any of the negative ones. With regard to the reaction-time task, problematic drivers were faster in agreeing with positive driving statements than they were in disagreeing. There was some ambiguity with regard to the reaction-time task, but the broad results did support the initial hypothesis relating to performance on this task.

5.4.4.1 Hypothesis 1.

This hypothesis was very similar to the first hypothesis of the previous study. It stated that problematic drivers see the risks of speeding as being lower when asked behaviour focused questions while they see the benefits of speeding as being higher. In this study, this hypothesis was tested using binary choice statements (agree vs. disagree) and comparing the number of positive and negative statements endorsed by the two groups. The groups did not differ with regard to the impact of the nature of the statements (i.e. cognitive vs. emotional) on their likelihood of endorsing. Problematic drivers endorsed more positive speeding statements than non-problematic drivers while they endorsed fewer negative speeding statements. The difference in numbers of positive statements had a very large effect size, while the difference in negative statements had a medium effect size. The differences with regard to risk perception are in line with the previous study given that all of the statements in this task were behaviour focused. Consequently, these results were also in line with previous research in other risk-taking areas (e.g. Johnson et al., 2002). However, the outcome relating to perception of benefits is particularly interesting given that this is seldom considered in driving behaviour research. The positive aspects of dangerous driving, such as immediate enjoyment, are rarely studied by researchers who seem to focus almost entirely on the perception of risks (e.g. Machin & Sankey, 2008). These results are somewhat in line with Ben-Zur and Reshef-Kfir's (2003) although, in their case, they found that it was only benefit perception that predicted behaviour with risk perception not appearing to be related at all to behaviour. Again, the direction of the causality of the relationship between risk and benefit perception and risk behaviour cannot be established in this study.

5.4.4.2 Hypothesis 2.

This relatively simple hypothesis stated that, regardless of the difference between problematic and non-problematic drivers, the latter group would not endorse all of the positive speeding statements or reject all of the negative ones. This hypothesis was

supported with both groups endorsing significantly more than zero negative statements and significantly fewer than eight positive ones (the maximum number of driving statements). The problematic drivers endorsed more than half of the positive statements suggesting that, in general, they did see benefits in speeding. However, these drivers actually endorsed the same number of negative driving statements suggesting that they did see the risks in the behaviour as well. These results, coupled with those relating to hypothesis 1, further emphasise the important role played by attitudes of the benefits of risk behaviours.

5.4.4.3 Hypothesis 3.

The third hypothesis related to the reaction-time aspect of the task. This hypothesis suggested that problematic drivers are faster to agree with positive speeding statements than to disagree and that they are faster to disagree with negative statements than to agree with them. The reverse is the case for non-problematic drivers. This hypothesis assumed that the second was true since comparisons between speed of agreement and disagreement requires that participants in both groups do actually agree and disagree with statements in each category. The results offered some support to this hypothesis though there were some ambiguous findings. The main analysis produced a four-way interaction between the driving groups (problematic vs. non-problematic), condition (swimming vs. driving), valence (positive vs. negative) and agreement (agree vs. disagree). The difficulty with such an interaction is that there are a large number of ways that it can be investigated. Based on a number of follow-up analyses, the effect will be explained as follows. Firstly, there was a difference between the groups with regard to their response times for driving statements but not for swimming statements.

Within driving statements, the groups did differ in how fast they agreed and disagreed with speeding statements, but this difference was dependent on whether they were positive or negative statements. Follow-up tests revealed that the main differences were found between the groups with regard to positive speeding statements. Problematic drivers were significantly faster at endorsing positive statements than they were at rejecting these statements. Furthermore, they were significantly faster at agreeing with positive statements than non-problematic drivers were. The trend was reversed for non-problematic drivers who were quicker at disagreeing with positive driving statements than they were at agreeing with them. Their speed in disagreeing was

also quicker than the problematic group. Interestingly, such a trend was not found for negative statements. This is not the first instance of positive stimuli distinguishing between risk groups. van Hanswijck de Jonge and Gormley (2005) found that smokers and non-smokers did not differ in their ratings of the emotionality of negative smoking stimuli. However, smokers were found to rate positive pictures as being more positive than non-smokers.

A problem in the interpretation of the results stems from the relationship between the number of endorsements a participant made and their reaction-time. Non-problematic participants disagreed with many of the positive driving statements and so perhaps this continuous disagreement led them to respond faster. Non-problematic drivers agreed with many of the positive statements, and so the reverse effect could have occurred for them. There are a number of reasons why this may not be the cause of the differences in response latencies between the groups. Firstly, the correlations between reaction-times and number of endorsements vary greatly for agreeing and disagreeing with the two valences of questions. For example, number of negative speeding statements endorsed was positively related with speed of agreeing with these statements. However, there was no significant relationship between number of positive speeding statements endorsed and reaction-time when agreeing with these statements. If reaction-times within the task were solely due to number of endorsements, then the relationship should be roughly similar for variable pairs such as these. Furthermore, the relationships found within the swimming condition were quite different from those in the driving condition which, again, is not a result that supports the idea that number of endorsements is the causal factor behind reaction-time. Finally, the differences between the participants in their reaction-times to agreeing and disagreeing with positive speeding sentences were found when number of positive speeding statements endorsed was a covariate.

This task was carried out in order to get a more nuanced picture of the role that risk and benefit perception play in dangerous driving among young people. The results of this study suggest two things. Firstly, young people's perception of the risks may not actually be as important as their perceptions of the benefits. While problematic drivers did endorse fewer risk statements, the effect associated with their increased endorsement of positive speeding statements was far greater. Reaction-times were measured to ascertain participants' accessibility to the attitudes they expressed.

Participants were encouraged to respond as fast as possible to the statements in the task. Given that there were no differences in reaction-times between the driving and swimming conditions, it does appear that participants did not deliberate any more on the experimental trials compared with the control trials. The issue of deliberation is important since the goal of the task was to assess the accessibility of automatically activated attitudes. If participants did deliberate for too long, then the task would not be measuring attitude accessibility.

As per the MODE model (Fazio & Towles-Schwen, 1999), the present findings suggest that problematic young drivers are those who are particularly fast at agreeing with positive attitudes. In fact, another explanation of the four-way interaction in this study is that it is caused by problematic drivers agreeing with benefits quicker than they agree with risks, while the reverse is true for non-problematic drivers. The only complication with this explanation is that this relationship between access of benefits and risks was only found when participants were agreeing with statements. The results did not find problematic drivers to disagree with negative statements quicker than they disagreed with positive ones or the reverse for non-problematic drivers. Participants' reaction-times when disagreeing with negative statements were out of line with much of the other categories. It may be the case that the pattern would have been found for disagreeing statements in general if it was not for this category. It may be the case that these sentences were a little confusing since they require participants to give a negative response to a negative statement; a double negative of sorts.

Non-problematic drivers appeared to be safer drivers, not because they see speeding as having no benefits or being outright dangerous, but because their automatically activated attitudes are more likely to be of the nature of "speeding does not have benefits". Rhodes and Ewoldsen (2009) found similar results for smoking with those individuals who had fast access to their smoking attitudes being more likely to display behaviour that is consistent with these attitudes. However, the causality may be in the opposite direction. In their longitudinal study of the impact of risk perception on dangerous driving, Gerrard et al. (1996) found that participants' driving behaviour actually preceded changes in their attitudes and this could be the case for the present results. Participants who speed or drive dangerously at some stage may increase their accessibility to positive attitudes towards these behaviours. This introduces the possibility of a cyclical relationship where non-detrimental dangerous driving leads to

increased accessibility for positive attitudes which in turn leads individuals to be more likely to engage in dangerous driving. A great deal of further research is required to establish whether this is an accurate description.

A disadvantage of the MODE model is that it seems to describe situations as eliciting one attitude at a time. However, as in the present study, the same behaviour can induce different attitudes at once (e.g. speeding might make somebody feel good, but it could also risk their safety). Fazio (2007) does touch upon this aspect of attitudes and suggests that people do not have multiple attitudes towards the same objects, but rather, they are capable of conceptualising the same object in different ways (i.e. speeding as a means of enjoyment and speeding as a risk). However, Fazio does not offer any suggestions for which conceptualisation will win out or if attitude accessibility is related to this issue. Note that this is not just an issue for the MODE model, but is really one that most descriptions of attitudes face. For example, the Theory of Planned Behaviour describes intentions to commit a behaviour as resulting from a number of factors including attitudes towards the behaviour. However, as demonstrated in this study, people can have both positive and negative attitudes towards risk behaviours such as speeding, perhaps due to different conceptualisations of the behaviour.

5.4.4.4 Limitations.

The task in this study had only 16 experimental trials; not a particularly large number compared with other cognitive tasks in the area of attitudes (e.g. 120 experimental trials in the IAT (Rothermund & Wentura, 2004)). Furthermore, when the trials are broken into positive and negative statements, there were only eight trials in each category. This did not give participants a lot of time to get used to the task and to begin responding to categories consistently. The decision to include such a small number of trials was based on two factors. The online nature of this task meant that it was less likely that participants would give a long study their full attention or even complete it. In a lab scenario, participants have already committed to taking part in the research, while in an online experiment they have just clicked on a link which involves much less commitment. The other reason for a small number of trials was based on Olson and Fazio's description of how, in a previous study, they induced accessible attitudes by having participants repeat a phrase a number of times (2009). If a short-term increase in attitude accessibility can be achieved using such a method, then a task with too many

trials could end up impacting on the phenomenon it is aiming to measure. Previous studies may have employed a single target stimulus (e.g. Smith & Terry, 2003) for this very reason.

Another limitation that this study shares with study 5 was that the focus of the risks and benefits questions was exclusively on speeding related questions. While speeding is a particularly dangerous and prevalent driving behaviour, there are other behaviours (e.g. tail-gating) that can be characterised as dangerous driving. This study is unable to state whether the findings with regard to attitude accessibility of speeding attitudes can be applied to other risky behaviours. On a statistical note, a greater number of participants would have allowed for more sophisticated analyses. The distinction between cognitive and emotional statements could be investigated and more powerful overall ANOVAs could be conducted. Lastly, this task assumes that participants are indicating attitudes that are automatically activated. While the instruction to “respond as fast as possible” was followed consistently for both swimming and driving statements, there is no way to know if participants were still deliberating before responding to both.

5.4.4.5 Further study.

A number of future lines of reasoning could be followed from this study and these can be divided among those that relate to attitudes to dangerous driving and those that relate to attitude accessibility in general. Loewenstein et al. (2001) discusses the differences between hot and cold reasoning with reaction-time measures such as the present one addressing the latter. Hot reasoning occurs when participants in a real-life situation, which incorporates issues such as emotions and motivations, engage in a risky behaviour. While such a situation is difficult to recreate in a laboratory environment, simulators could possibly be used to at least prime participants in some way to how they feel in a driving scenario. The impact of this on attitudes and their accessibility could inform us about the ways that young people think about speeding and dangerous driving when they are actually engaging in them. It would be interesting to see if perceptions of risks and benefits and the accessibility of these follow similar patterns across different age groups. Much of the research in the area of risk and benefit perception has focused on younger people. It would be interesting to investigate if people’s perception of benefits, or their reliance on this perception, changes as they age. For accessibility in general, an understanding of the factors that influence this may assist in developing ways

to alter it. For example, if having fast access to the attitude “speeding will make me feel good” leads people to drive dangerously then perhaps methods that reduce the accessibility of this could reduce their levels of dangerous driving.

5.5 General Discussion

The three studies described in this chapter represent an attempt to understand the relationship between problematic driving and perceptions of risks and benefits. Study 5 consisted of a short online questionnaire which participants completed before doing the reaction-time task. This study found that problematic drivers saw their chance of being in an accident as being higher but rated the overall riskiness of speeding lower (study 5; hypothesis one). Furthermore, participants in both the problematic and non-problematic groups displayed an optimism bias (study 5; hypothesis two). While the main role of study 6a was to provide stimuli for the reaction-time task, it also addressed the relationships between risk perception and negative attitudes, and benefit perception and positive attitudes. Participants were asked to supply either positive or negative words to complete a number of speed-related sentences. Those who were asked to supply negative words completed the sentences so that they were risk related while participants in the positive condition created sentences that related to the immediate benefits of driving. This supported the single prediction of study 6a. While these were not ground-breaking findings, they suggest that attitude accessibility may play a role in risk and benefit perception. Study 6b investigated the accessibility of participants’ attitudes. Problematic drivers endorsed more positive and fewer negative statements about dangerous driving (study 6b; hypothesis one), but, on average, problematic drivers did not endorse all positive speeding statements or reject all negative speeding statements (study 6b; hypothesis two). Problematic drivers responded faster when endorsing positive speeding statements (e.g. “Driving at fast speeds is fun”) while non-problematic drivers were faster when they were disagreeing with such attitudes and these effects were found even after the variance associated with number of positive attitudes endorsed was accounted for (study 6b; hypothesis three).

One of the key findings from study 6b, both from the endorsement and the reaction-time aspects of the task, was that perception of benefits plays an important role. Typically, driver research has focused on the perception of risk (e.g. Machin & Sankey,

2008; McKenna & Horswill, 2006; Waylen & McKenna, 2008). However, the results of study 5 found that, although problematic drivers gave lower risk estimates than non-problematic drivers, both groups of drivers rated speeding as being closer to “extremely risky” than “not at all risky” (i.e. on a 7 point Likert scale, both groups had scores that were higher than four, with 7 representing “extremely risky”). Furthermore, on the endorsement task, both groups endorsed more negative speeding statements than they rejected. However, when it came to positive driving statements problematic drivers endorsed much more than they rejected. Halpern-Felsher, Biehl, Kropp, and Rubinstein (2004) found the same trend for smoking among young people with these smokers placing particular emphasis on the benefits of smoking.

As detailed in the introduction to this thesis, popular explanations for dangerous driving among young people emphasise their inability to appreciate the risks of their behaviours. Furthermore, driving courses typically focus on teaching young people more about the risks of speeding and other dangerous driving behaviours. While the present results suggest that there may be some merit in these approaches, addressing perceptions of benefits may be a possibility for future interventions. However, a great deal of work is needed first to determine how benefits can be addressed. Dangerous driving is risky, and so emphasising this to young people is relatively easy; whether such an approach is effective is a different question. However, activities such as speeding, even if they are risky, are clearly enjoyable for some people given the number of positive statements endorsed by some participants in this study. If they offered no enjoyment, then people would be unlikely to engage in them.

The results relating to attitude accessibility are a reminder of the complexities of the relationship between attitudes and behaviours. Though the results were slightly ambiguous, even when problematic drivers held negative attitudes about speeding, they were slower at accessing these attitudes compared with non-problematic drivers; and they were much slower at accessing them compared with their speed of accessing positive attitudes to speeding. Whether the accessibility of attitudes plays a causal role in driving behaviour cannot be determined from this study. As Rhodes and Ewoldsen (2009) point out, it could be that accessibility develops as people engage in a behaviour more. Olson and Fazio (2009) state that previous attitude accessibility studies demonstrate that accessibility can be temporarily increased by having a participant repeat a statement a number of times. However, they also found that this increased accessibility did

subsequently affect behaviour. This highlights the possibility that attitude accessibility and behaviour have a cyclical relationship with one reinforcing the other. Further research is of course needed to establish if such a relationship exists for risk behaviours.

5.6 Conclusion

The results of the studies in this chapter depict a complicated relationship between risk perception and behaviour among young drivers. Previous research has typically made conclusions about young drivers by comparing them with older drivers. The current studies instead focused on the differences between those who engage frequently in problematic driving and those who rarely do so. Many authors have been quick to suggest that young people do understand the risks of dangerous driving and other risk behaviours (Reyna & Farley, 2006; Steinberg, 2008), yet the results of the present studies should serve as a reminder that simply possessing these attitudes may not always be enough; drivers need to actually access them in a driver situation. Lastly, the results of these studies, along with previous research, highlight the importance of not just looking at the negative aspects of dangerous driving, but also focusing on the benefits that young people may believe that it offers.

Chapter 6: General Discussion

The aim of this thesis has been to test some of the predictions and assumptions of developmental theories of adolescent risk-taking. The developmental theory that has been the focus of this thesis is the Dual Systems Model (DSM) proposed by Steinberg (2008) and the results of many of the studies address a number of aspects of the DSM. As discussed in chapter 1, Steinberg is not the only researcher to have highlighted the role of developmental factors such as cognitive control (e.g. Casey et al., 2008; Reyna & Farley, 2006). Specific focus is placed on the DSM as it represents one of the more clearly formulated theories regarding the role of developmental factors in adolescent risk-taking. Additionally, many of the results from these studies address other issues related to problematic driving such as the role of gender and possible directions for intervention programmes. A summary of the separate studies will first be provided before discussing the relationship between the results of these studies and the DSM. This will be followed by a discussion of other driving issues that these results can provide information about. The chapter will conclude with a discussion of the overall limitations of the thesis and possible future directions for research.

6.1 Summary of Results

Study 1 (chapter 2) investigated the relationship between psychometrically measured impulsivity and self-reported driving violations. In line with previous research, these results found that levels of violations were positively related to impulsivity. The participants in this study also served as a pool of participants for study 2.

Study 2 (chapter 3) compared problematic and non-problematic drivers, as determined by self-reported violations, on two behavioural measures of response inhibition and a behavioural measure of reflection impulsivity. No differences between the groups were found on the two response inhibition tasks while the results of the reflection impulsivity task were more ambiguous.

Study 3 (chapter 4) presented the results of a confirmatory factor analysis (CFA) of the Driver Behaviour Questionnaire (DBQ) for young drivers. The results of the CFA were in line with past research displaying an acceptable, though not particularly strong, fit for the three-factor structure of the DBQ. Furthermore, the results indicated that there was factorial invariance for the DBQ for both young (17-21) and older (22+) drivers. Chapter 4

also included the results of study 4 which was a replication of study 2 with a different problematic driver sample. The problematic drivers in study 4 were drivers who were attending a speed awareness course having been apprehended by the police for speeding. The results of this study found there to be no difference between problematic and non-problematic drivers on the reflection impulsivity task or on one of the response inhibition tasks, the Stop-Signal Task. However, problematic drivers were found to commit more errors on the other measure of response inhibition; the Go/NoGo Task.

Study 5 (chapter 5) asked participants to estimate the risks associated with speeding and their own risks of being in a crash. Problematic drivers, who were identified on the basis of self-reported driving behaviour, rated their likelihood of being in a negative driving incident as being higher than non-problematic drivers. However, the trend was reversed when estimating the risks of dangerous driving with non-problematic drivers giving a higher risk estimate than problematic ones. Study 6a (also chapter 5) asked participants to complete a number of speeding-related driving sentences with words that would make the sentence either positive or negative. The positive words that participants provided related to the immediate benefits that one might experience while speeding. The negative words that participants gave related to the risks associated with dangerous driving. These words were subsequently used in study 6b. Study 6b was the final study detailed in chapter 5 and looked at participants' accessibility of positive and negative driving attitudes. Participants responded to a number of positive and negative speed-related driving statements. Problematic drivers were faster to endorse positive speeding sentences than they were to reject them. Non-problematic drivers were faster at rejecting these sentences than they were at endorsing them. Furthermore, non-problematic drivers were quicker at endorsing negative statements compared to positive ones, while problematic drivers were quicker at endorsing positive statements compared with negative ones.

6.2 Dual Systems Model

6.2.1 Cognitive control

The DSM suggests that during early adolescence, activation in a number of areas, particularly limbic ones, increases and leads to greater sensation seeking behaviour among young people (Steinberg, 2008). The theory further suggests that this sensation

seeking behaviour leads to increased risk-taking among young people which during the late teens and early twenties is gradually curbed by the development of cognitive control systems, predominantly based in the frontal lobe. Study 1 tested an aspect of this theory by examining the relationship between levels of impulsivity, measured using the Barratt Impulsiveness Scale (BIS), and engagement in dangerous driving (measured using the Violations scale of the DBQ) among drivers aged 17-21. There was a positive relationship between Violations and the subscales of the BIS, which was in line with previous research (e.g. Dahlen et al., 2005). Number of violations had its strongest relationship with the Motor Impulsiveness, which was also in line with previous driving research (Constantinou et al., 2011). However, the other scales of the DBQ (Lapses and Errors) were also related to the BIS scales though, on the face of it, these driving scales would appear to have nothing to do with deliberative risk-taking; lapses are instances of lack of attention while errors are mistakes that were not committed intentionally (Åberg & Rimmo, 1998). The significant relationships between the BIS and all of the DBQ scales do detract from the importance of the relationship between Violations and the BIS scales (the relationship predicted by the DSM). While this study was in line with the predictions of the DSM, these ambiguous results do not offer resounding support for it.

Chapter 3 described the results of a study in which problematic and non-problematic young drivers were compared on a number of behavioural tasks that purport to measure response inhibition and reflection impulsivity. These constructs were examined since, among other reasons, they fit with Steinberg's description of the kinds of cognitive control that young people are lacking. The results of this study offered no support for the DSM. The Stop-Signal and Go/NoGo Tasks, which have been associated with those neurodevelopmental areas that undergo change during the late teens and early 20s (Sowell et al., 2001), revealed no differences between those participants who reported high levels of driving violations and those who reported low violations. The results of the test of reflection impulsivity were more nuanced but ultimately did not offer any support for the DSM. These results conflict with those from study 1 which did offer some support for the DSM. However, no correlation was found between the BIS measures from study 1 and the main measures of response inhibition in study 2. These null relationships reduce the support that the DSM receives from the first study since the response inhibition tasks of study 2 have been associated with those neurological areas that undergo development during adolescence and which are areas that are often

associated with cognitive control. However, the questionnaire methods of study 1 have not been associated with any such neurological areas. The only point of support for the DSM that might be taken from study 2 is that the results of the Stop-Signal Task were in the expected direction and that a larger sample may have provided significant results. With the same sample sizes in which Logan et al. (1997) found differences between their groups (~136 participant), the differences in this study would have been significant; assuming that the same mean difference remained with these additional participants.

The null results of study 2 have three logical explanations: the DSM is not correct or, at the very least, does not apply to problematic driving; the tasks used in study 2 do not assess the kinds of cognitive control related to risk-taking; or the problematic drivers were not really problematic. As described above, response inhibition tasks have been associated with areas of the brain that are late to develop. Furthermore, individuals typically thought to have impulse control problems (e.g. those with ADHD or substance abuse problems), have been found to perform poorly on both the response inhibition and reflection impulsivity tasks (Clark et al., 2006; Kaufman et al., 2003; Logan et al., 1997). Given these previous findings, it seems premature to reject the tasks as being unrelated to the cognitive control system described in the DSM. Rather than write the whole theory off, a more reasonable approach is to address the potential sampling issues of study 2 in which both problematic and non-problematic driving groups were made up entirely of students attending a top Irish university.

The main focus of study 3, which utilised the data collected in study 1, was an assessment of the suitability of the three-factor structure of the DBQ for this young Irish sample. However, an interesting result emerged in this study as the younger participants actually had a smaller score on the DBQ Violations scale compared with the older participants. This is not in line with previous investigations of the impact of age on violations (see Westerman & Haigney, 2000). While the younger participants were recruited through college departments, many of the older drivers (those older than 22 years) were recruited through internet message boards. This difference suggests that the college students may not be typical young drivers –an assertion supported by the very small number of penalty points obtained by even the problematic drivers in study 2. So while study 3's CFA did indicate that the general factor structure is just as good a fit for young people, the findings described above cast doubt over how representative the young college drivers are of the rest of the young driver population.

In study 4, problematic and non-problematic drivers were compared on the exact same tasks as study 2. However, the problematic drivers in study 4 were recruited in a different manner. In study 2 problematic drivers were those who had reported a large number of driving violations while non-problematic drivers were those who reported much fewer. In study 4 problematic drivers were young people who had been apprehended by the police for speeding and were subsequently attending a speed awareness course. The non-problematic group were participants from study 2 who had reported never having been caught speeding or having been involved in an accident. The results for this study, while not without ambiguity, did offer some support for the DSM. On the Go/NoGo Task, problematic drivers made more errors while there was no difference between the groups on the Stop-Signal Task. There was, once again, no difference between the groups on the measure of reflection impulsivity. The Information Sampling Task (the measure of reflection impulsivity) was the only task that had not been related to a late developing neurological area (since there is currently no neuroimaging research involving the task) and it is a much more recent task than the two response inhibition measures. Accordingly, its null results in comparison to the Go/NoGo Task in this study are somewhat understandable. However, since both the Stop-Signal and the Go/NoGo Tasks purport to measure the same construct, the differences between the two present a more difficult explanatory challenge. Furthermore, the difference between the groups on the Stop-Signal Task was actually greater in study 2 compared with study 4. There have been previous suggestions that the tasks measure different stages of inhibition with the Go/NoGo Task requiring inhibition at an earlier stage of the response process with Stuart J. Johnstone et al. (2007) finding that the EEG activity associated with inhibition with the two tasks does differ. In both study 2 and study 4, there was no correlation between the main measures of inhibition for each task.

The correlations among the variables within each of the tasks reveal a number of characteristics about these measures of response inhibition. In the Stop-Signal Task in both studies 2 and 4, there was a very high correlation between reaction-time and number of errors made. This poses a problem for the interpretation of the results of this task given that these variables should be unrelated. The timing algorithms used in the task are supposed to ensure that, on average, participants successfully inhibit half of the trials. The number of incorrect trials plays a role in the calculation of the primary measure of response inhibition in this task and so the above-mentioned correlation

suggests that the response inhibition score for an individual is related to their reaction-time despite the fact that the theory underlying the task specifically states that these two measures are separate (Logan et al., 1997). This outcome raises questions over whether the task does actually allow for the measure of participants' unique inhibitory abilities. The Go/NoGo Task is not without its own interpretational problems. In study 2 and study 4, there was a high negative relationship between reaction-time and number of commission errors on the task, which is in line with previous studies. In study 4, problematic drivers made more errors than non-problematic drivers but also had a faster reaction-time. Accordingly, the results seem to indicate a trade-off between speed and accuracy. It is not clear whether such a trade-off is indicative of poorer response inhibition, but since participants were free to choose how fast they wanted to respond, the difference in performance between the groups on this measure is still interesting. The fact that problematic and non-problematic participants differed on a task that has been associated with neurological areas such as the Dorsolateral Prefrontal Cortex does offer some support for the DSM. The DSM states that the development of cognitive control underlies decreased risk-taking in late adolescence and early adulthood. The theory does not commit to any particular type of cognitive control such as response inhibition. Accordingly, while questions remain as to whether the results of study 4 demonstrate differential response inhibition performance, they do still suggest differences in some kind of cognitive control.

6.2.2 Risk perception

The second strand of research covered in this thesis is described in chapter 5 and investigates Steinberg's assertion that risk-taking among young people is not due to problems in understanding the risks. Steinberg's DSM is not the only theory formulated to counter this relatively popular conception of youth risk-taking such as dangerous driving. Many dual process models (e.g. Fuzzy Trace Theory (Reyna & Farley, 2006)), share the DSM's starting point of questioning whether rational explanations of risk-taking offer any solution to the young driver problem. Study 5 described the results of a risk questionnaire which asked participants about the risks of speeding and about their own risk of being in a negative incident due to speeding. The relationship between risk behaviour and attitudes was dependent on the types of questions asked. For behaviour-focused questions, both problematic and non-problematic groups thought that speeding

was risky, though non-problematic drivers gave a higher risk-rating. This does suggest that viewing speeding as risky may lead individuals not to engage in it, although the reverse could be the case with those who engage in more speeding reducing their view of the risk of it, having not experienced any negative attitudes towards it. However, for outcome-focused questions where participants were asked about their chances of being in a car accident, problematic drivers saw themselves as being at more risk than the non-problematic drivers; though both groups did still rate their risks as being lower than others. Longitudinal research suggests that dangerous driving behaviour precedes changes in perceptions of the risk of experiencing a negative outcome (Gerrard et al., 1996). The findings of study 5 suggest that seeing oneself as being not at risk is not associated with increased risk-taking—especially since participants in the problematic group were most likely to indicate relative invulnerability (i.e. stating that they had no risk of being involved in an accident). According to Gerrard et al. findings, the increased feelings of risk among problematic drivers develop as a consequence of increased risk-taking. This suggests those drivers who engage in a large degree of speeding are very aware of the risks and, thus, support is offered for Steinberg's description of youth risk-taking as not being associated with a lack of understanding of the risks.

Study 6b added to these findings by investigating young people's attitudes towards both the risks and the benefits of speeding. The results relating to the risk were in line with the behaviour-focused questions from study 5 with both problematic and non-problematic drivers endorsing more negative speeding statements (e.g. "Driving at fast speeds is dangerous") than they rejected; though again, non-problematic drivers did see speeding as being more risky. However, the difference between the groups was much greater with regard to perception of the benefits of speeding. The non-problematic groups endorse very few of the positive speeding statements ("driving at fast speeds is fun") while the problematic drivers endorse much more than half of these statements. It's not immediately clear if these findings go against the predictions of the DSM. Focusing on just the risk results of study 5 and study 6b would suggest, in line with Steinberg's description, that risk perception may not be the causal factor in risky driving. However, the perception of the benefits of risk-taking seems to suggest that rational models may not be as far from the truth as supporters of developmental of dual-processing theories would suggest. Causal claims cannot be made from the present research and so, as with risks, perhaps engaging in speeding leads young people to

experience benefits while those who never speed will never experience these same positive outcomes. Nonetheless, the results, while not disproving the DSM, are not exactly in line with its conception of the role that cognitions play in risk-taking.

The final and most novel aspect of the investigations of risk and benefit attitudes among young drivers was the exploration of attitude accessibility. Problematic drivers not only endorsed more positive attitudes towards speeding, but they were also able to access these attitudes quicker than non-problematic drivers could. Furthermore, problematic drivers accessed positive attitudes quicker than they accessed negative ones while the reverse was the case for non-problematic drivers. Past research in attitude accessibility suggests that attitudes that are highly accessible are more likely to be predictive of future behaviour (Fazio & Williams, 1986). These findings do not provide support for those researchers who believe that risk perception is not a contributor to risk-taking among young people (e.g. Reyna & Farley, 2006; Steinberg, 2008). Instead, these findings suggest that problematic drivers see speeding as having much more benefits than non-problematic drivers do and that even when these same problematic drivers support risky statements about speeding, they are much slower to access their attitudes of the risks than they are of the benefits.

6.2.3 Assessment of the DSM

The findings above can be divided into those that support the role of the neurodevelopmental factors in dangerous driving among young people and those that do not. Findings of the cognitive control studies offer more direct assessments of the theory but, as described previously, questions of risk perception are indirectly related to this theory. The differences between the groups on the Go/NoGo Task in study 4 offer some of the clearest support for the neurodevelopmental theories such as the DSM. The relationship between impulsivity (measured using the Barratt Impulsiveness Scale (BIS)) and violations (measured using Driving Behaviour Questionnaire (DBQ)) in study 1 is also in the direction that would be predicted by the DSM since they suggest that increased cognitive control is associated with less dangerous driving. The finding that problematic drivers count themselves as being more at risk than non-problematic drivers is also in line with the DSM since it does suggest that cognitive factors such as feeling “at risk” do not offer the protection that more rational theories of decision making would suggest. Furthermore, in studies 5 and 6b both problematic and non-problematic drivers viewed

speeding as being risky –though the non-problematic drivers did view it as being more risky. This finding that both groups viewed speeding as being risky is also something that would not be predicted by rational models of decision making since groups who believe an activity to be risky shouldn't engage in it.

The failure to find differences between the groups on any of the tasks in the first study does not offer support for the suggestion that the cognitive control measured by these tasks plays a role in risk-taking among young people. Furthermore, the lack of any differences between the two driving groups on the Stop-Signal Task and Information Sampling Task in study 4 calls into question just how important cognitive control is in dangerous driving. Steinberg assumes that differences in risk perception do not explain youth risk-taking. While some evidence exists to support this (see previous paragraph), the difference between the groups in terms of their perceptions of the benefits is more consistent with rational models of decision making and risk-taking (e.g. the Theory of Planned Behaviour).

6.3 Dangerous driving and gender

Many of the studies throughout this thesis have examined the differences between males and females. The outcomes of such analyses have been ambiguous and offer little explanation for the typical gender differences that are an important issue in both dangerous driving and youth risk-taking (CSO, 2009). There were no differences between males and females on the BIS scales for the online questionnaire in study 1. Furthermore, there were no differences between the genders on any of the behavioural tasks in chapters 3 and 4. However, the selection methods for these studies ensured that there were as many female problematic drivers as there were male. The lack of differences between males and females for such a study design suggests that the impact that cognitive control has on risk behaviours is similar for both groups. Studies that have compared random samples of males and females have found females to perform slightly better on cognitive control tasks. This suggests that cognitive control could explain some of the typical driving differences between the genders. For those analyses in chapter 5 that included gender as a variable, there were some differences between males and females. While neither group saw themselves as being at more risk of a negative driving outcome, the females did see speeding as being more risky. Figner and Weber (2011)

reported similar findings in their studies with females typically seeing recreation risks as being more risky than males. An interaction term in this instance revealed a larger difference between problematic and non-problematic drivers for males. It's not altogether clear what the implications of this interaction are. Problematic males could be more problematic than problematic females or perhaps attitudes towards the risks of dangerous driving play a larger role in the driving behaviour of males. These are speculative suggestions and further research is required to establish the basis of this difference if it is a robust one.

As described in the introduction, fatal crashes are much more prevalent among young males compared with females and young men are much more likely to be hospitalised due to loss of control while driving (Tavris et al., 2001). It is not essential that a theory of adolescent risk-taking addresses the differences between males and females. Gender differences exist for all age groups and, in the US at least, the gap between males and females in total crash rate is smaller among 16-20 year-olds compared with older age groups (NHTSA, 2010). As was also discussed in the introduction, there is some debate over just how different males and females are in terms of dangerous driving. Data from the Central Statistics Office reveals that young Irish males were no more likely to be injured in a car accident than young Irish females (CSO, 2009) while Lourens et al. (1999) found that males and females have the same accident rate when mileage is accounted for. However, the large gender differences in fatal accident rates (CSO, 2009) is still indicative of differences in risky behaviour between males and females. The research described above suggests that differences in risk perception show greater potential in explaining risk-taking differences between the genders. From a theoretical perspective, developmental theories have typically not attempted to address gender differences (e.g. Casey et al., 2008; Steinberg, 2008) and this is not necessarily a criticism of them. By definition, those theories, such as the DSM, seek to explain changes in risk-taking across age groups. Those supporting developmental explanations for youth risk-taking can appeal to entirely separate theories to explain typical gender differences. More social-based theories may be suitable candidates with researchers finding that the gap in risk-taking between males and females may actually be reducing (Abbott-Chapman, Denholm, & Wyld, 2008).

6.4 Driving intervention programmes

An increased understanding of risk-taking among young people could have significant implications for road safety intervention. The studies in this thesis made no investigations and so no concrete recommendations can or should be derived from their outcomes. However, a number of suggestions can be made to those researchers seeking to test improvements in existing safety programmes or seeking to design entirely new ones. After his review of the DSM, Steinberg (2008) suggests that the best way to reduce risks among young people is not to focus on education, but rather to restrict their access to situations where they might be tempted to engage in risk (e.g. unsupervised parties). However, while this explanation might be realistic for young adolescents, young people in their late teens are one of the highest risk groups for a number of risk behaviours. Many parents would find it difficult to ensure that their 18 year old son or daughter does not attend an unsupervised party. For dangerous driving in particular, Steinberg recommends restrictive driving licences for young people. Evidence suggests that such graduated driver licensing can greatly reduce crash risk among young people (Shope, 2007). However, while findings such as this may support Steinberg's recommendations, they do not necessarily support the DSM. The research from the cognitive control chapters in this thesis does offer support for Steinberg's theory, but it also suggests that there is much variance unexplained by these factors. Additional measures of cognitive control, or measures of sensation seeking, might increase the variance in problematic behaviour explained by the DSM, but it is doubtful that they could explain all of it. If future evidence does offer additional support to the DSM, an additional approach to reducing problematic driving could be to improve the cognitive control of young people. Isler et al. (2011) have met with success in training higher-order cognitive skills (e.g. hazard perception, risk appreciation) for young drivers. Accordingly, an opportunity may exist to train young drivers in exercising more low-level cognitive functioning or to recognise those social situations that could lead them to engage in greater risk-taking.

The results of the studies in chapter 5 lend themselves to much more concrete suggestions for potential intervention approaches. Carcary, Power, and Murray (2001) investigated the impact of a course designed to educate pre-drivers about a number of issues. They found that the course did not appear to have any beneficial effects. The aspects of the course that dealt with actual driving behaviour focused entirely on the risks of dangerous driving and the possible outcomes of engaging in it. The results from

chapter 5 suggest that problematic drivers in some cases are more aware of the risks and in those cases where they view the behaviour as less risky, a much greater difference is found in their attitudes towards the benefits. Rather than focus on risks, as many programmes do (e.g. Divall, 2011), these results suggest that more success may be found in focusing on young drivers' cognitions regarding the benefits of things such as speeding. Some attempts have been made to address drivers perception of the time-saving benefits of speeding, which are often quite small (e.g. DPTI, n.d.), but there have been few attempts to address young people's perceptions of less instrumental benefits (e.g. having fun). Furthermore, some researchers have made recommendations that are in direct conflict with the findings of the present study and much previous research. Christie (2001) suggests that the optimism bias found among young people should be addressed to reduce their dangerous driving. However, in study 5 problematic drivers actually displayed less of an optimism bias than non-problematic drivers – and this was not the first study to find such counter-intuitive results. It is uncertain what the results of the attitude accessibility component of study 6b might mean for interventions. However, if accessibility of risks and benefits does play a causal role in problematic driving, then efforts to enhance or reduce these, respectively, may have potential to reduce risky driving.

6.5 Limitations

The limitations associated with the individual studies can be found in the respective chapters. This general limitation section, while still referring to the separate studies, will focus on the overall shortcomings of the methods and approaches described in the thesis. The studies described in chapters 2 and 3 were based on young people, most of whom were attending a relatively prestigious Irish university situated in a very urban environment. The number of these people who engage in problematic driving, or who even get the chance to, may be smaller than in the general population which could limit the size of any effects related to dangerous driving. Furthermore, any findings for such a sample may not be generalisable to other young road users, such as those living in more rural settings where traffic accidents can have different characteristics (Chen et al., 2009). While the risk-perception studies in chapter 5 also relied on third level students, these students were sampled from a number of urban and rural colleges around the

country. In chapter 4, problematic drivers were those attending a driver training course having been apprehended by the police for speeding. While this recruitment strategy offered an interesting alternative to those utilised in the other studies of the thesis, those individuals attending this course had been caught speeding only once. Such sampling issues are not unique to the present thesis with very few driver behaviour studies offering satisfactory methods for identifying problematic drivers.

The approach of this thesis has been to compare those individuals who often drive dangerously with those who rarely do so. The logic underpinning this approach is that, in order to understand which factors may lead to a decrease in problematic driving as participants age, it is necessary to understand those factors that are associated with problematic driving for this age group. Speculation as to the role of changing cognitive control in risk-taking in adults is slightly premature if we have not yet determined whether such a factor plays any role at all. Nonetheless, such study designs mean that the studies in this thesis do not directly contribute to more developmental type questions. This thesis cannot say whether those problematic drivers who perform poorly on the Go/NoGo Task get better at such a task as they age or whether such a hypothetical change subsequently impacts on problematic driving behaviour. This same issue exists for the risk perception research in chapter 5. Do attitudes towards positive and negative driving behaviours, and the accessibility of these, change over time? Do they have the same association with problematic driving for each age group? These are all extremely important developmental questions that cannot be answered by the present research given the focus on a single age group.

An additional limitation that is present in many of the studies in this thesis relates to the issue of normative data. Non-drivers were not participants in any of the main studies of the present thesis. Accordingly, where differences do exist between problematic and non-problematic drivers, it is not possible to state which group deviates from the population at large or, indeed, whether both groups do. The omission of such participants from these studies was simply due to time constraints. However, the absence of non-drivers can be defended from a theoretical perspective. It is questionable whether such a group really represents the norm for participants of this age. The CSO (2008) estimated that 176,000 people aged 17-21 had a driving licence. The most recent Census data (2011) suggests that there 229,719 people in this age group living in Ireland. Even if a large number of those with licences do not drive, it is still possible that drivers

outnumber non-drivers in this age group. The inclusion of non-drivers as a source of normative data could run the risk of using a minority sample as a baseline. It could be the case that those individuals who do not drive a car avoid doing so because they view driving as being more risky than drivers do.

There was a big focus on speeding in this research. Studies 1 and 2 used the Violations scale of the DBQ which does include a number of problematic driving behaviours. However, the problematic drivers of study 4 were those who were attending a course for speeding. Drivers in studies 5 and 6b were identified as problematic and non-problematic on the basis of two questions, one of which was about speeding. Furthermore, the behaviour-focused risk questions of these latter two studies were all about speeding. As described in the Introduction chapter, there are a number of behaviours that can be classified as problematic driving (e.g. breaking red lights, tailgating, etc.). Further research is needed to determine whether the present findings regarding speeding can be applied to all dangerous driving, though an obstacle for such research is the degree of subjectivity in measuring other forms of dangerous driving.

6.6 Further Study

Based on the outcomes of the studies described above, a number of suggestions can be made for future research. A relatively simple extension of the above work would be to apply it to other risk-taking behaviours. Inhibition tasks like the Go/NoGo Task have been used with impulsive individuals such as drug users (Colzato, van den Wildenberg, & Hommel, 2007; Hester & Garavan, 2005; Kaufman et al., 2003). However, few studies have used these tasks with young risk-takers. The promising results of the Go/NoGo Task in study 4 may apply only to driving behaviours; driving is much more of a motor-based task compared with other risks such as binge drinking or drug taking. The investigation of other risky behaviours would also have the advantage of allowing researchers to work with even younger age groups than the topic of dangerous driving allows. Another simple and related extension would be to utilise tasks other than response inhibition and reflection impulsivity ones. As explained in chapter 3, these tasks were selected for a number of behavioural neurodevelopmental reasons. However, a huge number of tasks have been associated with frontal lobe functioning (e.g. Luna et al., 2001; Newman et al.,

2003). The concept of “cognitive control” is broad enough that a large number of constructs may be viable candidates (e.g. task-switching and delayed discounting).

A greater understanding of the causal direction of risk and benefit attitudes could provide vital information for intervention strategies with dangerous drivers. A longitudinal study of changes in attitudes and behaviours could address this causal question. Gerrard et al. (1996) did conduct a study similar to this description, but they only used outcome-focused questions and did not look at benefits at all. Pre-drivers also provide a unique opportunity to understand the causal impact of attitudes and while some researchers have worked with these age groups, few have done so using a longitudinal design (e.g. Waylen & McKenna, 2008). With regard to attitude accessibility, the causal role of this may be better established using simulator methods. Olson and Fazio (2009) found that accessibility could be increased by having participants simply repeat a statement. If participants’ accessibility to positive and negative driving statements could be altered temporarily in this manner, then perhaps subsequent performance in a driving simulator or instrumented vehicle could be altered. Such an outcome would better establish the role that accessibility plays in risk-taking and could also provide the basis for future interventions which could attempt to permanently alter accessibility to risk and benefit attitudes.

6.7 Conclusion

The research in this thesis addressed, both directly and indirectly, the proposition that developmental issues may underlie problematic driving among young people. The specific aims of the thesis were to investigate the cognitive control aspects of the DSM with regard to dangerous driving and, separately, the contribution of risk perceptions, and their accessibility, to dangerous driving. While a number of findings did offer support for the role of inhibitory control in reducing dangerous driving, not all of the results pointed to this conclusion. An investigation of the perception of risks and benefits of problematic driving also provided conflicting results for developmental models. Perception of risks was not always in line with predictions of rational models. However, problematic drivers’ support for the benefits of speeding suggests that rational explanations of dangerous driving still have great potential for explaining risk-taking among young people. Given the number of people killed in traffic accidents every year,

any progress in understanding the factors underlying risky behaviour could have enormous implications.

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Appendix 1: Materials for Study 1 and Study 4

Email Message:

Hello,

I'm a researcher at Trinity College, Dublin conducting research in the area of driver behaviour. In particular, I'm interested in the different driving styles that people have.

As part of my research I am looking for people to complete my questionnaire. It only takes about 10 minutes. Furthermore, anyone who completes the questionnaire will be entered into a draw to win a 50 euro HMV voucher.

If you wish take part in the survey, then please click on the link below.

[\[Link\]](#)

Any information supplied will be kept strictly confidential.

Thank you for your time,

Fearghal O'Brien

Online Questionnaire:

Welcome

Hello.

This study is being conducted by researchers of the School of Psychology at Trinity College, Dublin.

We are investigating the different driving styles that people have and the factors that lead people to drive the way they do.

Please complete this survey only if you have a provisional driving licence (learner's permit) or a full driving licence for a car.

It should only take about 10 minutes to answer the questions and all information provided will be kept strictly confidential.

At the end of the questionnaire you will have the opportunity to enter into a raffle for a 50 euro voucher.

Thank you.

Demographics

Please enter you...

Date of Birth	Day	Month	Year

Are you male or female?

- ☐ Male
- ☐ Female

In which county is your primary residence?

Driving demographics

What type of licence do you currently hold?

- ☐ Provisional licence (or drivers permit)
- ☐ Full licence
- ☐ Don't know

What is the engine size of the car you drive most often?

- ☐ 1 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

How many kilometres have you driven in the last year?

Have you been driving for more than 12 months?

- ☐ Yes
- ☐ No

Not driving more than a year

How many months has it been since you started driving?

Please give your answer to the nearest month.

Driving more than a year

How many years has it been since you started driving?

Please give your answer to the nearest year.

Please answer the questions below as honestly as possible. All information provided will be kept strictly confidential.

In the last 3 months, how often have you:

	Never	Rarely	Once or twice a month	Once or twice a week	3-5 times a week	Most days	Don't Know
Driven in a built up area (where there is a 50km/hr limit)?	☐	☐	☐	☐	☐	☐	☐
Driven at 60km/hr in a 50km/hr zone?	☐	☐	☐	☐	☐	☐	☐
Driven at 70km/hr in a 50km/hr zone?	☐	☐	☐	☐	☐	☐	☐
Driven at 80km/hr or more in a 50km/hr zone?	☐	☐	☐	☐	☐	☐	☐
Driven on a main road between towns (where there is a 100km/hr limit)?	☐	☐	☐	☐	☐	☐	☐
Driven at 115km/hr on a main road between towns?	☐	☐	☐	☐	☐	☐	☐
Driven at 130km/hr on a main road between towns?	☐	☐	☐	☐	☐	☐	☐
Overtaken dangerously (i.e. made it just in time, caused an oncoming vehicle to slow down or caused the overtaken vehicle to brake)?	☐	☐	☐	☐	☐	☐	☐
Followed another vehicle very closely to make them speed up?	☐	☐	☐	☐	☐	☐	☐
Driven when you may have been over the legal Blood Alcohol Content (BAC) limit?	☐	☐	☐	☐	☐	☐	☐
Raced another vehicle?	☐	☐	☐	☐	☐	☐	☐

Penalty points

How many penalty points do you currently have on your licence?

Have you ever been involved in a motor accident in which you were the driver?

☐ Yes

☐ No

Accidents

How many motor accidents have you been involved in as a driver?

How many motor accidents have you been involved in where you were at fault?

How many motor accidents have you been involved in as a driver in which there was damage to a vehicle but no injuries?

How many motor accidents have you been involved in as a driver which involved serious injury or death?

DBQ 1

While driving, how often do you:

	Never	Hardly Ever	Occasionally	Quite Often	Frequently	Nearly all the time
Hit something when reversing that you had not previously seen?	☐	☐	☐	☐	☐	☐
"wake up" to find yourself on the road to destination A, when you intended to drive to destination B?	☐	☐	☐	☐	☐	☐
Get into the wrong lane approaching a roundabout or a junction?	☐	☐	☐	☐	☐	☐
Queue to turn left onto a main road, but find that you pay such close attention to the main stream of traffic that you nearly hit the car in front?	☐	☐	☐	☐	☐	☐
Fail to notice that pedestrians are crossing when turning into a side street from a main road?	☐	☐	☐	☐	☐	☐
Sound your horn to indicate your annoyance to another road user?	☐	☐	☐	☐	☐	☐
Fail to check your rear-view mirror before pulling out, changing lanes, etc.?	☐	☐	☐	☐	☐	☐
Brake too quickly on a slippery road or steer the wrong way in a skid?	☐	☐	☐	☐	☐	☐
Pull out of a junction so far that the driver with "right of way" has to stop and let you out?	☐	☐	☐	☐	☐	☐
Disregard the speed limit on a residential road?	☐	☐	☐	☐	☐	☐
Switch on one thing, such as the headlights, when you meant to switch on something else, such as the wipers?	☐	☐	☐	☐	☐	☐
On turning left nearly hit a cyclist who has come up on your inside?	☐	☐	☐	☐	☐	☐
Miss "Give Way" signs and narrowly avoid colliding with traffic having right of way?	☐	☐	☐	☐	☐	☐
Attempt to drive away from the traffic lights in third gear?	☐	☐	☐	☐	☐	☐

DBQ 2

While driving, how often do you:

	Never	Hardly Ever	Occasionally	Quite Often	Frequently	Nearly all the time
Attempt to overtake someone you had not noticed to be signalling a right turn?	☐	☐	☐	☐	☐	☐
Become angered by another driver and give chase with the intention of giving him/her a piece of your mind?	☐	☐	☐	☐	☐	☐
Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane?	☐	☐	☐	☐	☐	☐
Forget where you left your car in a car park?	☐	☐	☐	☐	☐	☐
Overtake a slow driver on the inside?	☐	☐	☐	☐	☐	☐
Race away from traffic lights with the intention of beating the driver next to you?	☐	☐	☐	☐	☐	☐
Misread the signs and exit from a roundabout on the wrong road?	☐	☐	☐	☐	☐	☐
Drive so close to the car in front that it would be difficult to stop in an emergency?	☐	☐	☐	☐	☐	☐
Cross a junction knowing that the traffic lights have already turned against you?	☐	☐	☐	☐	☐	☐
Become angered by a certain type of driver and indicate your hostility by whatever means you can?	☐	☐	☐	☐	☐	☐
Realise that you have no clear recollection of the road along which you have just been travelling?	☐	☐	☐	☐	☐	☐
Underestimate the speed of an oncoming vehicle when overtaking?	☐	☐	☐	☐	☐	☐
Disregard the speed limit on a motorway?	☐	☐	☐	☐	☐	☐

Please read each of the following statements and tick the box that you think applies most to you. Don't spend too much time on any of the statements. Answer quickly and honestly.

	Rarely/Never	Occasionally	Often	Almost Always/Always
I plan tasks carefully.	☐	☐	☐	☐
I do things without thinking.	☐	☐	☐	☐
I make-up my mind quickly.	☐	☐	☐	☐
I am happy-go-lucky.	☐	☐	☐	☐
I don't "pay attention."	☐	☐	☐	☐
I have "racing" thoughts.	☐	☐	☐	☐
I plan trips well ahead of time.	☐	☐	☐	☐
I am self controlled.	☐	☐	☐	☐
I concentrate easily.	☐	☐	☐	☐
I save money regularly.	☐	☐	☐	☐
I "squirm" at plays or lectures.	☐	☐	☐	☐
I am a careful thinker.	☐	☐	☐	☐
I plan for job security.	☐	☐	☐	☐
I say things without thinking.	☐	☐	☐	☐
I like to think about complex problems.	☐	☐	☐	☐
I change jobs.	☐	☐	☐	☐
I act "on impulse."	☐	☐	☐	☐
I get easily bored when solving thought problems.	☐	☐	☐	☐
I act on the spur of the moment.	☐	☐	☐	☐
I am a steady thinker.	☐	☐	☐	☐
I change residences.	☐	☐	☐	☐
I buy things on impulse.	☐	☐	☐	☐
I can only think about one thing at a time.	☐	☐	☐	☐
I change hobbies.	☐	☐	☐	☐
I spend or charge more than I earn.	☐	☐	☐	☐
I often have extraneous or irrelevant thoughts when thinking.	☐	☐	☐	☐
I am more interested in the present than the future.	☐	☐	☐	☐
I am restless at the theatre or lectures.	☐	☐	☐	☐
I like puzzles.	☐	☐	☐	☐
I am future oriented.	☐	☐	☐	☐

Voucher

If you would like to be entered into the raffle to win a 50 euro HMV voucher, then please enter your email address below.

Email Address:

At a future stage, I will be contacting some of the people who have completed this questionnaire to ask them to participate in an additional part of this study. If you do NOT wish to be contacted in the future, then please tick the box below.

☐ I do NOT wish to be contacted.

Future Research

Please enter your details below so that you can be contacted at a future stage.

Email Address:

Mobile Number
(optional):

Thank you

You have finished the survey. If you chose to enter it, then good luck in the raffle! You will be contacted by email if you win.

All information that you have provided will be kept strickly confidential.

If you have any questions or comments regarding this research, then please send them to the email address below.

Thank you for your time,
Fearghal O'Brien

Email: obrienfk 'at' tcd.ie

This was the order that participants completed the DBQ in the online study.

1. Hit something when reversing that you had not previously seen
2. Intending to drive to destination A, you “wake up” to find yourself on the road to destination B
3. Get into the wrong lane approaching a roundabout or a junction
4. Queuing to turn left onto a main road, you pay such close attention to the main stream of traffic that you nearly hit the car in front
5. Fail to notice that pedestrians are crossing when turning into a side street from a main road
6. Sound your horn to indicate your annoyance to another road user
7. Fail to check your rear-view mirror before pulling out, changing lanes, etc.
8. Brake too quickly on a slippery road or steer the wrong way in a skid
9. Pull out of a junction so far that the driver with right of way has to stop and let you out
10. Disregard the speed limit on a residential road
11. Switch on one thing, such as the headlights, when you meant to switch on something else, such as the wipers
12. On turning left nearly hit a cyclist who has come up on your inside
13. Miss “Give Way” signs and narrowly avoid colliding with traffic having right of way
14. Attempt to drive away from the traffic lights in third gear
15. Attempt to overtake someone that you had not noticed to be signaling a right turn
16. Become angered by another driver and give chase with the intention of giving him/her a piece of your mind
17. Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane
18. Forget where you left your car in a car park
19. Overtake a slow driver on the inside
20. Race away from traffic lights with the intention of beating the driver next to you
21. Misread the signs and exit from a roundabout on the wrong road
22. Drive so close to the car in front that it would be difficult to stop in an emergency
23. Cross a junction knowing that the traffic lights have already turned against you
24. Become angered by a certain type of a driver and indicate your hostility by whatever means you can

- 25. Realise that you have no clear recollection of the road along which you have just been travelling
- 26. Underestimate the speed of an oncoming vehicle when overtaking
- 27. Disregard the speed limit on a motorway

Appendix 2: Materials for Study 2

Email:

Hi,

About a month ago, you completed my online questionnaire which asked questions about driving behaviour.

At the end of the questionnaire, you indicated that I could contact you back regarding further research and you provided contact details (this email address in fact).

We have now moved onto the 2nd (and final) phase of the study in which we are contacting some of the people who did the online questionnaire and asking them to come in to School of Psychology in Trinity and complete some tasks.

This is a vital part of the research project and I would be very appreciative if you could take part. To do so, please click on the link below where you can organise a testing time and date to suit your own schedule.

[\[Link\]](#)

Thanks so much for your participation,

Fearghal O'Brien

Consent Form:

The following tasks should take about 45 minutes to complete and you will be paid 10 euro for your participation

Any information that you provide in this study will be kept strictly confidential and at no time will your name be associated with this research.

Please note that even though you are asked to supply your name below, this does not affect the confidentiality of your participation as your identity will be coded. Your name is only required so that you yourself may access your results at a future date if you wish in accordance with the freedom of information act.

You are free to withdraw from this study at any time without prejudice.

Name (in BLOCK letters):

Signature:

Date:

Debriefing Sheet:

Thank you for taking part in this research.

The tasks that you completed are all measures of impulsivity. The completion of these tasks requires one to inhibit automatic responses or to plan their responses carefully.

The goal of this research is to see if the scores that individuals obtain in these tasks are related to the answers that those people provided in the driving questionnaire that they filled out at an earlier stage.

Specifically, we are interested in seeing if there is a relationship between performance in these tasks and the number of violations that participants reported having made in the past.

If you have any further questions regarding this study, then please do not hesitate to contact me using the details below.

Thanks again for your participation.

Fearghal O'Brien

Email: obrienfk@tcd.ie

Appendix 3: Materials for Study 4

Consent Form:

The following tasks should take about 45 minutes to complete and you will be paid 10 euro for your participation

Any information that you provide in this study will be kept strictly confidential and at no time will your name be associated with this research.

Please note that even though you are asked to supply your name below, this does not affect the confidentiality of your participation as your identity will be coded. Your name is only required so that you yourself may access your results at a future date if you wish in accordance with the freedom of information act.

You are free to withdraw from this study at any time without prejudice.

Name (in BLOCK letters):

Signature:

Date:

Debriefing Sheet:

Thank you for taking part in this research.

The tasks that you completed are all measures of impulsivity. The completion of these tasks requires one to inhibit automatic responses or to plan their responses carefully.

The goal of this research is to see if the scores that individuals obtain in these tasks are related to the answers that those people provided in the driving questionnaire that they filled out at an earlier stage.

Specifically, we are interested in seeing if there is a relationship between performance in these tasks and the number of violations that participants reported having made in the past.

We are also interested in comparing the performance of those attending the National Driver Improvement Scheme with those not attending it.

If you have any further questions regarding this study, then please do not hesitate to contact me using the details below.

Thanks again for your participation,

Fearghal O'Brien

School of Psychology,

Aras an Phiarsigh,

Trinity College, Dublin 2

Tel: 01 896 3083; Email address: obrienfk@tcd.ie

Supervisor:

Dr. Michael Gormley

School of Psychology,

Aras an Phiarsigh,

Trinity College, Dublin 2

Tel: 01 896 1886; Email address: michael.gormley@tcd.ie

Appendix 4: Materials for Study 5 and Study 6b

Email:

Hi,

I am looking for people to take part in a really short online study concerning driving behaviour and attitudes.

Participants must be **aged 17-21** (inclusive) and have either a **learner's permit (provisional licence)** or a **full driver's licence**.

The study takes about 6-8 minutes to complete and at the end you will have the chance to enter a **raffle for a Sony music player**.

To take part in the study, please click on the link below:

[\[link\]](#)

Thanks,

Fearghal O'Brien

Questionnaire:

- 1) Are you a fluent English speaker?
 - Yes
 - No
- 2) If not, how would you describe your level of English?
 - Very Good
 - Good
 - Moderate
 - Weak
 - Very Weak
- 3) Do you have any reading difficulties?
 - Yes
 - No
- 4) Age

- 5) Sex
 - Male
 - Female
- 6) Type of Licence
 - Full
 - Learner's permit (Provisional)
 - Don't know
- 7) How long since you first started driving?
Years: _____
Months: _____
- 8) Estimated mileage in the last 6 months?

_____ kms

9) Which of the statements below best describes you?

- I drive a car most days
- I drive a car about once a week
- I drive a car a few months
- I don't drive very often

10) Have you, as a driver, ever been involved in a road traffic accident in which you were at fault?

- Yes
- No

11) How many penalty points have you received?

12) Sometimes people drive carelessly or recklessly (too fast or in a dangerous way). How many times in the last 3 months have you driven recklessly?

- Never
- Once or twice
- A few times
- More than a few times
- Regularly

13) How many times in the last 3 months have you driven at speeds that were slightly higher than the speed limit for the road you were on?

- Never
- Once or twice
- A few times
- More than a few times
- Regularly

14) In the last 3 months, how often have you driven at speeds that were much faster than the speed limit for the road you were on?

- Never
- Once or twice
- A few times
- More than a few times
- Regularly

15) How likely do you think it is that, while driving, you will be involved in a car accident in the next 6 months?

- 1(No change)
- 2
- 3
- 4
- 5
- 6
- 7(will definitely happen)

16) How likely do you think it is that, while driving, you will be involved in a car accident before you are 25?

- 1(No change)
- 2
- 3
- 4
- 5
- 6
- 7(will definitely happen)

17) How likely do you think it is that your driving could lead to your car been damaged?

- 1(No change)
- 2
- 3

- 4
- 5
- 6
- 7(will definitely happen)

18) How likely do you think it is that your driving could lead to someone being injured?

- 1(No change)
- 2
- 3
- 4
- 5
- 6
- 7(will definitely happen)

19) Compared with others your age, how likely do you think it is that, while driving, you will be involved in a car accident in the next 6 months?

- 1(Much less likely than others)
- 2
- 3
- 4
- 5
- 6
- 7(much more likely than others)

20) Compared with others your age, how likely do you think it is that, while driving, you will be involved in a car accident before you are 25?

- 1(Much less likely than others)
- 2
- 3
- 4

- 5
- 6
- 7(much more likely than others)

21) Compared with others your age, how likely do you think it is that your driving could lead to your car been damaged?

- 1(Much less likely than others)
- 2
- 3
- 4
- 5
- 6
- 7(much more likely than others)

22) Compared with others your age, how likely do you think it is that your driving could lead to someone being injured?

- 1(Much less likely than others)
- 2
- 3
- 4
- 5
- 6
- 7(much more likely than others)

23) How risky is it to drive at very fast speeds?

- 1(Not at all risky)
- 2
- 3
- 4
- 5
- 6

- 7(Extremely risky)

Please fill out the questions below using the scale of 1-6 on the right hand side. The numbers refer to the following options:

1 = Never

2 = Hardly Ever

3 = Occasionally

4 = Quite Often

5 = Frequently

6 = Nearly all the time

- 24) Sound your horn to indicate your annoyance to another road user?
- 25) Pull out of a junction so far that the driver with right of way has to stop and let you out?
- 26) Disregard the speed limit on a residential road?
- 27) Become angered by another driver and give chase with the intention of giving him/her a piece of your mind?
- 28) Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane?
- 29) Overtake a slow driver on the inside?
- 30) Race away from traffic lights with the intention of beating the driver next to you?
- 31) Drive so close to the car in front that it would be difficult to stop in an emergency?
- 32) Cross a junction knowing that the traffic lights have already turned against you?
- 33) Become angered by a certain type of a driver and indicate your hostility by whatever means you can?
- 34) Disregard the speed limit on a motorway?

Instructions for reaction-time task:

These instructions were presented to participants one at a time.

This is the last part of the study. You're going to be presented with a really short task that takes about 3 minutes to complete.

It's really easy, but there are a few instructions you have to read before you're ready to begin. For the 3 minutes that it's running, you really have to concentrate on what's happening.

You're going to be presented with a number of sentences. However, each sentence will be presented in 2 parts.

First, you'll be shown the entire sentence except for the final word. For example: "Taking a roller coaster is..."

The sentence will stay on screen for long enough so that you can read it (about 3 seconds). The sentence will then disappear.

After a short break, a single word will appear to complete the sentence. For example: "fun"

So in that last example, the full sentence would be: "Taking a roller coaster is...fun"

Ok, now here's where you come in. Once the finishing word is given (e.g. "fun"), you have to decide whether you agree with the sentence or not.

If you agree with the sentence, press the "S" key on your keyboard. "Agree" will be written in the top left corner of the screen for the whole task.

If you disagree with what the sentence says, then press the "K" key. Again, "disagree" will be written in the top of the screen.

Don't worry if this sounds a little confusing at first, you'll have a chance to practice the task before it actually begins.

The practice trials will begin in a moment, so now is probably a good idea to place your fingers over the keys "S" and "K".

Debriefing Sheet:

Thank you for taking part in this research.

The purpose of the study is to investigate whether there is a relationship between people's attitudes towards dangerous driving and the degree to which they engage in it themselves.

In the final part of the study, you were asked to respond as fast as possible to a number of sentences that were presented to you. Along with the choices that you made, the time that it took you to respond to each word was also recorded. The reason for this is that the current research is not just interested in what people's attitudes towards dangerous driving are, but also how long it takes them to access those attitudes.

If you would like to entered into a raffle to win a music player, then please enter your email address in the space below and click "Submit". Please note that should you choose to enter this raffle, your email address will not be associated with your responses.

If you have any questions, don't hesitate to contact myself or my supervisor at the details below:

Thanks again,

Fearghal O'Brien

School of Psychology,

Aras an Phiarsigh,

Trinity College, Dublin 2

Tel: 01 896 3083; Email address: obrienfk@tcd.ie

Supervisor:

Dr. Michael Gormley

School of Psychology,

Aras an Phiarsigh,

Trinity College, Dublin 2

Tel: 01 896 1886; Email address: michael.gormley@tcd.ie

Appendix 5: Materials for Study 6a

Consent Form 1:

Hi,
My names Fearghal O’Brien and I’m conducting this research as part of my PhD at the School of Psychology at Trinity College, Dublin.

The task

On the following page, you will be presented with 10 simple sentences.
The aim of the task is to complete each sentence using **only one word** so that the overall message of the sentence is a **positive** one.
Please finish each sentence with a different word.

Purpose

The purpose of this research is simply to provide sentences that the researcher can use in future studies.

Consent

If you do not wish to take part then simply do not write anything on this page or the next and leave it to be collected.
If you do agree to take part, please sign your name in the section below.

Name (in print)

Signature

Date

Consent Form 2:

Hi,
My names Fearghal O’Brien and I’m conducting this research as part of my PhD at the School of Psychology at Trinity College, Dublin.

The task

On the following page, you will be presented with 10 simple sentences.
The aim of the task is to complete each sentence using **only one word** so that the overall message of the sentence is a **negative** one.
Please finish each sentence with a different word.

Purpose

The purpose of this research is simply to provide sentences that the researcher can use in future studies.

Consent

If you do not wish to take part then simply do not write anything on this page or the next and leave it to be collected.
If you do agree to take part, please sign your name in the section below.

Name (in print)

Signature

Date

Debriefing Sheet:

Thanks for taking part in this study. As was mentioned on the information sheet at the beginning, the purpose of this research is to provide sentences that the researcher can use in future studies related to driving behaviour.

If you have any questions or comments regarding the study, please do not hesitate to contact myself or my supervisor at the details below.

Thanks again,

Fearghal O'Brien

School of Psychology,

Aras an Phiarsigh,

Trinity College, Dublin 2

Tel: 01 896 3083

Email address: obrienfk@tcd.ie

Supervisor:

Dr. Michael Gormley

Tel: 01 896 1886

Email address: michael.gormley@tcd.ie

Appendix 6: Letters of Ethics Approval

Ethics letter for studies 1, 2 and 3:



COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
Ollscoil Átha Cliath

TRINITY COLLEGE DUBLIN
The University of Dublin

4th November 2010

F.A.O. Fearghal O'Brien

School of Psychology Research Ethics Committee

Dear Fearghal,

I am pleased to inform you that your application entitled "Contributing factors to problematic driving" has been approved by the School of Psychology Research Ethics Committee.

Yours sincerely,

Dr. Tim Trimble
Chair
School of Psychology Research Ethics Committee

SCHOOL OF PSYCHOLOGY
Aras an Phairsaigh
Trinity College
Dublin 2

Scoil na Siceolaíochta,
Dámh na nEolalochtai Sóisialta agus Daonna,
Áras an Phairsaigh, Coláiste na Tríonóide,
Baile Átha Cliath 2, Éire

School of Psychology,
Faculty of Arts, Humanities and Social Sciences,
Áras an Phairsaigh, Trinity College,
Dublin 2, Ireland

T: 353 (0)1 896 1886
F: 353 (0)1 671 2006
psychology@tcd.ie
www.psychology.tcd.ie

Ethics letter for study 4:



COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
Ollscoil Átha Cliath

TRINITY COLLEGE DUBLIN
The University of Dublin

21st September 2009

F.A.O. Fearghal O'Brien

School of Psychology Research Ethics Committee

Dear Fearghal,

The Research Ethics Committee has approved the proposed amendments to your application entitled "Contributing factors to problematic driving", which received ethical approval in June 2009.

Yours sincerely,

Luisa Byrne
Executive Officer
School of Psychology Research Ethics Committee

SCHOOL OF PSYCHOLOGY
Aras an Phairsaigh
Trinity College
Dublin 2

Scoil na Siceolaíochta,
Dámh na nEolaíochtaí Sóisialta agus Daonna,
Áras an Phairsaigh, Coláiste na Tríonóide,
Baile Átha Cliath 2, Éire

School of Psychology,
Faculty of Arts, Humanities and Social Sciences,
Áras an Phairsaigh, Trinity College,
Dublin 2, Ireland

T 353 (0)1 896 1886
F 353 (0)1 671 2006
psychology@tcd.ie
www.psychology.tcd.ie

Ethics letter for studies 5 and 6b:



COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH | TRINITY COLLEGE DUBLIN
Ollscoil Átha Cliath | The University of Dublin

15th June 2011

F.A.O. Fearghal O'Brien

School of Psychology Research Ethics Committee

Dear Fearghal O'Brien

I am pleased to inform you that your application entitled "Prediction of driving accidents" has been approved by the School of Psychology Research Ethics Committee.

Yours sincerely,

Dr. Tim Trimble
Chair
School of Psychology Research Ethics Committee

SCHOOL OF PSYCHOLOGY
Aras an Phairsaigh
Trinity College
Dublin 2

Scoil na Síceolaíochta,
Dámh na nÉolaíochtaí Sóisialta agus Daonna,
Áras an Phairsaigh, Coláiste na Tríonóide,
Baile Átha Cliath 2, Éire

School of Psychology,
Faculty of Arts, Humanities and Social Sciences,
Áras an Phairsaigh, Trinity College,
Dublin 2, Ireland

T 353 (0)1 896 1886
F 353 (0)1 671 2006
psychology@tcd.ie
www.psychology.tcd.ie



Ethics letter for study 6a:



COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
Ollscoil Átha Cliath

TRINITY COLLEGE DUBLIN
The University of Dublin

28th October 2010

F.A.O. Fearghal O'Brien

School of Psychology Research Ethics Committee

Dear Fearghal,

I am pleased to inform you that your application entitled "Dangerous driving among young people" has been approved by the School of Psychology Research Ethics Committee.

Yours sincerely,

Dr. Tim Trimble
Chair
School of Psychology Research Ethics Committee

SCHOOL OF PSYCHOLOGY
Aras an Phairsaigh
Trinity College
Dublin 2

Scoil na Siceolaíochta,
Dámh na nEolaíochtaí Sóisialta agus Daonna,
Áras an Phairsaigh, Coláiste na Tríonóide,
Baile Átha Cliath 2, Éire

School of Psychology,
Faculty of Arts, Humanities and Social Sciences,
Aras an Phairsaigh, Trinity College,
Dublin 2, Ireland

T 353 (0)1 896 1886
F 353 (0)1 671 2006
psychology@tcd.ie
www.psychology.tcd.ie