Putative Mechanisms Underlying Risky Decision Making in High-Risk Drivers

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Abstract

Introduction

High-risk drivers (HRDs) are disproportionately responsible for road traffic crashes. The Iowa Gambling Task (IGT) is a task that measures two types of decision making: i) under risk and ii) under ambiguity. Evidence based upon the IGT suggests that decision making under risk may underlie the dangerous behaviour of HRDs, especially driving while impaired (DWI) offenders. Given its complexity, however, the IGT may also be sensitive to other cognitive dimensions that may obscure the nature of the decision making being measured. In addition, neuropsychological tasks in general may lack the ecological validity required to predict risky driving behaviour. Study of HRD is needed using more precise measurement of decision making under risk (e.g., Game of Dice Task (GDT)) and more context-specific decision making tasks (e.g., driving simulation). The present study tests the following main hypotheses: 1) HRDs exhibit a deficit in decision making under risk compared to non-HRD controls (CTLs) as measured by both the IGT and the GDT; 2) decision making under risk scores as measured by the IGT are positively correlated to the GDT scores in HRDs and CTLs and 3) decision making under risk scores as measured by the IGT and GDT (higher scores indicating better decision making) are negatively correlated with the number of risky overtaking manoeuvres in a simulated driving scenario involving decision making under risk.

Methods

Participants were between 21-35 years old. HRDs possessed either three or more moving violations in the previous two years, or two or more DWI convictions in the previous ten

years. CTLs were conviction free. Participants were administered the IGT, the GDT, sociodemographic and substance use questionnaires and two driving simulation scenarios that attempted to challenge their decision making under risk and under ambiguity.

Results

HRDs (n = 28; *age: M* = 29.1; *SD* = 4.7) did not differ from CTLs (n = 15; *age: M* = 27.5; *SD* = 4.2) on the IGT or the GDT. GDT and IGT Risk Scores were not correlated. GDT scores alone were negatively correlated with the number of risky overtaking manoeuvres made in driving simulation challenging decision making under risk ($r_s(34)$=-0.41, p=.021).

Conclusions

HRDs were not characterized by poorer decision making compared to controls, but risky driving was predicted by the GDT. Decision making under risk, especially in the driving context, may prove useful to better understand risky driving.

Résumé

Introduction

Les conducteurs à haut risque (CHR) sont responsables d'une part disproportionnée des accidents de la route. L'Iowa Gambling Task (IGT) est une tâche qui permet de mesurer deux types de prise de décision : 1) face au risque et 2) sous ambiguïté. Les études qui ont utilisées l'IGT suggèrent que la prise de décision face au risque pourrait être à la base des comportements dangereux des CHR, particulièrement chez les contrevenants de la conduite avec capacités affaiblies. Cependant, considérant sa complexité, il est possible que l'IGT mesure également d'autres dimensions cognitives, ce qui ne nous permet pas de déterminer la nature exacte de la prise de décision mesurée. De plus, les tâches neuropsychologiques manquent possiblement de validité écologique, une caractéristique nécessaire pour prédire la conduite à risque. En conséquence, des mesures plus directes de la prise de décision face au risque (par exemple la Game of Dice Task (GDT)) ainsi que des tâches plus contextuelles (par exemple des tâches de simulation de conduite) sont nécessaires chez les CHR. Les hypothèses suivantes ont été testées lors de la présente étude : 1) la prise de décision face au risque des CHR, telle que mesurée par l'IGT et le GDT serait altérée lorsque comparée aux conducteurs contrôles; 2) la prise de décision face au risque mesurée par l'IGT va être positivement corrélée aux scores du GDT chez les CHR et les conducteurs contrôles; 3) les scores de la prise de décision face au risque de l'IGT et du GDT (où un score élevé indique une meilleure capacité à prendre des décisions) seront négativement corrélés avec le nombre de manœuvres de dépassement risquées mesuré par une tâche de simulation de conduite impliquant des prises de décisions face au risque.

Méthodologie

Les participants étaient âgés de 21 à 35 ans. Les CHR avaient au moins trois infractions routières au cours des deux dernières années ou avaient au moins deux arrestations pour conduites avec capacités affaiblies par l'alcool au cours des dix dernières années. Les participants contrôles n'avaient aucune infraction. Les participants ont complété l'IGT et le GDT, un questionnaire sociodémographique, un questionnaire sur la consommation de substances, en plus de deux scénarios de simulation de conduite où leur capacité à prendre des décisions face au risque et sous ambiguïté étaient mises à l'épreuve.

Résultats

Les CHR (n=28; *âge : M* = 29,1; *ÉT* = 4,7) ne sont pas différents des conducteurs contrôles (n = 15; *âge : M*= 27,5; *ÉT* = 4,2) en ce qui a trait à l'IGT ou au GDT. De plus, les scores liés au risque de l'IGT et du GDT ne sont pas corrélés. Seuls les scores du GDT étaient négativement corrélés avec le nombre de manœuvres de dépassement risquées lors de la simulation de conduite qui mettait à l'épreuve la prise de décision face au risque ($r_s(34)$=-0.41, p=.021).

Conclusions

Lorsque comparés aux sujets contrôles, les CHR n'étaient pas caractérisés par une prise de décision plus faible, mais la conduite à risque était prédite par la GDT. La prise de décision face au risque, particulièrement dans le contexte de conduite, peut s'avérer utile pour mieux comprendre la conduite à risque.

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Introduction

The High-Risk Driving Problem

The Burden of Road Traffic Crashes

Road traffic safety is a major global health concern. In 2004, road traffic crashes (RTC) accounted for 1.3 million deaths and were ranked as the ninth most important burden on global health (World Health Organization, 2008). Fatalities due to injury are expected to increase by almost 30% by the year 2030, due in large part to an expected surge in the number of RTCs (World Health Organization, 2008). Non-fatal injuries also represent a significant burden on individuals and society, with costs associated with rehabilitation and loss of productivity being particularly onerous (Sleet & Branche, 2004; World Health Organization, 2011). Few estimates of the total cost of RTCs are available. Nevertheless, one study conducted in 2000 suggested that RTCs have an annual economic cost of $518 billion worldwide, representing approximately 1-3% of the gross national product of developed countries such as Canada (World Health Organization, 2011). Increased general RTC prevention campaigns and more stringent law enforcement policies introduced in the 1970s and 1980s have been associated with reductions in RTCs and fatalities (Peden, 2004). This decline, however, has plateaued in recent years (Nochajski & Stasiewicz, 2006). One group of dangerous, repeat-offender drivers, known as high-risk drivers (HRDs), are considered to be a major impediment to further progress in road traffic safety (Transport Canada, 2009).

High-Risk Driving

From one perspective, HRD is defined as: 1) having engaged in three or more distinct high-risk driving events (i.e., Criminal Code offence, collision or road traffic violation such as speeding, driving without a seat-belt, running a red light or stop sign and driving with a suspended licence) over the course of the last two years; or 2) having either been convicted for a first DWI offence at blood alcohol concentration (BAC) >0.16 mg/ml, refusing to provide a breath sample, or having committed two or more DWI over the course of the last ten years (Vezina, 2001). This operational definition, however, is not universal. For example, HRD has been defined elsewhere as drivers who have had at least three accidents over a three-year period or have lost at least nine demerit points, excluding alcohol-related infractions, over a three-year period (Wilson, 1992).

One thing is certain; HRD, however operationalized, is disproportionately responsible for fatal RTCs. Despite representing only 3.5% of all drivers, HRDs are implicated in approximately 12% of RTCs involving death and approximately 8% of RTCs involving injury (Vezina, 2001). HRDs, compared to normal drivers, are 4.5 times more likely to be implicated in deadly RTCs. It is also known that current strategies aimed at reducing subsequent infractions in this population have limited utility. A subsequent RTC conviction in offenders occurs at rate significantly higher than a first-time conviction in non-offenders (Vezina, 2001; Voas & Fisher, 2001). Despite the deadly threat of HRDs, and the extensive research that has resulted, a comprehensive understanding of the nature and underlying causes of HRD remain elusive for both conceptual and methodological reasons (Vezina, 2001).

Conceptual and Methodological Shortcomings in HRD Research

Heterogeneity

A conceptual issue that plagues the road traffic safety research, and specifically the study of HRD, is population heterogeneity (Fernandes, Job, & Hatfield, 2007; Nochajski & Stasiewicz, 2006; Vezina, 2001). As opposed to population homogeneity in which individuals can all be regarded as fundamentally similar in nature (low within-population variability), population heterogeneity means that widely different types of individuals are observed (high within-population variability). Hence, most HRDs appear to resemble the general driving population on key characteristics such as sensation-seeking and hostility, which have been purported to distinguish DWI offenders and possibly other HRD groups (Beirness & Simpson, 1997; Vezina, 2001; Wilson, 1992). This suggests that there are multiple pathways towards HRD behaviour. For example, two HRDs may present with very different characteristics, such as varying levels of impulsivity or substance use. The manner by which individuals are categorized as "HRD" also varies greatly. For example, a driver who was caught for speeding once, driving without a seat-belt on a different occasion and had a serious accident, all over the course of two years, may be inherently different from someone convicted of drinking and driving twice, though both would be considered as HRDs in some jurisdictions. Given the heterogeneity in behaviour observed in the HRD population, and the fact that some subgroups such as DWI recidivists may be distinct, it is difficult to generalize findings in the literature regarding the broad population of HRDs.

Level of analysis

A second conceptual issue is the nature of constructs studied in HRD populations. Distal behavioural endpoints, such as personality-related characteristics, have been a main focus in the field of road traffic safety. For example, research has demonstrated that DWI recidivists exhibit more impulsivity compared to first-time DWI offenders and controls (Nochajski & Stasiewicz, 2006). These effects, however, have been criticized for their weak sizes (Ivers et al., 2009; Oltedal & Rundmo, 2006), their indirect association with driving behaviour (Dahlen & White, 2006) as well as their limited predictive utility (Chang, Lapham, C'De Baca, & Davis, 2001).

The above measurement strategy is referred to as the psychometric approach (Sjöberg, Moen, & Rundmo, 2004). The psychometric approach generally involves acquiring descriptive data through self-report questionnaire methods to understand behaviour. This approach is easy to execute, unobtrusive for the participant and typically inexpensive. At the same time, data acquired through this method are self-reported perceptions of behaviour that are vulnerable to several sources of bias including subjectivity, underreporting and social desirability (Llewellyn, 2008). In the context of HRD generally, and DWI specifically, individuals are prone to underreport risky behaviour (Corbett, 2001; Lapham, C'De Baca, Chang, Hunt, & Berger, 2002).

Neuropsychological Approach to HRD

In contrast to the psychometric approach adopted in much of the traffic safety literature, the risk taking research has moved to a focus on dynamic self-regulatory processes of behaviour (Bechara & Damasio, 2002). This neuropsychological approach

attempts to identify explanatory and dynamic underpinnings of behaviour (Levin et al., 2012; Llewellyn, 2008) by using performance-based functional tasks. As opposed to investigating what individuals say about their own behaviour, the neuropsychological approach attempts to observe actual behaviour. One criticism of the neuropsychological approach, however, is that the cognitive mechanisms evoked in a neuropsychological task are sometimes difficult to discern (Fellows, 2004). Nevertheless, this more objective and explanatory approach to understanding risky behaviour is likely to benefit the study of HRD.

HRD is a risky behaviour

Risk taking behaviour with potentially catastrophic consequences is a sentinel feature of HRD, as it is in gambling, substance use and unsafe sexual practices. In addition, HRD shares similarities with other risky behaviours on key sociodemographic, psychological and personality dimensions of behaviour. Among the most consistent sociodemographic and psychological risk factors are younger age (Zador, Krawchuk, & Voas, 2000), male sex (Lapham, Skipper, Hunt, & Chang, 2000), substance misuse (Chang, et al., 2001), psychopathology (Holmes et al., 2009; Smoski et al., 2008) and emotional dysregulation (Chou, Lee, & Ho, 2007; Martin & Delgado, 2011). Personality traits associated with HRD and other forms of risky behaviour include hostility, sensation-seeking and impulsivity (Beirness & Simpson, 1997; Cherpitel, 1999; Horvath & Zuckerman, 1993; Paaver, Eensoo, Pulver, & Harro, 2006; Vezina, 2001; Zakletskaia, Mundt, Balousek, Wilson, & Fleming, 2009), These commonalities suggest that the literature on general risky behaviour is relevant for the study of HRD.

Definition of risky behaviour

Risk taking, in its simplest form, is posited to reflect a neglect for the negative consequences of one's actions (Assailly, 2010). Three levels of factors have been posited to influence engagement and participation in risky behaviours; i) individual-level characteristics; ii) organizational-level characteristics; and iii) problem-specific characteristics (Sitkin & Pablo, 1992).

Individual-level characteristics include risk preferences, risk perceptions and risk propensity (Sitkin & Pablo, 1992). These factors involve the extent to which individuals appreciate the challenge of risk, how they assess risk in various situations as well as their tendency towards or willingness to engage in risky behaviours. Organizational-level characteristics include group composition, cultural risk values, leader risk orientation and organizational control systems (Sitkin & Pablo, 1992). These factors relate to how group context, such as group culture and group leaders, affect an individual's engagement and participation in risky behaviours. Group contexts can influence individual's risky decision making, for example, by either encouraging or discouraging risky behaviour. Problem-specific characteristics include problem familiarity and problem framing (Sitkin & Pablo, 1992). These factors relate to how the problem is presented (i.e., positively or negatively) to the individual and how experienced an individual is with certain types of risky behaviours. For example, individuals are more likely to engage in risky behaviours if the situation is presented in a more positive light, or in terms of gains rather than losses. It is clear that in most cases, no one factor is uniquely involved in risk taking. Rather, multiple factors likely interact to influence initiation and engagement in risk taking behaviour.

Transversality versus specificity

The extent to which risk taking behaviours, including those related to HRD, are a reflection of a risky personality feature or trait is a question that has long been of interest to researchers (Bem & Allen, 1974; Chaplin & Goldberg, 1984; Fernandes, et al., 2007; Junger, West, & Timman, 2001). Cross-situational consistency, or the transversality of risky behaviours, refers to the generalizability of risk taking across multiple domains. If risky behaviours are perceived to be transversal, an individual who engages in risky behaviours will do so in many aspects of their life, including drinking, dating, sports, etc. Specificity, on the other hand, refers to risk taking behaviours as being domain-specific. If risky behaviours are perceived to be specific, an individual who engages in risky drinking, for example, will not necessarily take risks in their dating life, extreme sports, etc. To date, there is little consensus in this debate (Assailly, 2010) and several studies support each perspective (Adams & Moore, 2007; Gonzalez et al., 1994; Overman et al., 2004; Upchurch & Kusunoki, 2004). It is possible therefore that the phenomenon of risky behaviour may be at times context specific while at other times may involve stable traits and dispositions.

Executive Control and Driving

Executive control refers to a set of cognitive functions "that are responsible for the planning, initiating, sequencing, and monitoring of complex goal-directed behavior" (Royall, Lauterbach, Cummings, Reeve, & et al., 2002, p. 378). Executive control dysfunction is posited as a pathway leading to maladaptive risk taking behaviours (Pharo, Sim, Graham, Gross, & Hayne, 2011). Executive control functions are dependent in large

part on the integrity of the prefrontal cortex and its maturation throughout adolescence and young adulthood (Fuster, 2002).

Safe driving is a complex task involving the orchestration and integrity of numerous executive control functions, which include high-order sensory, cognitive and motor processes (Friedman et al., 2008). Mental shifting, working memory updating and response inhibition are three executive control functions that appear especially critical to safe driving (Mantyla, Karlsson, & Marklund, 2009). DWI offenders have been shown to exhibit executive control deficits in visuospatial, memory, motor and perceptual abilities (Fine & Steer, 1979; Glass, Chan, & Rentz, 2000; Ouimet et al., 2007).

Neurodevelopment

Several factors influence executive control. Engagement in risky behaviours is typically initiated and most frequent during adolescence or early adulthood, a key period in life when the attraction of reward outweighs concern for negative consequences (Assailly, 2010). The neural underpinnings of this phenomenon are posited to involve imbalances in the maturation of cortical regions that govern rewards (hypersensitivity) versus punishments (hyposensitivity) (Casey, Getz, & Galvan, 2008). The propensity for engaging in risky behaviour continues beyond adolescence into young adulthood in some individuals, however, with adverse life events in early childhood being posited as one contributing factor (Archer, Oscar-Berman, Blum, & Gold, 2012).

Alcohol

One of the better-known factors that influence executive control is alcohol. Executive function impairments have been demonstrated following acute alcohol intoxication, especially on the descending limb of the BAC curve (Domingues, Mendonca, Laranjeira, & Nakamura-Palacios, 2009; Ogden & Moskowitz, 2004; Pihl, Paylan, Gentes-Hawn, & Hoaken, 2003; Weissenborn & Duka, 2003). For example, alcohol consumption has been demonstrated to have a negative effect on cognitive-motor performance, sustained and divided attention, decision making, and information processing (Rzepecki-Smith et al., 2010). Functional magnetic resonance imaging studies (fMRI) have established that areas including the orbital frontal cortex (OBC), anterior cingulated cortex (ACC), motor areas and cerebellum are significantly affected by alcohol intake and result in impaired executive control performance (Calhoun, Pekar, & Pearlson, 2004; Meda et al., 2009).

Aetiologically, excessive alcohol use during key developmental periods such as adolescence can disrupt development of executive control function later in adulthood, specifically impulsivity (Crews, He, & Hodge, 2007). The long-term toxic effects of alcohol intoxication on executive control function are also well established (Casbon, Curtin, Lang, & Patrick, 2003; Pihl, et al., 2003; Schweizer et al., 2005). Individuals who have engaged in long-term heavy drinking continue to exhibit impairments in verbal and non-verbal memory after they have stopped drinking (O'Mahony & Doherty, 1996; Parsons, 1983). Studies have demonstrated that sober drivers previously convicted of DWI have deficits in executive control functions including visuospatial constructional abilities and visual memory (Ouimet, et al., 2007).

Executive Control Constructs Related to Risky Behaviour and HRD

Individuals who engage in HRD events have also demonstrated deficits in executive control (Lev, Hershkovitz, & Yechiam, 2008). In particular, DWI offenders have been shown to exhibit executive control deficits in visuospatial, memory, motor and perceptual abilities as well as in disinhibition (Fine & Steer, 1979; Glass, et al., 2000; Ouimet, et al., 2007). Two executive control constructs that appear particularly relevant to the study of HRD are impulsivity and decision making.

Impulsivity

Impulsivity broadly refers to a trait that reflects "actions that are poorly conceived, prematurely expressed, unduly risky, or inappropriate to the situation and that often result in undesirable outcomes" (Evenden, 1999, p. 348). Several subcomponents of impulsivity have been posited, including sensation-seeking and novelty-seeking (Whiteside & Lynam, 2001). Impulsivity has been incorporated into some of the main theories of personality (Eysenck & Eysenck, 1977) as well as the diagnosis for psychopathology (Robbins, Gillan, Smith, de Wit, & Ersche, 2012). Impulsivity has also been associated with a variety of risky behaviours including gambling (Maccallum, Blaszczynski, Ladouceur, & Nower, 2007), risky sex practices (Donohew et al., 2000) and substance misuse (Dawe, Gullo, & Loxton, 2004; Perry & Carroll, 2008).

Impulsivity in HRD

There are several neuropsychological tasks that measure impulsivity and that have been used in the study of HRD. The Balloon Analogue Risk Task (BART) is a reliable

and valid task that involves having a participant inflate a computerized balloon by clicking on the computer mouse with the goal of winning as much money as possible without the balloon exploding (Lejuez et al., 2002). Each click inflates the balloon by one "puff" and adds a fixed amount of money to an account. If the participant cashes out before the balloon explodes, they can keep the money they have earned inflating the balloon but if it explodes before the participant cashes out, they receive nothing. Performance on the BART has distinguished between smokers and non-smokers (Lejuez et al., 2003) and has been found to be associated with real-life risk taking behaviours, such as seatbelt compliance in adolescents (Lejuez, Aklin, Zvolensky, & Pedulla, 2003).

Chein and colleagues have developed the Stoplight Task to measure impulsivity in the specific context of driving (Chein, Albert, O'Brien, Uckert, & Steinberg, 2010). In the Stoplight Task, participants are required to drive down a virtual road with numerous intersections as quickly as possible. Each intersection in the task is equipped with a traffic light that switches from red, green and yellow in a way that is unpredictable to the participant. As participants approach yellow lights, they must decide whether to cross the intersection when the probability of a crash is unknown. If they cross, this is construed as impulsive action; if they wait until the light switches to green, this is construed as less impulsive action (Chein, et al., 2010).

A recent study by our research group utilized both the BART and the Stoplight Task in a sample of first-time DWI offenders in an effort to better understand the relationship between age, sex and impulsivity in this population (Di Leo, 2013). Younger offenders were hypothesized to exhibit greater impulsivity as measured by both tasks compared to older offenders. While younger female first-time DWI offenders self-

reported more impulsivity compared to younger males, results from the BART and the Stoplight Task were inconclusive. Experimental studies using neuropsychological measures of impulsivity are needed to better clarify its potential role in HRD.

Decision making

Decision making is another construct associated with executive control. Decision making involves "the rapid evaluation of a set of possible outcomes with respect to the future consequences associated with each course of action" (Purves et al., 2008, p. 753). At the same time, decisions are often made without explicit knowledge of the precise probabilities of rewards and punishments (Brand, Labudda, & Markowitsch, 2006). Decision making deficits have been specifically proposed as an underlying mechanism leading to persistent and self-destructive high-risk behaviours such as substance abuse (Shiv, Loewenstein, & Bechara, 2005), unsafe sex practices (Kaplan & Shayne, 1993), and at-risk gambling (Linnet, RØJskjÆR, Nygaard, & Maher, 2006).

Theories of Decision Making

Among the many theories of decision making (i.e., (Bechara, Damasio, Tranel, & Damasio, 2005; Bekiaris, Amditis, & Panou, 2003; Kahneman & Tversky, 1979)), few have been directly applied to the HRD problem. An example of one theory that has been applied to the issue of HRD is Steele & Joseph's theory of alcohol myopia (1990). Here, DWI is thought to occur because individuals, when intoxicated by alcohol, become short-sighted. Under these conditions, individuals tend to overestimate their driving capacity and underestimate their cognitive impairment (Bornewasser & Glitsch, 2000, May). This

in turn influences their decision to drive as well as the riskiness of their decisions on the road.

Another theory of decision making that has been frequently applied in HRD research is Azjen's theory of planned behaviour (1991). According to this theory, DWI is posited to represent an intentional act based on the appraisal of various expected outcomes. An individual may decide to commit a DWI offence because the advantages of that choice are expected to outweigh its disadvantages (Bornewasser & Glitsch, 2000, May). For example, in the context of DWI, an individual must weigh the negative consequences of getting caught against the convenience of taking one's own car and not having to pay for a taxi or using public transportation. While the above theories are useful for the conceptualization of decision making in HRD, few studies have directly applied such theories to real-world decision making problems (MacDonald, Fong, Zanna, & Martineau, 2000). Support for Azjen's theory, for example, has come mainly from hypothetical decision making situations involving intentions to behave in certain ways (i.e., "If I took my car to the bar, I would…") and not actual behaviour.

The Somatic Marker Hypothesis (SMH) is unique as a theory of decision making by its neuropsychological basis. The SMH hypothesizes that the decision making process relies on the integrity of two parallel, interacting neural systems: the "impulsive" amygdala-based system that transmits the value of immediate consequences, and the "reflective" prefrontal cortex (PFC)-based system that transmits the value of future consequences (Shiv, et al., 2005). Disadvantageous decision making is therefore thought to be the result of an overactive "impulsive" system which renders the "reflective" system's signals less efficient. The SMH hypothesis has been corroborated by studies

demonstrating that damage to the ventromedial prefrontal cortex results in a loss of effortful goal-directed behaviour in favour of more impulsive and emotionally-driven behaviour (Barrash, Tranel, & Anderson, 2000; Volkow, Fowler, & Wang, 2004).

The Iowa Gambling Task (IGT) is a neuropsychological task developed from the SMH. The IGT is a validated, reliable and complex neuropsychological task that measures various types of decision making (Bechara, Damasio, Damasio, & Lee, 1999). In the IGT, the participant must choose between several decks of cards, some leading to overall gains (advantageous) and some to overall losses (disadvantageous). The task contains 100 trials and is often broken down into five blocks; Block 1 contains the first 20 trials, Block 2 contains the next 20 trials and so on. Blocks 1 and 2 are referred to as decision making under ambiguity, because the outcome probabilities are not known, whereas the last three blocks, Blocks 3, 4 and 5 are considered decision making under risk, because the outcome probabilities at that point are known (Buelow & Suhr, 2009). Hence, most participants tend to develop a "feeling" for which decks are more advantageous and disadvantageous towards the last blocks of the task and base their selections accordingly (Brand, et al., 2006; Brand, Recknor, Grabenhorst, & Bechara, 2007; Maslowsky, Keating, Monk, & Schulenberg, 2010). Poor performance on the IGT usually involves a higher number of disadvantageous card selections compared to advantageous card selections. It has been suggested that decision making under risk is particularly related to executive control given that individuals systematically evaluate situations based on knowledge of the consequences of their alternative actions (Brand, et al., 2006). Interestingly, impaired performance on the IGT is not a result of impaired knowledge, learning or cognition as participants almost always come to recognize which

decks are advantageous and disadvantageous (Bechara, et al., 1999). Nevertheless, individuals who perform poorly on the IGT persist in in disadvantageous decision making despite this awareness.

The Somatic Marker Hypothesis and the IGT in HRD

The exploration of decision making has been posited as a necessary step for further development of vehicle and road traffic safety (Callan, Osu, Yamagishi, Callan, & Inoue, 2009). Driving is a task that involves numerous decisions and decision making appears particularly relevant to crash involvement (French, West, Elander, & Wilding, 1993). For example, individuals are often faced with the decision to speed under certain circumstances. In this context, they must weigh between conflicting potential outcomes, such as being stopped or getting into an accident, getting to one's desired destination more quickly, and experiencing the thrill of driving fast. In the context of DWI, some individuals repeatedly drive their vehicle to a drinking venue where excessive drinking is likely, despite knowledge of the potential negative consequences. This has led to the study of decision making as a factor underlying DWI. This literature is the foundation for the current study.

To the author's knowledge, four recent studies have investigated decision making in the context of HRD using the IGT. Yechiam and colleagues (Yechiam, 2008) investigated the decision making style of 81 criminal offenders, including four DWI offenders, and 18 matched controls. DWI offenders as well as the criminal group made significantly more disadvantageous card selections than controls. Moreover, the risky decision making style of DWI offenders resulted from the tendency to attribute more

weight to gains as opposed to losses. Lev and colleagues (Lev, et al., 2008) studied 51 traffic offenders enrolled in a remedial relicensing course following traffic offences (i.e., missing a stop sign, driving without a seat belt, speeding, etc.) along with 36 penalty-free drivers from the general population. Consistent with the previous study, the proportion of disadvantageous card selections was higher for traffic offenders than for controls. Kasar and colleagues (Kasar, Gleichgerrcht, Keskinkilic, Tabo, & Manes, 2010) demonstrated that 34 male DWI recidivists recruited from a relicensing program chose significantly more cards from risky decks than 31 age-matched controls. Interestingly, the discrepancy in group performance was only seen towards the end of the task, specifically in Block 5. This finding suggests that the DWI recidivists exhibited a deficit in decision making under risk. A study conducted by our research group investigated decision making deficits in community-recruited DWI recidivists and non-DWI controls using the IGT (Maldonado-Bouchard, Brown, & Nadeau, 2012). Low performers on the IGT had more past DWI convictions as well as worse alcohol problems compared to high performers.

In sum, these studies provide preliminary evidence that poor decision making capacities, as measured by the IGT, especially in decision making under risk, are associated with HRD. Given that these studies were largely directed at populations of DWI offenders, however, it remains uncertain how generalizable these findings are to other forms of HRD behaviour.

Critical Analysis of the IGT in HRD Research

What does the IGT measure?

One criticism levelled at the IGT is that it may tap into multiple potentially overlapping cognitive processes, such as reversal learning, working memory and stimulus-reinforced learning (Busemeyer & Stout, 2002; Fellows & Farah, 2005). As a result, poor performance may not reflect decision making alone. This limits our ability to conclusively demonstrate the source of apparent decision making problems associated with DWI, or any other problem behaviours for that matter. At the moment, the specific deficits underlying the risky decision making of HRDs is unclear, or are at best supported by preliminary studies in samples of DWI offenders. In order to assess whether deficits in decision making under risk underlie the behaviours of HRD offenders, it is imperative to utilize a neuropsychological task that more specifically taps into decision making under risk.

The Game of Dice Task (GDT) is a simple neuropsychological test that may be a purer measure of decision making under risk than the IGT (Brand et al., 2005). At the beginning of the task, participants are told that the goal is to maximize their gains with a starting capital of $1,000. They are informed that there will be 18 virtual throws of the dice and that they must choose between different betting decisions, all with varying winning probabilities. Specifically, the amounts of gains or losses possible on the task range from a $1,000 gain or loss for the least likely combination of dice, which is the most risky decision, to a $100 gain or loss for the most likely, or safest decision. At any point during the task, half of the betting decisions are “advantageous”, defined as a winning probability of 50%, and half of the decisions are “disadvantageous”, defined as a

winning probability of 50% (Brand, et al., 2006; Brand, et al., 2007). Advantageous betting decisions involve three or four number combinations as they are the most likely to occur and yield smaller rewards/losses and disadvantageous betting decisions involve one or two number combinations as they are the least likely to occur and yield bigger rewards/losses. Given that the outcome probabilities are explicitly known to the participant (e.g., any number on a dice has a 1/6 chance of being rolled), the GDT exclusively taps into decision making under risk.

The GDT has been directly compared to the IGT in a number of studies (Brand, et al., 2006; Brand, et al., 2007; Maslowsky, et al., 2010). The results indicate that a significant positive correlation exists between the latter blocks of the IGT and the GDT, suggesting that both tap into decision making under risk. Despite the correlation between the latter blocks of the IGT and the GDT, deficits in decision making under risk in DWI offenders based upon the IGT have not been validated using the GDT in HRDs.

Sampling

Shortcomings in sampling in the aforementioned studies may also limit our ability to conclusively state that disadvantageous decision making is associated with HRD. Most of the studies investigating decision making in these populations focused on samples of DWI offenders (Kasar, et al., 2010; Maldonado-Bouchard, et al., 2012). Another study investigated the decision making capacities of incarcerated individuals, only four of which were DWI offenders (Yechiam, 2008). Most importantly, the study in which a deficit in decision making under risk was discovered in DWI recidivists had recruited a sample of offenders without substance abuse problems, mood or psychiatric problems.

This sampling strategy, which controls for possible confounding by these characteristics, limits the generalizability of the findings in more representative samples of offenders (Kasar, et al., 2010; Maldonado-Bouchard, et al., 2012). Whether or not these preliminary findings apply to the broader population of HRDs is not clear.

Population heterogeneity

The results of an extensive literature review completed by the Société de l'assurance automobile du Québec (SAAQ) highlights the heterogeneity of the HRD population. It concluded that more than half of the HRD population is indistinguishable from the general driver population on many key characteristics (Vezina, 2001). This suggests that comparisons between groups of HRDs and non-HRDs have limited utility given high within-group variability. Instead, looking at subgroups within the HRD population may allow us to better understand potential heterogeneity in the pathways to HRD.

The IGT has previously identified a high-risk group of substance abusers who display decision making deficits similar to patients with bilaterial ventromedial prefrontal cortex damage (Bechara et al., 2001) and has also helped assist in revealing a high-risk subgroup of DWI recidivists (Maldonado-Bouchard, et al., 2012). In the latter study, after dividing DWI recidivists according to a median split of scores on the IGT data, two groups were created: poorer and better performers. Analyses then revealed that poorer performers had more past DWI convictions and reported more drinking than better performers. The performance on the IGT of better performers was indistinguishable from the performance of non-offender controls (Maldonado-Bouchard, et al., 2012). Given

these preliminary findings, focusing on poorer performers using the IGT has the potential to lead to the identification of a distinct subgroup whose members share a distinct pathway to HRD behaviour (Chang, Gregory, & Lapham, 2002; Vezina, 2001; Wilson, 1992).

Ecological validity

Risky decision making is highly contextual and is dependent on a variety of internal and external factors (Bechara, 2003; Petridou & Moustaki, 2000). Experience and context have been shown to influence decision making in a simulated gambling task (Levin, Snyder, & Chapman, 1988) while the motivation (Cooper, Agocha, & Sheldon, 2000) and risk appraisal (Horvath & Zuckerman, 1993) inherent in a specific context may influence risk taking behaviour. The ecological validity of neuropsychological gambling tasks for understanding HRD is therefore uncertain. In contrast, observation of driving-related decision making could increase the ecological validity of findings.

Driving simulation research offers intriguing research possibilities related to driving-related decision making (e.g., Calhoun, et al., 2004; Callan, et al., 2009; Chein, et al., 2010; Dastrup, Lees, Bechara, Dawson, & Rizzo, 2010; Farah, Yechiam, Bekhor, Toledo, & Polus, 2008; Schwebel, Severson, Ball, & Rizzo, 2006). Driving simulators allow researchers to observe driving behaviour in different situations in a safe, experimentally-controlled setting, with evidence indicating adequate external validity with respect to real-world driving (Bédard, Parkkari, Weaver, Riendeau, & Dahlquist, 2010; Boyle & Lee, 2006; Wang et al., 2010). Chein and colleagues' Stoplight Task described above, while acting as a measure of impulsivity, also measures decision

making (Chein, et al., 2010). Because the probability of crash is unpredictable to the participant, this task may evoke decision making under ambiguity. Similarly, Rizzo *et al*. created a Go/No Go Task to assess decision making in a PC-based virtual driving environment (Rizzo & Severson, 2003). Participants drive down a virtual road as quickly as possible, attempting to avoid hitting gates at various intersections along the way using the traffic lights for guidance. Traffic lights correctly predict gate closure ~80% of the time (e.g., green light for an open gate) and incorrectly predict gate closure ~20% of the time (e.g., red light for an open gate) (Rizzo & Severson, 2003). Like the Stoplight Task, it appears to approximate a decision making under ambiguity paradigm. Another simulation study investigated a type of risky driving, overtaking manoeuvres, as an indicator of decision making in general population sample (Farah, et al., 2008). Overtaking manoeuvres were not only correlated with other measures of risky driving such as speeding, but were also correlated with the proportion of disadvantageous cards selected during the IGT (Farah, et al., 2008).

Despite these developments, our knowledge of decision making under risk in simulated driving remains unclear. The simulation tasks described above fall short because they either uniquely tap into decision making under ambiguity and/or represent driving scenarios that poorly mimic real-life driving. To the author's knowledge, the literature on decision making both under ambiguity and under risk using driving simulation is non-existent. Advancing the preliminary findings from neuropsychological studies regarding decision making under risk by using driving simulation would be a first step in investigating the nature and generalizability of decision making deficits in the real world of driving and its cognitive demands.

In order to clarify the role of specific types of decision making in driving, our laboratory created two original driving tasks intended to measure decision making in an ecologically valid manner. Given that over 60% of fatal RTCs occur on two-way rural roads (Transport Canada and Canadian Council of Motor Transport Administrators, 2011), both simulation tasks involve driving down a two-way rural road without a median. Participants are told that the purpose of the task is to drive down the road as quickly and as safely as possible. As the participant drives down the road, they are confronted with a slow-moving truck ahead of them and are faced with several opportunities to make a risky overtaking manoeuvre. The road is curved in both tasks, which serves to obstruct the view of drivers, thereby making overtaking manoeuvres inherently risky. One scenario attempts to parallel the characteristics of decision making under ambiguity, which is characterized by unknown risk probabilities. In this scenario, the flow of oncoming traffic is random, making the probability of accident risk unpredictable to the participant. In contrast, another scenario attempts to parallel the characteristics of decision making under risk, which is characterized by known risk probabilities. Here, the flow of oncoming traffic is fixed, making the probability of accident risk more predictable to the participant. While overtaking manoeuvres have been used to measure risky driving behaviour by other researchers and have been systematically correlated to performance on the IGT (e.g., Farah, et al., 2008), the manipulation of the flow of oncoming traffic in the effort to parallel decision making under ambiguity and risk is novel and remains to be validated.

Summary

Preliminary evidence suggests that poor decision making may represent a neurocognitive marker of one HRD subgroup. Three major limitations exist in the literature, however, which mitigate our understanding of decision making problems in HRD. Firstly, much of the literature regarding decision making deficits in HRD has focused on DWI offenders though HRDs are a heterogeneous group. In order to properly investigate decision making in HRD, sampling from a more broad and representative sample of HRDs, including drivers who disregard speed limits and stop signs as well as engage in distracted and dangerous driving is essential. Secondly, most of the research in this field has utilized the IGT, which is a complex neuropsychological task that has been widely criticized as tapping into multiple cognitive functions. In order to accurately assess if HRDs are characterized by poor decision making, a more pure measure of decision making under risk is needed. Finally, decision making may be contextual. Utilization of driving simulation would be advantageous to increase the ecological validity of research findings, which rely heavily on neuropsychological tests. Overall, using more specific and context-appropriate tasks in a more generalizable group of HRDs could clarify whether deficits in decision making under risk underlie the maladaptive driving behaviours observed in HRD. The purpose of this study is to explore decision making under risk as a putative mechanism underlying risky decision making in HRDs. The specific objectives and hypotheses of the current study are now presented.

Objectives and Hypotheses

***Objective 1*: Compare the decision making capacities of High-Risk Drivers and Controls**

Hypothesis 1: HRDs will exhibit poorer decision making under risk as measured by the IGT compared to CTLs.

***Objective 2*: Validate previous findings regarding decision making in High-Risk Drivers based on the IGT using the Game of Dice Task (GDT)**

Hypothesis 2: Decision making under risk measured by the IGT will be positively correlated to the GDT in both groups.

***Objective 3*: Investigate a potential high-risk subgroup within the High-Risk Driver sample based on the IGT by comparing an IGT-High Performers group (IGT-HP) and an IGT-Low Performers group (IGT-LP) to the Control group**

Hypothesis 3: Group IGT-LP will represent a high-risk subgroup compared to Group IGT-HP and CTLs.

***Objective 4*: Explore decision making using novel vehicle simulation scenarios aimed at paralleling the characteristics of decision making under ambiguity (Drive A) and decision making under risk (Drive R)**

Hypothesis 4: GDT Scores will be negatively correlated with the number of overtaking manoeuvres a driver performs in Drive R.

Hypothesis 5: IGT Risk Scores will be negatively correlated with the number of overtaking manoeuvres a driver performs in Drive R.

Hypothesis 6: Group-LP will make significantly more overtaking manoeuvres in Drive R compared to Group-HP and controls.

Hypothesis 7: Group-LP will make significantly more overtaking manoeuvres in Drive R compared to Drive A.

Methods

Recruitment and Procedures

This study was conducted at the Addictions Research Program (ARP) of the McGill University-affiliated Douglas Mental Health University Institute in Montreal, Quebec, Canada. The Research Ethics Board of the Douglas Mental Health University Institute approved the protocol and Informed Consent forms (Certificate #11/34).

Participant Inclusion/Exclusion criteria

Participant inclusion criteria were: i) being male between ages 21-35 years; and ii) residence within a 50 km radius from Montreal. For the HRD group, an additional inclusion criterion was the following:1) having engaged in three or more distinct high-risk driving events (i.e., Criminal Code offence, collision or road traffic violation such as speeding, driving without a seat-belt, running a red light or stop sign and driving with a suspended licence) over the course of the last two years; or 2) having either been convicted for a first impaired driving offence (DWI) at blood alcohol concentration (BAC) > 0.16 mg/ml, refusing to provide a breath sample, or having committed repeated DWI offences in the previous ten years. For the CTL group, an additional inclusion criterion was having a clean driving record for DWI, road traffic and criminal code convictions in the past two years. Exclusion criteria were: 1) a Breathalyzer© test indicating alcohol use on the day of testing that could impair experimental test performance (i.e. > BAC 0.00 mg/ml); 2) reading skills of less than sixth grade level; 3) history of psychotic disorder; and 4) evidence that participation in the study could present

significant medical risk to the participant (i.e. alcohol withdrawal), as signalled by the Clinical Institutes of Withdrawal Assessment (described below).

Recruitment procedures

Participants were recruited in two ways. Advertisements describing various studies conducted by the Addiction Research Program laboratory were published in English and French newspapers in the Montreal region and in a newsletter sent through the Association des Centres de Réadaptation en Dépendance du Québec. Eligible individuals who had participated in previous studies at the ARP and who consented to be recontacted were also invited to participate.

Experimental Procedures

The full protocol for the current study consisted of a five-minute telephone interview and a three-hour testing session. Trained research assistants answered telephone calls from interested individuals and screened for study eligibility. Eligible participants were scheduled. Upon arrival at the ARP, individuals were asked to present their driver's license and SAAQ driving records. Individuals were then read the Informed Consent form aloud and were invited to ask any questions pertaining to the study and their participation, rights, and the limits of confidentiality. See Appendix 1 for the Consent Forms in French and Appendix 2 for the Consent Forms in English. Eligible individuals who signed the Informed Consent form were inducted into the study. Participants then completed the Breathalyzer© test and the Clinical Institutes of Withdrawal Assessment. All participants exhibiting signs of alcohol or drug use on the

day of testing or of alcohol or drug withdrawal would have had their testing session delayed or rescheduled. The research assistant then administered a brief sociodemographic questionnaire to collect data to the participant's income, family history, scolarity and judicial history. Participants were then asked to complete computerized versions of the Alcohol Use Disorder Identification Test, the Drug Abuse Screening Test, the Michigan Alcohol Screening Test and the Manchester Driving Behaviour Questionnaire. The research assistant then administered the Iowa Gambling Task and Game of Dice Task. Participants were then asked to complete the Timeline Follow-Back.

Prior to beginning the neuropsychological tasks and driving simulation tasks, participants were told that they would receive $10 extra compensation ($5 for the neuropsychological tasks and another $5 for the driving simulation tasks) if they performed among the five best of the last ten participants in the study. In reality, however, the scores were never tabulated and everyone received the additional compensation. This deception was incorporated into the protocol to motivate participants to engage in the test taking and to perform their best. At the end of the testing session, participants were given reports based on their alcohol and drug consumption, a photocopy of the Informed Consent form as well as $50 CAD monetary compensation. They were also debriefed about the study's deception.

Sampling notes: Several characteristics of the sample are worthy of note. Given the time constraints of completing a Master's thesis and difficulties recruiting as an independent study, the initial study population of DWI recidivists only was expanded to include a broader range of HRD offenders. Efforts were also made to start the study as soon as

possible (prior to the simulation being ready), which resulted in some participants having to come into the lab twice. For these individuals (n = 12), they completed questionnaires and the neuropsychological testing in the first session, and returned to complete the two driving simulation tasks in the second session. As well, efforts were made to superimpose the current project into a larger research initiative underway at our laboratory. With its considerable funding, recruitment was facilitated by greater monetary compensation for participants. In these cases, participants (n = 30) completing the other study were invited to stay at the lab for an additional 45 minutes to complete remaining tasks and questionnaires for the current study.

Instruments

The Iowa Gambling Task

The IGT (see Figure 1) is a neuropsychological task designed to measure decision making and has demonstrated adequate parametric quality in clinical populations (Buelow & Suhr, 2009). In the IGT, the participant must choose between four packs of decks, labelled A, B, C and D, each resulting in monetary rewards (wins) or punishments (losses). The purpose of the task is to maximize the amount of money won. Decks A and B lead to higher immediate wins but long term losses and are therefore considered "disadvantageous" while decks C and D lead to lower immediate wins but long term gains and are therefore considered "advantageous". See Appendix 3 for IGT task instructions in French and Appendix 4 for IGT task instructions in English. The IGT took approximately 10 minutes to complete.

Figure 1. The Iowa Gambling Task (IGT) computer display

Scoring

The three main outcome measures in this task were: (1) an aggregate score for decision making under ambiguity; (2) an aggregate score for decision making under risk; and (3) a total score. Based on previous work in our lab, derivation of the decision making under ambiguity and decision making under risk aggregate scores for the IGT were calculated as follows, with a range of possible scores between -40 to +40 for decision making under ambiguity and between -60 and +60 for decision making under risk:

Decision Making Under Ambiguity = ([Σ advantageous cards $_{\text{blocks 1,2}}$]-[Σ disadvantageous cards $_{\text{blocks 1,2}}$])/2

Decision Making Under Risk = ([Σ advantageous cards $_{\text{blocks 3-5}}$]-[Σ disadvantageous cards $_{\text{blocks 3-5}}$])/3

Total Scores = ([Σ advantageous cards $_{\text{blocks 1-5}}$]-[Σ disadvantageous cards $_{\text{blocks 1-5}}$])

The Game of Dice Task

The GDT (see Figure 2) is a neuropsychological test that measures decision making under risk. Prior to beginning, participants are told that the point of the task is to maximize their starting budget of $1,000. They are informed that there will be 18 virtual throws of the dice and that their job is to choose between different betting decisions, all with varying winning probabilities. Specifically, the amounts of gains or losses possible on the task range from a $1,000 gain or loss for the least likely combination of dice, which is the most risky decision, to a $100 gain or loss for the most likely, or safest decision . At any point during the task, half of the betting decisions are "advantageous", defined as a winning probability of 50%, and half of the decisions are "disadvantageous", defined as a winning probability of 50% (Brand, et al., 2006; Brand, et al., 2007). Advantageous betting decisions involve three or four number combinations as they are the most likely to occur and yield smaller rewards/losses and disadvantageous betting decisions involve one or two number combinations as they are the least likely to occur and yield bigger rewards/losses. Appendix 3 provides GDT task instructions in French and Appendix 4 for GDT task instructions in English. The GDT took approximately five minutes to complete.

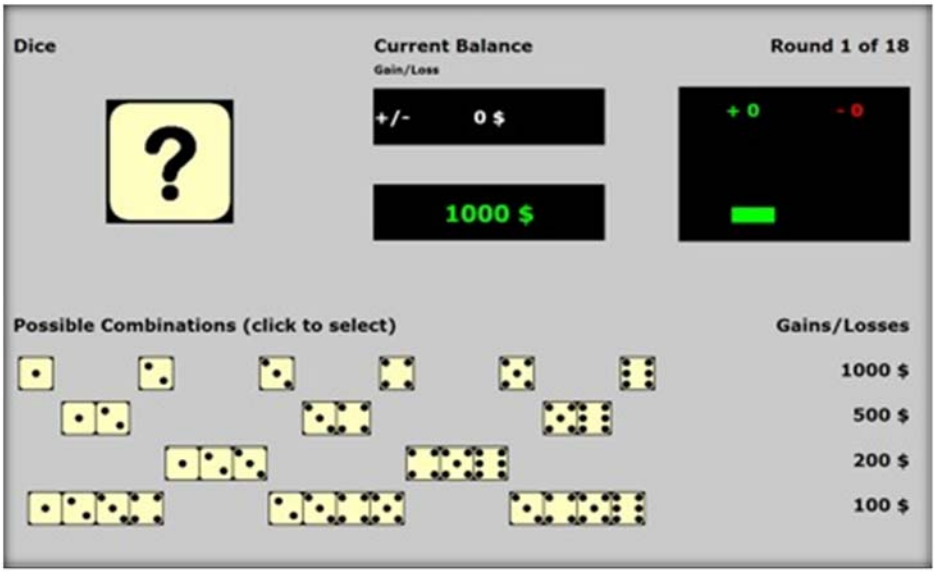

Figure 2. The Game of Dice Task (GDT) computer display

Scoring

The main outcome measure in this task was; (1) an aggregate score for decision making under risk. Derivation of the decision making under risk aggregate score for the GDT will be calculated as follows, with a range of possible scores between -18 to +18:

Decision Making Under Risk = ([Σ three, four number combinations]-[Σ one, two number combinations])

Driving simulation

Both simulator tasks involved hardware and PC-based software whose development was subsidized by a Canadian Institutes of Health Research team grant (SAF-195811). Figure 3 depicts the simulator from the perspective of the driver. The simulator uses a steering wheel and foot controlled pedals that interact with a computer-

generated simulated roadway displayed on three monitors. When the driver accelerates, turns, decelerates, goes up an incline, etc., the simulator reacts to the driver's commands on the simulated road as it would on an actual road. The two driving simulation tasks described below were intended to parallel the characteristics of decision making under ambiguity and decision making under risk. Participants completed a two-minute practice sessions prior to the testing session to familiarize themselves with the simulator as well as practice overtaking manoeuvres.

Figure 3. Driving Simulation Tasks

Drive A

In the original decision making driving scenario, known as Drive A, drivers were asked to drive down a virtual, curved road that had only one lane in each direction. The virtual road was in the shape of a circle. Drivers were asked to drive down this road as quickly as possible and to avoid crashing into other cars on the road. Participants had the

opportunity to pass slow-moving vehicles ahead of them in their lane, by overtaking them, at the risk of crashing into oncoming vehicles in the other lane. At the start of the task, there was a speed limit sign on the right hand side of the road, indicating to participants that the speed limit for the task was 90 km/hr. Because the road was curved and the other vehicles in their lane were large (trucks), the driver's view of the oncoming lane was obstructed. As the participant starts the task, they are confronted with approximately ten oncoming cars driving in the opposite direction, while they drive in their lane with nothing ahead of them. This was to allow participants to get a "feel" (implicitly or explicitly) for the flow of oncoming traffic in the other lane. After they pass approximately ten cars, a slow-moving, large blue truck going approximately 60 km/h appears in their lane ahead of them. Because participants are encouraged to finish the task as quickly but as safely as possible, they can decide to overtake the truck at the risk of crashing into an oncoming car in the opposite lane, given their obstructed view. In pilot testing of this task, the manoeuvre to overtake the truck ahead can be completed in as little as 250 metres (~5 seconds at 90 km/h) but more comfortably at 400m (~8 seconds at 90 km/h). With this information in mind and with the goal of mimicking decision making under ambiguity in which the outcome probabilities for a task are unknown, the rate of oncoming traffic in the opposite direction for this task was created using a random number sequence of numbers between 250 and 550, in intervals of 50 with both a mode and a median of 400. Hence, participants, when confronted with the option of an overtaking manoeuvre, were not aware of whether a car was coming in the opposite direction or what the probability was of successfully overtaking the truck or getting into a crash. In Drive A, participants were exposed to a total of approximately ten trucks and 35

oncoming cars. The number of trucks that they encountered as well as the number of cars that they passed depended on both the speed at which they decided to drive as well as how many overtaking manoeuvres they decided to make. Drive A took six minutes to complete. Appendices 5 and 6 present driving simulation task instructions in French and English respectively.

Drive R

The second simulation task, known as Drive R, involves participants completing a drive down the same virtual, curved road as in Drive A. Drive R differs from Drive A in that the frequency of oncoming traffic in the opposite direction is fixed. Given that an overtaking manoeuvre can be completed comfortably in 400 metres (~8 seconds at 90 km/h), the rate of oncoming traffic in the opposite direction for this task was set at fixed intervals of 400 metres. The fixed rate of oncoming traffic that characterizes Drive R is intended to mimic the characteristics of decision making under risk, in which the outcome probabilities of a task are known. The Drive R took six minutes to complete.

Scoring

The main outcome measure in the driving simulation task is the number of overtaking manoeuvres made by the driver in a driving scenario. Overtaking manoeuvres involve a driver crossing the median line, passing the vehicle directly in front of the driver, and returning to his initial lane. Appendix 7 provides a more detailed description of this variable. Two raters (blinded to both the participant as well as the scenario)

independently coded each video. Discrepancies were reconciled by taking the average rating from the two coders for a particular video.

Sociodemographics Questionnaire

The Sociodemographics Questionnaire is a brief interview-style questionnaire that consists of items related to the participant's personal, social, educational, medical, occupational and familial history. The questionnaire also contains items that assess an individual's drinking, driving, legal and DWI history. The Sociodemographics Questionnaire took approximately 10 minutes to complete.

Clinical Institute Withdrawal Assessment-Alcohol revised (CIWA-Ar)

The CIWA was administered in order to assess signs of intoxication and withdrawal symptoms in participants (Puz & Stokes, 2005). This protocol consisted of assessing symptoms such as anxiety, nausea and agitation. The CIWA protocol took approximately five minutes to administer.

Alcohol Consumption

The Timeline Follow-Back (TLFB) is a well-validated method for assessing recent drinking behaviour (Sobell & Sobell, 1992, 1995). The TLFB was administered by an interviewer who asked respondents, with the use of a calendar, to retrospectively estimate their daily alcohol consumption over a time period of 90 days prior to the interview. The TLFB took approximately 20 minutes to complete.

The Alcohol Use Disorders Identification Test (AUDIT) is a 10-item self-administered screening instrument providing an index of alcohol problem severity and related negative consequences with adequate parametric qualities in high-risk driver samples (Conley, 2001). The AUDIT took approximately five minutes to complete.

The Michigan Alcohol Screening Test (MAST) (Selzer, 1971) is a brief self-administered questionnaire that consists of 25 items that is used to screen for alcohol dependence and abuse in the general population. The MAST has adequate parametric qualities in high-risk driver samples (Conley, 2001). The MAST took approximately five minutes to complete.

Drug Consumption

The Drug Abuse Screening Test (DAST) (Skinner, 1982; Yudko, Lozhkina, & Fouts, 2007) is brief self-administrated questionnaire that yields a quantitative index of drug problem severity. The DAST has strong internal consistency (Skinner, 1982). The DAST took approximately five minutes to complete.

Self-Report Driving Behaviours

The Manchester Driving Behaviour Questionnaire (MDBQ) (Reason, Manstead, Stradling, Baxter, & Campbell, 1990) is a widely used self-administered questionnaire in traffic safety research and consists of 28 well-validated items that measure four hypothesized human sources of accidents; errors, lapses, aggressive violations and ordinary violations (Lajunen & Summala, 2003). The DBQ took approximately five minutes to complete.

Analytic Plan

All statistical analyses were conducted using SPSS® Statistics 20 software. An alpha level of 0.05 was set for inferences, and alpha between 0.05 and 0.10 for trends. For testing assumptions of normality, group data were examined using the Kolmogorov-Smirnov test. If data were not distributed normally in one or more groups per variable, transformation procedures described in Table 1 below were followed sequentially 1-4:

Table 1

Method of Transformation

Positively skewed data	Negatively skewed data
1. Truncate outliers	1. Truncate outliers
2. Square root transformation	2. Reflect & Square root transformation
3. Log10 transformation	3. Reflect & Log10 transformation
4. Inverse transformation	4. Reflect & Inverse transformation

If normality was achieved by one of these transformations, parametric tests were used. If normality was not achieved by these transformations, non-parametric tests were used. For t-tests, *t* statistics are reported for equal variances (determined by Levene's test) and using alpha of 0.05 for inferences, if not otherwise stated. For ANOVAs, *F* statistics for main effects are reported for equal variances (determined using Levene's test) and using alpha of 0.05) for inferences if not otherwise stated, followed by Tukey *post-hoc* tests. If homogeneity of variance was incorrigibly violated in an ANOVA, Brown-Forsythe statistics were used followed by Dunnett T3 *post-hoc* tests.

Hypothesis 1: Independent Samples t-test was used to determine if significant group differences existed between HRDs and Controls. A Mann Whitney U test was performed instead if assumptions of normality were violated.

Hypothesis 2: The Pearson statistic was used to determine if IGT Risk Scores and GDT Scores were significantly correlated. Spearman was performed if assumptions of normality were violated.

Hypothesis 3: An ANOVA, followed by Tukey *post-hoc* tests, was conducted to determine if significant differences exist between IGT-LP, IGT-HP and CTLs. If homogeneity of variance was incorrigibly violated in an ANOVA, Brown-Forsythe statistics were used followed by Dunnett T3 *post-hoc* tests. If normality was incorrigibly violated, a Kruskal-Wallis test was performed followed by Mann-Whitney U *post-hoc* tests.

Hypothesis 4: A Pearson correlation was used to determine if GDT Scores and the number of overtaking manoeuvres a driver performs in Drive R were significantly correlated. Spearman was performed instead if assumptions of normality were violated.

Hypothesis 5: A Pearson correlation was used to determine if IGT Risk Scores and the number of overtaking manoeuvres a driver performs in Drive R were significantly correlated. Spearman was performed instead if assumptions of normality were violated.

Hypothesis 6: An ANOVA, followed by Tukey *post-hoc* tests, was conducted to determine if significant differences existed between IGT-LP, IGT-HP and CTLs. If homogeneity of variance was incorrigibly violated in an ANOVA, Brown-Forsythe statistics were used followed by Dunnett T3 *post-hoc* tests. If normality was incorrigibly

violated, a Kruskal-Wallis test was performed followed by Mann-Whitney U *post-hoc* tests.

Hypothesis 7: A Wilcoxon Signed Ranks test was conducted to determine if Group-LP made significantly more overtaking manoeuvres in Drive R compared to Drive A.

Sample Size and Power Calculation

Power and sample size calculations were based on previous work (Maldonado-Bouchard, et al., 2012) that relate to Hypothesis 3. In an HRD sample (specifically DWI recidivists; n=42), medium-sized effects (η^2= 0.36) were observed between low performers on the IGT (IGT-LP) and controls (CTLs). Hence, our sample size calculation was based upon power of 0.8 (i.e., likelihood of not committing Type II error) and medium-sized effects. Using the software program G*Power 3.1, these parameters resulted in a suggested sample size of fewer than five individuals per group. Based on the above findings and the feasibility in the context of conducting a Master's thesis project, a sample of 30 HRDs and 15 controls was set as targets for recruitment.

Results

Sample

Of the 101 individuals contacted to participate in the study, 46 agreed to participate and completed the study session. Three more participants were excluded from the control group once the inclusion and exclusion criteria for the participant groups were refined (See Methods section for more details). This resulted in a final sample of 43 participants. None of the participants failed the Breathalyzer test or had to have their appointment rescheduled due to obvious signs of alcohol or drug intoxication.

As described in detail above, the study design was adjusted to facilitate recruitment. Participants who completed the study in two sessions were significantly older (N=10; *M*= 30.50, *SD*=2.22) than participants who completed the current study as an addition to the larger research initiative at our laboratory (N = 31; *M*=27.42, *SD*= 4.47), $F_{(31.64)}$=4.30, p<.05. The change in study protocol, however, was not associated any other variable of interest. As well, there were several missing/incomplete data in the dataset. The Iowa Gambling Task (IGT) data were incomplete for one participant due to a technical error in the IGT recording equipment. There was also incomplete data for the Timeline Follow-back (TLFB; n=1) given that this measure was incorporated into the protocol once the study had already started. Lastly, there is incomplete data for the driving simulation (n=9) given that some participants who completed the neuropsychological testing separately did not return to the lab as well as due to technical difficulties. Table 2 presents descriptive variables related to the main sample and Table 3 summarizes the types of offences committed by the HRD group.

Table 2

Descriptive variables related to the study sample

	High-Risk Drivers (n=28)		Controls (n=15)	
	M	*SD*	*M*	*SD*
Age	29.1	4.7	27.5	4.2
Years of Education	14.1	2.7	16.1	3.4
AUDIT Total Scores	7.4	6.2	4.3	3.6
MAST Total Scores	12.0	10.7	3.2	2.1
DAST Total Scores	1.6	1.3	1.5	2.3
MDBQ Errors	0.36	0.35	0.46	0.42
MDBQ Lapses	0.89	0.61	0.81	0.52
MDBQ Aggressive Violations	0.90	0.75	0.88	0.50
MDBQ Ordinary Violations	0.96	0.68	0.88	0.56
Average drinks per week	5.1	5.1	5.5	5.8
Number of days of drug use	3.0	4.2	0.21	0.58

Table 3

Percentage of High-Risk Drivers having committed various types of infractions

Road Traffic Infractions	Observed percentage
Driving while impaired	68%
Speeding	54%
Neglecting to stop at a stop sign	29%
Cell phone use while driving	25%
Seatbelt non-compliance	14%
Neglecting to stop at a red light	11%

Main Results for Hypothesis 1: HRD versus CTL

For the IGT Risk Score, outliers were truncated to the next highest or lowest value and a square root transformation was applied to scores to normalize their distribution. Figure 4 summarizes the IGT Risk Scores for HRDs and CTLs. A t-test comparing the transformed IGT Risk Scores between HRDs (M=1.2, SD=4.9) and CTLs (M=-0.48, SD=2.7) found no significant difference, $t(40)$=-0.81, p=.42, d=.42.

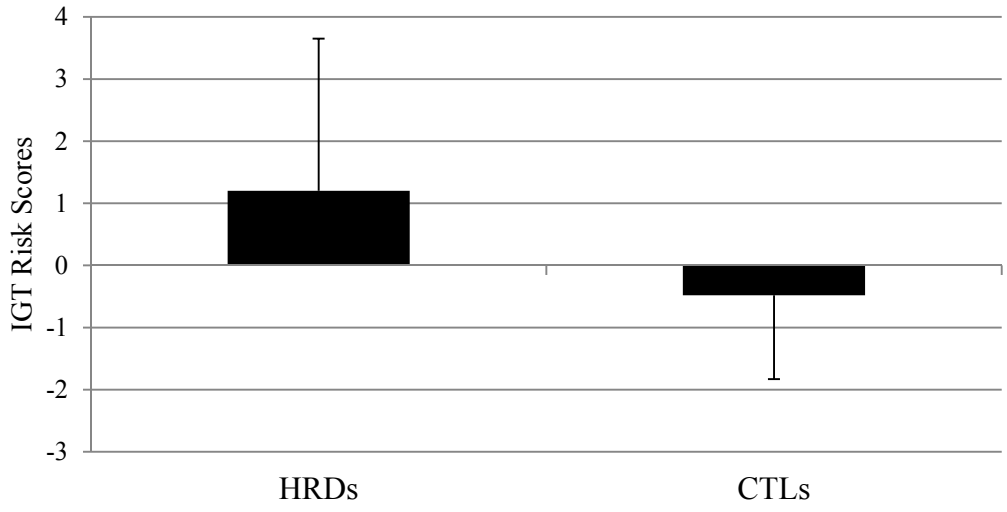

Figure 4. IGT Risk Scores for HRDs and CTLs

Main Results for Hypothesis 2: Correlation of IGT Risk Scores and GDT

Figure 6 illustrates the correlation between IGT Risk Scores and GDT Scores. IGT Risk Scores were not significantly correlated with GDT Total scores, Spearman's $r_s(42)=.088$, $p=.58$.

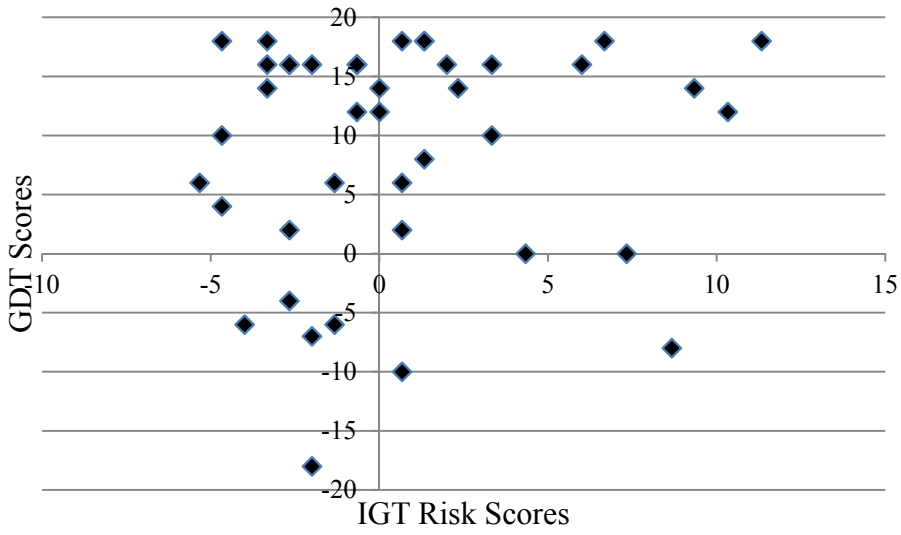

Figure 5. Scatterplot illustrating the correlation between GDT and IGT Risk Scores

Main Results for Hypothesis 3: Identification of a High-Risk Subgroup

Groups IGT-HP and IGT-LP were derived using a median split on the IGT Total Scores at cut point ≥-5. For the IGT Risk Scores, outliers were truncated to the next highest or lowest value to obtain normality.

Identifying Risk via Substance Use: IGT-HPs, IGT-LPs and CTLs

Outliers were truncated to the next highest or lowest value for the AUDIT and MAST to obtain normality. Methods for improving normality failed for the DAST. Given that normality was violated for the DAST, a Kruskal-Wallis test was performed for this measure. The Levene's test for homogeneity of variance was significant for the MAST, ($F(2,39)=10.28$, $p=0.00$), therefore the Brown-Forsythe Robust Test of Equality of Means is reported.

Significant differences were observed for the MAST, $F(2,22)=5.72$, $p=.01$. Dunnett T3 post-hoc tests demonstrated that CTLs ($M=3.14$, $SD=2.14$) scored significantly lower on the MAST compared to both IGT-HP ($M=14.50$, $SD=13.15$) and IGT-LPs ($M=9.21$, $SD=7.72$). As for the AUDIT, no significant differences were observed between IGT-HP ($M=7.00$, $SD=6.77$), IGT-LP ($M=7.14$, $SD=4.24$) or CTLs ($M=4.29$, $SD=3.65$), $F(2,39)=1.41$, p=.26. No significant differences were observed between IGT-HPs (average rank=24.00; $Mdn=1.50$), IGT-LPs (average rank=22.07; $Mdn=1.50$) and CTLs (average rank=18.43; $Mdn=0.50$) on the DAST, χ^2 (2, $N=42$) = 1.58, $p=.45$.

Methods for improving the normality of the variables from the TLFB failed so Mann-Whitney U tests were performed. Significant differences between the three groups were observed on several measures of drug use. The Kruskal-Wallis test was significant for the number of days of drug consumption, χ^2 (2, $N=42$) = 7.78, $p=.02$. Post-hoc Mann-Whitney U tests demonstrated a trend for IGT-HPs (average rank=17.18; $Mdn=3.50$) to have higher number of drug use days compared to IGT-LPs (average rank=11.82; $Mdn=0.50$), $U=60.5$, $p=.072$, $z= -1.8$, $r=.34$ and that IGT-HPs (average rank=17.93; $Mdn=3.50$) had a significantly higher number of drug use days compared to CTLs (average rank=11.07; $Mdn=0.00$), $U=50.0$, $p=.012$, $z= -2.5$, $r=.47$. The Kruskal-Wallis test was also significant for the highest number of consecutive drug use days, χ^2 (2, $N=42$) = 7.89, $p=.019$. Post-hoc Mann-Whitney U tests demonstrated a trend for IGT-HPs (average rank=17.00; $Mdn=1.0$) to have higher numbers of consecutive days of drug use compared to IGT-LPs (average rank=12.00; $Mdn=0.50$), $U=63.0$, $p=.086$, $z= -1.7$, $r=.32$ as well as a trend for IGT-LPs (average rank=16.75; $Mdn=0.50$) to have higher

numbers of consecutive days of drug use compared to CTLs (average rank=12.43; *Mdn*=0.0), *U*=66.5, *p*=.076, *z*= -1.8, *r*=.34. IGT-HPs (average rank=17.93; *Mdn*=1.0) also had significantly higher numbers of consecutive drug use days compared to CTLs (average rank=11.07; *Mdn*=0.0), *U*=50.0, *p*=.027, *z*= -2.5, *r*=.47. The Kruskal-Wallis test was significant for the number of days of cannabis use, χ^2 (2, N=42) = 8.48, *p*=.014. Post-hoc Mann-Whitney U tests demonstrated that IGT-HP (average rank=17.75; *Mdn*=2.50) had significantly higher numbers of days of cannabis use compared to IGT-LP (average rank=11.25; *Mdn*=0.0), *U*=52.5, *p*=.023, *z*= -2.3, *r*=.43 and that IGT-HP (average rank=17.86; *Mdn*=2.50) had significantly higher numbers of days of cannabis use compared to CTLs (average rank=11.14; *Mdn*=0.0), *U*=51.0, *p*=.014, *z*= -2.5, *r*=.47. Lastly, the Kruskal-Wallis was significant for the number of days of stimulant use, χ^2 (2, *N*=42) = 6.31, *p*=.043. Post-hoc Mann-Whitney U tests demonstrated a trend for IGT-HP (average rank=16.00; *Mdn*=0.0) to have a higher number of days of stimulant use compared to IGT-LP (average rank=13.00; *Mdn*=-), U=77.0, p=.072, z= -1.8, r=.34 and for IGT-HP (average rank=16.00; *Mdn*=0.0) to have a higher number of days of stimulant use compared to CTLs (average rank=13.00; *Mdn*=-), U=77.0, p=.072, z= -1.8, r=.34. There was no significant difference between IGT-HPs (average rank=23.04; *Mdn*=0.0), IGT-LPs (average rank=22.96; *Mdn*=0.0) and CTLs (average rank=18.50; *Mdn*=-) on the number of days of cocaine use, χ^2 (2, *N*=42) = 3.40, *p*=.18. No significant differences were observed between the three groups on TLFB variables related to alcohol consumption. There were no significant differences observed between IGT-HPs (average rank=20.50; *Mdn*=2.74), IGT-LPs (average rank=22.79; *Mdn*=5.0) and CTLs (average rank=21.21; *Mdn*=3.0) for the average number of standard drinks consumed per week, χ^2

(2, N=42) = 0.26, p=.88. There were no significant differences observed between IGT-HPs (average rank=20.29; *Mdn*=0.18), IGT-LPs (average rank=24.43; *Mdn*=1.0) and CTLs (average rank=19.79; *Mdn*=0.0) for the average number of standard drinks consumed per day, χ^2 (2, N=42) =1.33, p=.52. There were no significant differences observed between IGT-HPs (average rank=20.68; *Mdn*=20.0), IGT-LPs (average rank=18.11; *Mdn*=4.0) and CTLs (average rank=25.71; *Mdn*=47.50) for the percentage of one's drinking that is considered moderate, χ^2 (2, N=42) = 2.92, p=.23. There were also no significant differences observed between IGT-HPs (average rank=22.00; *Mdn*=2.0), IGT-LPs (average rank=23.04; *Mdn*=2.0) and CTLs (average rank=19.46; *Mdn*=0.0) for the number times five or more drinks were consumed in one day, χ^2 (2, N=42) = 0.69, p=.71.

Main Results for Simulation Data Analysis (Hypotheses 4 through 7)

The double coding for the simulation analysis underwent reliability analysis prior to data cleaning and data analysis. A two-way mixed model for absolute agreement type intra-class correlation coefficient (ICC) was conducted. An excellent inter-rater reliability was established, ICC=0.995, CI [0.992-0.997].

Methods for improving the normality of the simulation data failed so Mann-Whitney U tests were performed. Hypothesis 4 predicted an inverse correlation between GDT Scores and the number of overtaking manoeuvres completed in Drive R. GDT Scores were significantly and inversely associated to the number of overtaking manoeuvres completed in Drive R in HRDs, r_s(34)=-0.41, p=.021. No evidence was found to support this relationship in CTLs, r_s(34)=-0.12, p=.38.

Hypothesis 5 predicted an inverse correlation between IGT Risk Scores and the number of overtaking manoeuvres completed in Drive R. There was no evidence to support an inverse correlation between IGT Risk Scores and the number of overtaking manoeuvres completed in Drive R in HRDs, $r_s(34)=-0.097$, p=.32 or in CTLs, $r_s(34)=-0.27$, p=.24.

Hypothesis 6 predicted that group IGT-LP would have the greatest number of overtaking manoeuvres completed in Drive R compared to IGT-HPs and CTLs. No significant differences were found between IGT-HPs (average rank=16.96; *Mdn*=10.0), IGT-LPs (average rank=18.91, Mdn=10.0) and CTLs (average rank=16.61, *Mdn*=10.0) in the number of overtaking manoeuvres made in Drive R, χ^2 (2, *N*=34) = 0.36, *p*=.84.

Hypothesis 7 predicted that group IGT-LP would make significantly fewer overtaking manoeuvres in Drive A compared to Drive R. A Wilcoxon Signed Ranks Test indicated no significant difference between the number of overtaking manoeuvres made in Drive A (average rank=6.4; *Mdn*=9.0) and in Drive R (average rank=4.6; *Mdn*=10.0), *Z*=-0.461, *p*=.65, *r*=.14.

Exploratory Analyses

Supplementary Analyses Related to HRDs and CTLs

Other Neuropsychological Data for HRDs and CTLs

For the IGT Ambiguity Scores, IGT Total Scores and Game of Dice (GDT) Total Scores, outliers were truncated to the next highest or lowest value and an additional reflect and log10 transformation was applied to the GDT Total scores to obtain normality.

A t-test was performed on the IGT Ambiguity Score. No significant difference was observed between HRDs (*M*=-2.3, *SD*=3.6) and CTLs (*M*=-1.7, *SD*=4.8), *t*(41)=-0.009, *p*=.99, *d*=-.14. A t-test was performed on the IGT Total Score. No significant difference was observed between HRDs (*M*=-1.7, *SD*=14.6) and CTLs (*M*=-4.2, *SD*=11.6), *t*(40)=-0.57, *p*=.58, *d*=.19. Figure 5 summarizes the GDT Scores for HRDs and CTLs. A t-test was performed on the GDT Total Score. No significant difference was observed between HRDs (*M*=9.7, *SD*=8.4) and CTLs (*M*=7.3, *SD*=11.7), *t*(41)=0.57, *p*=.57, *d*=.24.

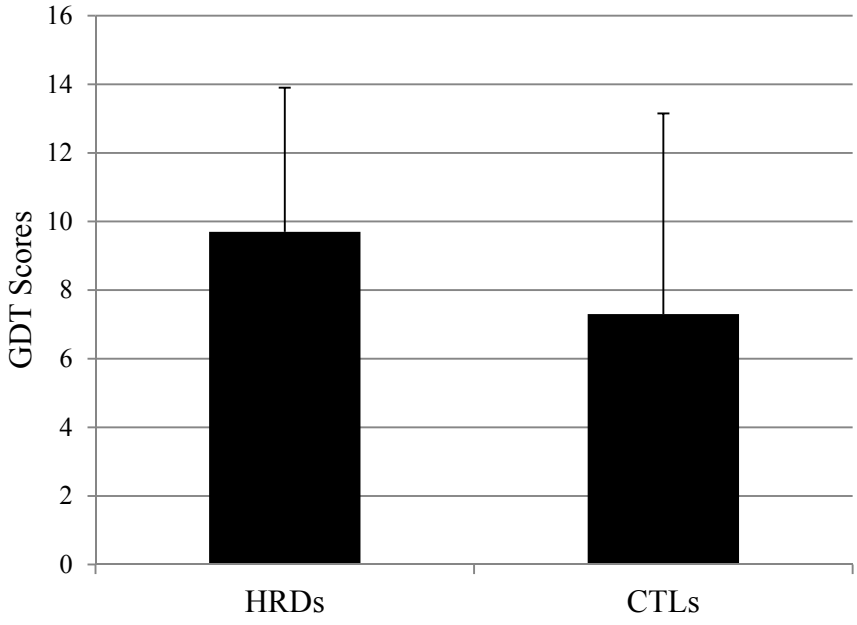

Figure 6. GDT Scores for HRDs and CTLs

Driving Simulation for HRDs and CTLs

There was no significant difference observed between HRDs (average rank=17.72; *Mdn*=9.5) and CTLs (average rank=16.89; *Mdn*=8.0) on the number of

overtaking manoeuvres completed in Drive A, U=107.0, p=.85, z=-0.22, r=.038. Likewise, there was no significant difference observed between HRDs (average rank=17.82; *Md*n=10.0) and CTLs (average rank=16.61; *Md*n=10.0) on the number of overtaking manoeuvres completed in Drive R, U=104.5, p=.759, z=-0.33, r=.057.

Explore the decision making capacities of DWI recidivists compared to non-recidivist HRD offenders and controls

The aim of these exploratory analyses was to explore the decision making capacities of DWI recidivists by dividing HRDs according to whether or not they meet the criteria for DWI recidivism (i.e., comparing a DWI recidivist group (DWI RCD; n=13), a non-DWI recidivist High-Risk Driving group (non-RCD HRD; n=15) and the Control group (CTL; n= 15).

Outliers were truncated to the next highest or lowest value to obtain normality for IGT Ambiguity Scores, IGT Risk Scores and IGT Total Scores. A reflect and log10 transformation was performed on the GDT Total Scores to obtain a more normal distribution.

No significant differences were observed between DWI RCDs (M=-2.2, SD=3.4), non-RCD HRDs (M=-2.4, SD=3.5) and CTLs (M=-1.7, SD=4.8) on the IGT Ambiguity Scores, F (2,40)=0.01, p=.99. No significant differences were observed between DWI RCDs (M=-0.54, SD=2.7), non-RCD HRDs (M=2.8, SD=7.0) and CTLs (M=-0.48, SD=2.7) on the IGT Risk Scores, F (2,39)=2.43, p=.10. No significant differences were observed between DWI RCDs (M=-3.23, SD=15.5), non-RCD HRDs (M=-0.33, SD=14.2) and CTLs (M=-4.2, SD=11.6) on the IGT Total Scores, F (2,39)=0.31, p=.74.

Finally, no significant differences were observed between DWI RCDs (*M*=6.5, *SD*=12.5), non-RCD HRDs (*M*=11.5, *SD*=6.1) and CTLs (*M*=7.3, *SD*=11.7) on the GDT Total Scores, F (2,40)=0.21, p=.81.

Discussion

This preliminary study investigated decision making in a broad sample of HRD using analyses of neuropsychological and driving simulation data. The current study specifically investigated whether a deficit in decision making under risk underlies the maladaptive behaviour of HRDs as has been observed previously in studies of DWI. The main finding related to our first hypothesis was that poor decision making as measured by the IGT or the GDT did not distinguish the HRD group from the non-HRD control group. This suggests that findings related to decision making in DWI offenders may not be readily generalizable to HRDs. One possible explanation for this finding is that the factors characterizing DWI and HRD differ, in particular with respect to decision making. It is also possible, however, that the failure to replicate findings from the DWI literature was due to the methodological characteristics of the current study, which were distinct from previous studies in a number of ways, including recruitment, design and use of multiple neuropsychological tasks.

Contrary to previous literature (Brand, et al., 2007), no evidence was found to support our second hypothesis, which predicted that IGT Risk scores would be directly correlated to the GDT. This result suggests that the IGT and the GDT may be tapping into different cognitive mechanisms in this population. Another possibility pertains to sampling in previous studies. The GDT has been used extensively in clinical populations (i.e., pathological gambling (Brand, et al., 2005), binge eating disorder (Svaldi, Brand, & Tuschen-Caffier, 2010) and Korsakoff's syndrome (Brand et al., 2009)). To the author's knowledge, only one study employed the GDT in a general population sample like the present one (Brand, et al., 2007). For the moment, despite being proposed as a more pure

measure of decision making under risk, the GDT may not be well suited to handle the heterogeneity inherent in the non-clinical HRD population.

Our third hypothesis investigated use of the IGT to identify a high-risk subgroup based on performance. A median split of the IGT Total Scores did not yield a HRD subgroup with riskier characteristics or behaviours such as increased alcohol or drug use. To the contrary, one paradoxical finding was that IGT high-performers had greater drug use compared to controls. In a previous study in our lab with a sample of DWI recidivists, it was the low-performers who displayed more substance misuse compared to the other groups (Maldonado-Bouchard, et al., 2012). This finding indicates that assumptions regarding HRDs based on the DWI literature must be made cautiously.

Hypotheses 4 and 5 specifically sought to test whether decision making under risk predicted risky driving. Results demonstrated a significant negative correlation between GDT Scores and the number of overtaking manoeuvres completed in Drive R in HRDs. There were no significant correlations between the neuropsychological tasks and Drive A and there were no significant correlations observed in controls. These findings add to previous research regarding the relationship between neuropsychological task performance and simulated driving performance (Farah, et al., 2008) to further substantiate the specificity in this relationship. While additional validation of the driving scenarios in the current study is needed, this novel finding suggests that driving–related risk taking can be predicted by a purer neuropsychological task of decision making under risk. More generally, these findings support the transversality of decision making across multiple domains, specifically gambling tasks and driving simulation tasks that both measure decision making under risk.

Regarding hypothesis 6, the low-performing group on the IGT did not differ from the high-performing group or controls on the number of overtaking manoeuvres completed in the driving simulation. Similarly, regarding hypothesis 7, the low-performing group did not make significantly more overtaking manoeuvres in Drive R compared to Drive A. Given the relationship between GDT scores and driving simulation, however, the GDT, as a purer measure of decision making under risk, may be a more advantageous measure for identifying a high-risk subgroup. Future research could attempt to identify a high-risk subgroup of HRDs based on the GDT performance.

Exploratory analyses were also conducted by dividing the HRDs according to whether they or not they met the criteria for DWI recidivism. Decision making deficits previously reported in the literature in groups of recidivist were not observed in the current study's DWI recidivist sample. The previous study in our lab, which inspired the current study's subgroup analysis, also did not find significant differences between recidivists and controls when compared directly (Maldonado-Bouchard, et al., 2012). The authors pointed out that the previous studies in the literature demonstrating decision making deficits in recidivists had used extensive exclusion criteria (Kasar, et al., 2010), small sample sizes (Yechiam, 2008) and possibly more extreme cases of DWI (e.g., incarcerated offenders or participants of a remedial program) (Lev, et al., 2008). These between-study discrepancies are relevant here as well and may have contributed to the inconsistent findings.

Strengths and Limitations

This study has both strengths and limitations worthy of mention. The study's main strengths lie in its novel and robust experimental design. The use of multiple neuropsychological tests was combined with more-ecologically appropriate driving simulation scenarios. A limitation of this study was its limited sample size. The power calculation for the current study was based on a previous study in the literature regarding decision making using the IGT in DWI recidivists. Given that recidivists are a more homogenous group compared to HRDs, the increased heterogeneity in the current sample may have contributed to the possibility of Type II error. We only recruited males. Given that males and females are inherently different on measures of decision making and executive control (Reavis & Overman, 2001), findings from the current study cannot be extended to female HRD offenders. As well, the driving simulations scenarios created, implemented and analyzed in the current study are novel. The evidence appears to support the notion that Drive R challenges cognitive capacities related to decision making under risk. Given their preliminary validation, however, interpretations based upon simulation data need to be broached cautiously. Lastly, because not every eligible participant completed a telephone screening, it is not possible to determine if participants who decided to participate were significantly different than participants who did not agree to participate.

Implications and Future Work

Preliminary evidence from the current study suggests that risky driving behaviour can be predicted by an individual's performance on a neuropsychological task that measures decision making under risk, specifically the GDT. These findings require replication in other samples of HRDs. Furthermore, the driving scenarios, especially Drive R which purports to challenge decision making under risk, must undergo additional validation exercises. Future studies should continue to investigate the different types of driving contexts and circumstances in which individuals display risky decision making. Assisting HRD offenders assess the salience of various risky situations may be useful and could be targeted in future intervention research. Likewise, design of driving simulation scenarios such as the ones used in the current study seems to be a promising avenue for incorporation into screening and detection of HRD.

Conclusion

In this study, a neuropsychological task challenging decision making under risk was able to predict risky driving behaviour in driving simulation aimed at challenging decision making under risk. Specifically designed driving simulation tasks may further our understanding of HRD as well as the detection and treatment of these high-risk offenders. The applicability of neuropsychological findings from the DWI literature to the understanding of HRD is uncertain.

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Appendix

Appendix 1: Consent Forms (FR)

FORMULAIRE D'INFORMATION ET DE CONSENTEMENT

1. TITRE DU PROJET DE RECHERCHE

Douglas INSTITUT UNIVERSITAIRE EN SANTÉ MENTALE / MENTAL HEALTH UNIVERSITY INSTITUTE	**Mécanismes sous-jacents à la prise de décisions chez les conducteurs à haut risque (CHR)**

Cette étude est menée par des chercheurs du Programme de recherche sur les addictions de l'Institut universitaire en santé mentale Douglas.

Chercheur principal:
Thomas G. Brown, Ph.D., Département de psychiatrie, Université McGill

Co-chercheure et coordinatrice de recherche:
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Commanditaire: Instituts de recherche en santé du Canada (IRSC)

2. INTRODUCTION

Nous sollicitons votre participation à un projet de recherche. Cependant, avant d'accepter de participer à ce projet et de signer ce formulaire d'information et de consentement, veuillez prendre le temps de lire, de comprendre et de considérer attentivement les renseignements qui suivent.

Ce formulaire peut contenir des mots que vous ne comprenez pas. Nous vous invitons à poser toutes les questions que vous avez au chercheur responsable du projet ou aux autres membres du personnel affecté au projet de recherche et à leur demander de vous expliquer tout mot ou renseignement qui n'est pas clair.

3. NATURE ET OBJECTIFS DU PROJET DE RECHERCHE

L'objectif de cette étude est de mesurer la prise de décisions chez les conducteurs à haut risque. Nous espérons déterminer si les conducteurs à haut risque prennent un certain type de décisions comparativement aux sujets contrôles. Nous voulons aussi examiner les mécanismes sous-jacents à la prise de décisions chez les conducteurs à haut risque en étudiant leurs performances dans diverses tâches de prise de décisions.

Deux groupes de participants sont recrutés pour l'étude dans le but de comparer la prise de décisions chez les conducteurs à haut risque et chez les contrôles:

- un premier groupe de vingt hommes conducteurs n'ayant jamais été condamnés pour conduite avec capacités affaiblies ni pour infractions routières au cours des deux dernières années.
- un deuxième groupe de quarante hommes conducteurs ayant été condamnés pour conduite avec capacités affaiblies au moins deux fois ou pour au moins trois évènements de conduite à risque au cours des deux dernières années.

4. DÉROULEMENT DU PROJET DE RECHERCHE

Ce projet de recherche se déroulera au laboratoire du Programme de recherche sur les addictions de l'Institut universitaire en santé mentale Douglas. Votre participation consiste en une seule visite d'une durée approximative de trois heures.

1. À votre arrivée au PRA, on vous demandera de présenter une preuve d'identité avec photo ainsi que votre permis de conduire.
2. On vous demandera aussi de fournir votre dossier de conducteur de la SAAQ.
3. Vous devrez vous soumettre à un ivressomètre pour vérifier que vous n'êtes pas sous l'influence de l'alcool ou des drogues au moment de votre séance. Un participant ayant un ivressomètre qui indique que de l'alcool a été consommé le jour de la visite ou un participant ayant visiblement les capacités affaiblies par des drogues ou des médicaments au moment de sa visite ne sera pas autorisé à participer et son rendez-vous sera retardé ou reporté.
4. Si vous avez déjà eu des convulsions ou souffrez d'hypertension, ou si vous prenez des médicaments pour le cœur, les poumons ou l'épilepsie, vous rencontrerez un infirmier qui mesurera votre pression artérielle et votre pouls et vous posera quelques questions sur votre état de santé. Selon les cas, il se pourrait que vous ayez à passer un examen physique sommaire effectué par un médecin licencié, c'est-à-dire l'examen du cou, du cœur, des poumons, de l'abdomen et des réflexes pour vérifier que vous êtes en mesure de participer à l'étude.
5. Pour les autres participants non visés par le point 4) ci-dessus : la coordonnatrice vous posera quelques questions sur votre état de santé. Selon les cas, il se pourrait que vous ayez à passer un examen physique sommaire effectué par un médecin licencié, c'est-à-dire l'examen du cou, du cœur, des poumons, de l'abdomen et des réflexes pour vérifier que vous êtes en mesure de participer à l'étude.
6. Nous vous demanderons de répondre à des questionnaires portant sur votre consommation d'alcool et de drogues, vos habitudes de conduite et certains de vos comportements et attitudes.
7. Nous vous demanderons de remplir deux tâches à l'ordinateur.
8. Nous vous demanderons de compléter une entrevue au sujet de votre consommation d'alcool et de drogues.
9. Nous vous demanderons de remplir deux tâches de simulation de conduite.
10. Cette étude devrait durer environ trois heures.
11. À la fin de la séance, nous vous remettrons 40$ pour votre temps, en plus de tout autre montant que vous pourriez recevoir au cours des diverses tâches. Nous vous remettrons aussi un court bilan portant sur vos habitudes de consommation d'alcool et/ou de drogues.

5. COLLABORATION DU SUJET AU PROJET DE RECHERCHE

On demande au participant de ne pas être sous l'influence de l'alcool ou de drogues avant ou pendant la participation au projet de recherche. C'est pourquoi nous demandons aux participants de ne pas consommer d'alcool pour une période d'au moins douze heures avant leur séance.

6. RISQUES ASSOCIÉS AU PROJET DE RECHERCHE

Il est peu probable que ce projet de recherche comporte un risque pour votre bien-être physique ou psychologique; cependant il est possible que la nature des questions qui vous seront posées soulève un malaise chez vous; si tel est le cas, vous êtes invité à discuter de la situation avec l'intervenant, qui pourra vous diriger vers les ressources appropriées. D'autres inconvénients possibles sont la fatigue, le stress, la frustration reliée à l'expérimentation, le transport, le déplacement, l'attente et le temps consacré à la recherche.

Certaines personnes peuvent ressentir le mal des transports dans le simulateur de conduite. Si c'est votre cas, vous devez en aviser l'assistant de recherche immédiatement. Le test sera alors suspendu et vous resterez sous surveillance jusqu'à ce que vos symptômes disparaissent. Si vous éprouvez le mal des transports et que nous devons suspendre les procédures, vous recevrez tout de même 40$ pour votre participation.

7. AVANTAGES

Vous ne retirerez aucun bénéfice personnel de votre participation à ce projet de recherche. Toutefois, les résultats obtenus pourraient contribuer à l'avancement des connaissances dans ce domaine.

8. PARTICIPATION VOLONTAIRE ET POSSIBILITÉ DE RETRAIT

Votre participation à ce projet de recherche est volontaire. Vous êtes donc libre de refuser d'y participer. Vous pouvez également vous retirer de ce projet à n'importe quel moment, sans avoir à donner de raisons, en faisant connaître votre décision au chercheur responsable du projet ou à l'un des membres du personnel affecté au projet.

Le chercheur responsable du projet de recherche, le comité d'éthique de la recherche de l'Institut universitaire en santé mentale Douglas ou les organismes subventionnaires peuvent mettre fin à votre participation, sans votre consentement, si de nouvelles découvertes ou informations indiquent que votre participation au projet n'est plus dans votre intérêt, si vous ne respectez pas les consignes du projet de recherche ou s'il existe des raisons administratives d'abandonner le projet.

Si vous vous retirez ou êtes retiré du projet, l'information déjà obtenue dans le cadre de ce projet pourra être détruite sur demande de votre part.

9. CONFIDENTIALITÉ

Nous comprenons bien que les informations que nous vous demandons peuvent être de nature délicate. Ni la Société d'assurance automobile du Québec (SAAQ), ni aucun autre organisme, légal ou autre, n'aura accès aux informations que vous nous fournirez. Un ensemble de mesures seront prises pour que ces informations demeurent strictement confidentielles, sauf s'il en est autrement stipulé par la loi.

En vertu de la Loi sur la protection de la jeunesse, le chercheur qui a un motif raisonnable de croire que la sécurité ou le développement d'un enfant est compromis, parce qu'il est victime d'abus sexuels ou est soumis à des mauvais traitements physiques par suite d'excès ou de négligence, est tenu de le déclarer au directeur de la protection de la jeunesse. De même, si les informations que vous nous fournirez suggèrent fortement qu'il existe un risque imminent de mort ou de blessures graves pour vous ou d'autres personnes (y compris par suicide), le chercheur se verrait dans l'obligation d'en prévenir la ou les personnes menacées et si nécessaire d'en avertir les professionnels de la santé et les autorités compétentes.

Durant votre participation à ce projet, le chercheur responsable ainsi que son personnel recueilleront et consigneront dans un dossier de recherche les renseignements vous concernant. Seuls les renseignements nécessaires pour répondre aux objectifs scientifiques de ce projet seront recueillis. Afin de préserver votre identité et la confidentialité des renseignements, vous serez identifié que par un numéro de code. La clé du code reliant votre nom et vos données personnelles à vos données de recherche sera conservée par le chercheur principal. Ces données personnelles seront détruites sept ans après la fin de la collecte. Seules les données ne permettant pas de vous identifier pourront être conservées après cette période pour une durée additionnelle de trois ans. La collecte devrait se terminer à la fin de 2012.

Pour s'assurer du bon déroulement de la recherche, il est possible qu'un membre du comité d'éthique puisse consulter vos données de recherche.

Les présentations ou publications qui découleront de ce projet de recherche ne permettront en aucune façon de vous identifier.

Vous avez le droit de consulter votre dossier de recherche pour vérifier les renseignements recueillis, et les faire rectifier au besoin, et ce, aussi longtemps que le chercheur responsable du projet ou l'établissement détiennent ces informations. Cependant, afin de préserver l'intégrité scientifique du projet, vous pourriez n'avoir accès à certaines de ces informations qu'une fois l'étude est terminée.

10. FINANCEMENT DU PROJET DE RECHERCHE

Le chercheur responsable du projet a reçu du financement des Instituts de recherche en santé du Canada pour mener à bien ce projet de recherche.

11. INDEMNISATION EN CAS DE PREJUDICE ET DROITS DU SUJET DE RECHERCHE

Si vous deviez subir quelque préjudice que ce soit dû à votre participation au projet de recherche, vous recevrez les soins et services requis par votre état de santé, sans frais de votre part.

En acceptant de participer à ce projet, vous ne renoncez à aucun de vos droits ni ne libérez les chercheurs, ou l'établissement de leur responsabilité civile et professionnelle.

12. CONSTATATIONS FORTUITES ET COMMUNICATIONS DES RÉSULTATS

Les résultats de cette étude ne sont pas sujets à une évaluation médicale ni psychologique. Cependant, nous vous remettrons un court bilan portant sur vos habitudes de consommation d'alcool et/ou de drogues. Si vos réponses suggèrent que votre consommation est problématique, vous serez encouragé à aller consulter votre professionnel de la santé.

13. COMPENSATION

Vous recevrez 40$ pour votre temps, en plus de tout autre montant que vous pourriez recevoir au cours des diverses tâches.

14. IDENTIFICATION DES PERSONNES-RESSOURCES

Si vous avez des questions concernant le projet de recherche ou si vous éprouvez un problème que vous croyez relié à votre participation au projet de recherche, vous pouvez communiquer avec le chercheur responsable du projet de recherche aux numéros suivants :

Thomas G. Brown, chercheur principal : (514) 761-6131, poste 3415

Samantha Wells, co-chercheure et coordinatrice de recherche: (514) 761-6131, poste 6181.

Pour toute question relative à vos droits en tant que sujet de recherche, vous pouvez également téléphoner à l'ombudsman de l'Institut universitaire en santé mentale Douglas au (514) 761-6131, poste 3287.
Courriel : Ombudsman@douglas.mcgill.ca

15. SURVEILLANCE DES ASPECS ETHIQUES DU PROJET DE RECHERCHE

Le comité d'éthique de la recherche de l'Institut universitaire en santé mentale Douglas a approuvé ce projet de recherche et en assure le suivi. De plus, il approuvera au préalable toute révision et toute modification apportée au formulaire d'information et de consentement ou au protocole de recherche.

Douglas INSTITUT UNIVERSITAIRE EN SANTÉ MENTALE / MENTAL HEALTH UNIVERSITY INSTITUTE	**Mécanismes sous-jacents à la prise de décisions chez les conducteurs à haut risque (CHR)**

Chercheur principal:
Thomas G. Brown, Ph.D., Département of psychiatrie, Université McGill

Co-chercheure et coordinatrice de recherche:
Samantha Ashley Wells, étudiante à la maîtrise, Département de psychiatrie, Université McGill

FORMULE D'ADHÉSION DU SUJET

J'ai pris connaissance du formulaire d'information et de consentement. Je reconnais qu'on m'a expliqué le projet, qu'on a répondu à mes questions et qu'on m'a laissé le temps voulu pour prendre une décision.

Je consens à participer à ce projet de recherche aux conditions qui y sont énoncées. Une copie signée et datée du présent formulaire d'information et de consentement me sera remise.

_____	_____	_____
Nom du participant (lettres moulées)	Signature	Date

	Oui	Non
Je consens à ce que les données recueillies dans le cadre de cette étude soient utilisées pour des projets de recherche subséquents sur l'alcool au volant durant les 10 prochaines années conditionnellement à leur approbation par un comité d'éthique de la recherche et dans le respect des mêmes principes de confidentialité et de protection des informations. La clé du code reliant mon nom et mes données personnelles à mes données de recherche sera conservée par le chercheur principal.	☐	☐

FORMULE D'ENGAGEMENT DU CHERCHEUR

Je certifie qu'on a expliqué au sujet de recherche les termes du présent formulaire d'information et de consentement, que l'on a répondu aux questions que le sujet de recherche avait à cet égard et qu'on lui a clairement indiqué qu'il demeure libre de mettre un terme à sa participation, et ce, sans préjudice.

Je m'engage, avec l'équipe de recherche, à respecter ce qui a été convenu au formulaire d'information et de consentement et à en remettre une copie signée au sujet de recherche.

_____	_____	_____	_____
Nom du chercheur	Fonction	Signature	Date

Autorisation de communiquer avec moi et

Prolongation éventuelle de la présente recherche

Il se peut que l'équipe de recherche ajoute un volet additionnel à cette étude, afin de voir si les informations recueillies maintenant peuvent aider à prédire certains événements dans le dossier des conducteurs. Si ce projet se réalisait, j'accepte que les membres de l'équipe de recherche entrent à nouveau en contact avec moi pour me demander si j'accepte d'y participer.

J'autorise les membres de l'équipe de recherche à entrer en contact avec moi aux numéros de téléphone mentionnés ci-dessous s'ils désirent me parler. S'ils rejoignent une autre personne que moi-même ou s'ils laissent un message sur mon répondeur, les membres de l'équipe de recherche prendront soin de ne pas mentionner le sujet de l'étude.

J'autorise les membres de l'équipe de recherche à me faire parvenir du courrier à mon adresse courante, pourvu que l'enveloppe ne fasse pas mention de l'Institut universitaire en santé mentale Douglas.

J'autorise les membres de l'équipe de recherche à entrer en contact avec les personnes dont les coordonnées se trouvent ci-dessous uniquement pour reprendre contact avec moi si j'ai déménagé ou si je ne peux pas être rejoint directement. Ils pourront mentionner que j'ai participé à un projet de recherche, sans mentionner l'Institut universitaire en santé mentale Douglas, le sujet de l'étude ou d'autres informations personnelles. Cette autorisation de communiquer à nouveau avec moi est valide jusqu'en décembre 2018.

Nom du participant (lettres moulées) : _____

Signature du participant : _____ Date : _____

Adresse : _____

_____

No de téléphone : maison : _____ travail : _____

Courriel :_____

Nom d'une première personne-ressource (lettres moulées) : _____

Lien avec vous : _____ No de téléphone : _____

Nom d'une deuxième personne-ressource (lettres moulées) : _____

Lien avec vous : _____ No de téléphone : _____

Appendix 2: Consent Forms (EN)

INFORMATION AND CONSENT FORM

1. TITLE OF THE RESEARCH PROJECT

Douglas INSTITUT UNIVERSITAIRE EN SANTÉ MENTALE / MENTAL HEALTH UNIVERSITY INSTITUTE	**Putative Mechanisms Underlying Decision Making in High Risk Drivers (HRD)**

This study is conducted by researchers from the Addictions Research Program of the Douglas Mental Health University Institute.

Principal Investigator:
Thomas G. Brown, Ph.D., Department of Psychiatry, McGill University

Co-Investigator and Research Coordinator:
Samantha Ashley Wells, M.Sc. student, Department of Psychiatry, McGill University

Granting Agency: Canadian Institutes of Health Research (CIHR)

2. INTRODUCTION

We are soliciting your participation in a research project. However, before accepting to participate in this project and signing the information/consent form, take the time to read, understand and carefully examine the following information.

This form may contain words that you do not understand. We are inviting you to ask any questions that you may have to the researcher or the other members of the team in charge of the research project, and ask them to explain any words or information that is unclear to you.

3. NATURE AND OBJECTIVES OF THE RESEARCH PROJECT

The objective of this study is to examine decision making in high risk drivers. We hope to determine if high risk drivers are characterized by a certain type of decision making compared to controls. We would also like to examine the mechanisms underlying decision making in high risk drivers by studying their performance on several decision making tasks.

Two groups of individuals are being recruited for this study in order to compare decision making in high risk drivers and controls:

- The first group consists of 20 male controls who have never been convicted of driving while impaired nor for road traffic infractions over the course of the last two years.
- The second group consists of 40 male high risk drivers who have been convicted of at least 3 road traffic infractions in the last two years or who have been convicted of driving while impaired at least twice.

4. PROCEDURES OF THE RESEARCH PROJECT

This study will take place at the Addiction Research Program at the Douglas Mental Health University Institute. Your participation consists of one single visit of approximately three hours.

1. Upon arrival at the ARP, you will be asked to present picture identification to validate your identity, as well as your driver's license.
2. You will be asked to provide proof of your SAAQ driving record.
3. You will be asked to complete a Breathalyzer© test to ensure that you are not under the influence of alcohol at the time of your study session. A participant having a Breathalyzer© test indicating alcohol use on the day of testing or a participant exhibiting signs of being under the influence of drugs or alcohol will not be allowed to continue the session. Their appointment will be delayed or rescheduled.
4. If you have ever had seizures or if you suffer from hypertension or take medications for the heart, lungs or epilepsy, you will meet with a nurse who will take your blood pressure and pulse and will ask you several questions regarding your health status. Depending on the case, it is possible that you will be asked to complete a brief physical examination by a licensed physician, involving an examination of your neck, heart, lungs, abdomen and reflexes to verify your overall fitness to participate in the study.
5. For all other participants for whom point 4) above does not apply: the coordinator will ask you several questions regarding your health status. Depending on the case, it is possible that you will be asked to complete a brief physical examination by a licensed physician, involving an examination of your neck, heart, lungs, abdomen and reflexes to verify your overall fitness to participate in the study.
6. You will then be asked to fill out several questionnaires related to substance use, attitudes and driving behaviours.
7. You will then be asked to complete two computer tasks.
8. You will then be asked to complete an interview regarding your alcohol and drug consumption.
9. You will then be asked to complete two driving simulation tasks.
10. This study is anticipated to take approximately three hours.
11. At the end of the session, you will be given $40 compensation for your time as well as any additional amount you may receive for various tasks. You will also be given a written report based on your alcohol and/or drug consumption.

5. COLLABORATION OF THE SUBJECT IN THE RESEARCH PROJECT

It is asked of the participant not to be under the influence of alcohol or any drugs immediately prior to or during the participation in the research project. For this reason, participants are asked to abstain from alcohol consumption for at least twelve hours prior to the study session.

6. RISKS ASSOCIATED TO THE RESEARCH PROJECT

It is not likely that this research project poses a risk for your physical or psychological well-being, however, it is possible that the nature of the questions that you will be asked to answer might create anxiety; if this becomes the case, you are invited to discuss the situation with the research coordinator who will be able to provide you with appropriate resources if necessary. Other possible disadvantages that might be experienced are fatigue, stress, and frustration related to testing, transportation, waiting and time devoted to research.

Some individuals experience motion sickness in the vehicle simulator. If you are experiencing simulation sickness, notify the research assistant immediately. Testing procedures will be stopped immediately without any prejudice. Participants who experience simulation sickness will be monitored until their symptoms disappear. If you experience motion sickness in the simulator and are withdrawn from the study, you will still receive $40 for your participation.

7. ADVANTAGES

You will not get any personal benefit from your participation in this research project. However, the study results may assist in the advancement of knowledge in this field.

8. VOLUNTARY PARTICIPATION AND POSSIBILITY TO WITHDRAW

Your participation in this research project is voluntary. You are therefore free to refuse to participate. You can also withdraw from the project at any moment, without giving any reason, by informing the researcher in charge of the project or one of the members of the research team.

The researcher in charge of the research project, the research ethics committee of the Douglas Mental Health University Institute or the granting agencies could put an end to your participation, without your consent, if new findings or information is no longer in your interest, if you do not follow the research project instructions, or for administrative reasons that would force ending the project.

If you withdraw or are withdrawn from the project, all information already collected in the course of the project can be destroyed upon your request.

9. CONFIDENTIALITY

We understand the potentially sensitive nature of the information we are requesting from you. The SAAQ or other organizations, legal or otherwise, will not have access to the information you provide. All measures will be taken to keep your information strictly confidential unless otherwise specified by law.

Based upon youth protection laws, researchers who have reasonable grounds to believe that the safety or development of a child is compromised due to sexual or physical abuse or negligence are required to report these suspicions to youth protection authorities. In addition, if the information you provide strongly suggests an imminent risk of suicide or physical abuse to yourself or others, we must inform the appropriate health and legal authorities.

During your participation in this project, the project researcher and his team will collect and record the information concerning you in a study file. Only the data required to meet the scientific goals of the project would be collected. In order to protect your identity and the confidentiality of the information you provide, only a code number will identify you. The key to the code linking your name to your study file will be kept by the principal investigator. These data will be destroyed seven years after data collection is completed. Only data without personal identifying information will be conserved for an additional three years after this period. We expect the data collection phase will be completed at the end of 2012.

To ensure the proper management of the research, it is possible that a member of an ethics committee may consult your research data.

Any presentations or publications arising from this project will not connect you with any of the information collected.

You have the right to consult your study file in order to verify the information gathered and to rectify it if necessary, as long as the project researcher or the institution holds this information. However, in order to protect the scientific integrity of the research project, you would have access to certain information only once this project has come to an end.

10. FUNDING OF THE RESEARCH PROJECT

The researcher in charge of the project received funding from the Canadian Institutes of Health Research for the successful completion of the research project.

11. COMPENSATION IN CASE OF INJURY AND RIGHTS OF THE RESEARCH SUBJECT

If you should suffer any injury following your participation in the research project, you will receive the appropriate care and services for your medical condition without charge to you.

By accepting to participate in this project, you are not waiving any of your legal right nor discharging the researchers of the institution of their civil and professional responsibility.

12. INCIDENTAL FINDINGS AND COMMUNICATION OF RESULTS

The results of this study are not subject to a medical or psychological evaluation. However, you will be given a written report based on your alcohol and/or drug consumption. If your responses suggest problematic substance use, you will be encouraged to seek help from your health care professional.

13. COMPENSATION

You will receive $40 for your time in addition to any compensation you may receive for various tasks.

14. IDENTIFICATION OF CONTACT PERSONS

If you have questions concerning the research project or if you feel you have a problem related to your participation in the research project, you can communicate with the project researcher and project coordinator at the following numbers:

Thomas G. Brown, principal investigator: (514) 761-6131, extension 3415

Samantha Wells, co-investigator and research coordinator: (514) 761-6131, extension 6181

If you would like to discuss your participation with an individual not directly involved in this project, you may contact the Ombudsman of the Douglas Mental Health University Institute, 6875 Lasalle blvd., Montreal (Quebec), H4H 1R3, telephone: (514) 761-6131 ext. 3287.
E-mail : Ombudsman@douglas.mcgill.ca

15. CONTROL OF THE ETHICAL ASPECTS OF THE RESEARCH PROJECT

The Ethics Research Board of the Douglas Mental Health University Institute approved this research project and guarantees the follow-up. In addition, it will first approve any review and amendment made to the information/consent form and to the study protocol.

Douglas INSTITUT UNIVERSITAIRE EN SANTÉ MENTALE / MENTAL HEALTH UNIVERSITY INSTITUTE	**Putative Mechanisms Underlying Decision Making in High Risk Drivers (HRD)**

Principle Investigator:
Thomas G. Brown, Ph.D., Department of Psychiatry, McGill University

Co-Investigator and Research Coordinator:
Samantha Ashley Wells, M.Sc. Candidate, Department of Psychiatry, McGill University

DECLARATION OF SUBJECT CONSENT

I took notice of the information/consent form. I acknowledge that the research project was explained to me, that my questions were answered and that I was given sufficient time to make a decision.

I agree to participate in this research project according to the conditions stated above. A dated and signed copy of the present information/consent form will be given to me.

Name of participant (please print)	Signature	Date

	Yes	No
I consent that data collected in this study could be used for future research projects on drinking and driving in the next 10 years if they have been previously approved by a research ethics committee and respect the same confidentiality and information protection policies. The key to the code linking my name to my study file will be kept by the principal investigator.	☐	☐

DECLARATION OF INVESTIGATOR ENGAGEMENT

I hereby certify that I have explained to the research subject the terms of the present information/consent form, that I have answered the questions that the subject had in that respect and that we have clearly indicated that he remains free to withdraw from the study, without suffering any prejudice.

I commit myself, as well as the research team, to respect what was agreed upon in the information/consent form and to give a signed copy of this form to the research subject.

Name of Researcher	Position	Signature	Date

Douglas INSTITUT UNIVERSITAIRE EN SANTÉ MENTALE / MENTAL HEALTH UNIVERSITY INSTITUTE	**Authorization to contact me and extension of the present study**

It is possible that the research team will add an additional part to this study, specifically to clarify whether future driving events can be predicted by current information. If this study is conducted, I authorize the members of the research team to re-contact me to ask me to participate in this study.

I authorize members of the research team to contact me at the phone numbers indicated below if they wish to reach me. If another person answers or a message is left on an answering machine, research personnel will not provide any information concerning the study.

I authorize members of the research team to send me mail at my present address. The envelope will provide no indication that it is from the Douglas Mental Health University Institute.

I authorize members of the research team to contact the individuals whose coordinates are provided below only to re-establish contact with me if I have moved or cannot be contacted directly. Only my participation in a research study will be mentioned, with no mention of the Douglas Mental Health University Institute, the subject of the study or any other personal details. This authorization to re-contact me is valid until December 2018.

Name of participant (print): _____

Signature of participant: _____ Date: _____

Address: _____

_____

Telephone #: home: _____ work: _____

Email address: _____

Name of first contact person (print): _____

Relationship with you: _____ Phone number: _____

Name of second contact person (print): _____

Relationship with you: _____ Phone number: _____

Appendix 3: Neuropsychological Task Instructions (FR)

Directives

Maintenant vous devrez compléter deux tâches. Si votre performance vous place parmi les cinq meilleurs des dix derniers participants, vous recevrez une compensation additionnelle de 5$. C'est important d'écouter les directives attentivement et de faire de votre mieux.

Iowa Gambling Task (IGT)

1. Devant vous à l'écran, il y a quatre paquets de cartes: A, B, C et D.

2. Je veux que vous choisissiez une carte à la fois, à partir du paquet de votre choix, en cliquant dessus.

3. Chaque fois que vous sélectionnez une carte, l'ordinateur vous dira que vous avez gagné de l'argent. Je ne sais pas combien d'argent vous allez gagner. Vous le découvrirez en cours de route. Chaque fois que vous gagnez, la barre verte s'allonge.

4. De temps à autre, toutefois, lorsque vous cliquez sur une carte, l'ordinateur vous indique que vous avez gagné de l'argent mais aussi que vous en avez perdu. Je ne sais pas quand vous allez perdre ou combien vous perdrez. Vous le découvrirez en cours de route. Chaque fois que vous perdez, la barre verte raccourcit.

5. Vous êtes tout à fait libre d'alterner entre les paquets en tout temps et aussi souvent que vous le voulez.

6. Le but du jeu est de gagner le plus d'argent possible. Si vous ne pouvez en gagner, évitez autant que possible d'en perdre.

7. Vous ne saurez pas quand la partie prendra fin. Vous devez continuer à jouer jusqu'à ce que l'ordinateur s'arrête.

8. Je vais vous donner un crédit (la barre verte) pour débuter la partie. La barre rouge, ici, est là pour vous rappeler combien d'argent vous avez emprunté pour jouer et combien d'argent vous devrez rembourser avant qu'on puisse voir combien vous avez gagné ou perdu.

9. Il est important que vous sachiez que l'ordinateur ne change pas l'ordre des cartes une fois que la partie est commencée, comme dans un vrai jeu de cartes. Vous n'arriverez peut-être pas à déterminer exactement quand vous perdrez de l'argent, mais le jeu est juste. L'ordinateur ne vous fait pas perdre de l'argent au hasard ou en fonction de la dernière carte que vous avez choisie. De plus, tous les paquets contiennent un nombre égal de cartes de chaque couleur (rouge et noir), donc la couleur des cartes ne peut vous aider à identifier quels sont les meilleurs paquets. Alors, n'essayez pas de comprendre ce que fait l'ordinateur. Tout ce que je peux

vous dire, c'est que certains paquets sont pires que d'autres. Vous trouverez peut-être que tous les paquets sont mauvais, mais certains sont pires que d'autres. Peu importe combien vous vous trouvez à perdre, vous pourrez encore gagner si vous évitez les pires paquets. Veuillez considérer l'argent de ce jeu comme de l'argent véritable; prenez toutes vos décisions comme s'il s'agissait de votre propre argent.

Game of Dice Task (GDT)

1. Bienvenue à la Jeu de Dés.

2. Pour cette tâche, vous allez lancer un dé virtuel 18 fois.

3. Avant chaque lancer, vous pourrez parier sur les résultats en sélectionnant un seul chiffre (par ex. «3») ou une combinaison de deux à quatre chiffres (par ex. «1-2-3»).

4. Le montant d'argent qui peut être gagné ou perdu varie selon ces combinaisons.

5. Vous recevrez un capital de départ de 1 000$.

6. Votre but est de maximiser ce capital en 18 lancers de dés.

Appendix 4: Neuropsychological Task Instructions (EN)

Instructions

Now you are going to be completing two tasks. If your performance ranks you within the 5 best of the last 10 participants in the study, you will receive an additional $5 compensation. It is important to listen to the instructions carefully and try to do your best.

Iowa Gambling Task (IGT)

10. In front of you on the screen, there are four decks of cards: A, B, C, and D.

11. I want you to select one card at a time, by clicking on the card, from any deck you choose.

12. Each time you select a card, the computer will tell you that you won some money. I do not know how much money you will win. You will find out as we go along. Every time you win, the green bar gets bigger.

13. Every so often, however, when you click on a card, the computer tells you that you won some money, but then it says that you also lost some money, too. I don't know when you will lose, or how much you will lose. You will find out as we go along. Every time you lose, the green bar gets smaller.

14. You are absolutely free to switch from one deck to another any time, and as often as you wish.

15. The goal of the game is to win as much money as possible and, if you can't win, avoid losing money as much as possible.

16. You won't know when the game will end. You must keep on playing until the computer stops.

17. I am going to give you a credit, the green bar, to start the game. The red bar here is a reminder of how much money you borrowed to play the game, and how much money you have to pay back before we see how much you won or lost.

18. It is important to know that just like in a real card game, the computer does not change the order of the cards after the game starts. You may not be able to figure out exactly when you will lose money, but the game is fair. The computer does not make you lose money at random, or make you lose money based on the last card you picked. Also, each deck contains an equal number of cards of each color (red and black), so the color of the cards does not tell you which decks are better in this game. So you must not try to figure out what the computer is doing. All I can say is that some decks are worse than others. You may find all of them bad, but some are worse than others. No matter how much you find yourself losing, you could still win if you stay away from the worst decks. Please treat the play

money in this game as real money, and any decision on what to do with it should be made as if you were using your own money.

Game of Dice Task (GDT)

1. Welcome to the Game of Dice Task.

2. In this task, you are going to throw a virtual dice 18 times.

3. Before each throw, you will be able to bet on the outcome by selecting a single number (e.g. '3') or combinations of 2 to 4 numbers (e.g. '1-2-3').

4. The amount of money that can be won or lost differs between these combinations.

5. You are given a starting capital of $1,000.

6. Your job is to maximize this capital within 18 throws of the dice.

Appendix 5: Simulator Task Instructions (FR)

Directives

Aujourd'hui, vous allez conduire le simulateur à trois reprises, la première fois sera une pratique. Les tâches sont censées prendre environ six minutes chacune. Il est important d'écouter attentivement les instructions et d'essayer de faire de votre mieux.

Pratique

1. La pratique vous permettra de vous habituer à la conduite du simulateur.

2. Prenez le temps d'ajuster le siège et les pédales.

3. Tout fonctionne comme un véhicule normal. L'accélérateur est à droite et le frein à gauche. Cependant, il n'est pas nécessaire d'utiliser les clignotants. Le simulateur est un véhicule automatique. Lorsque la pratique va débuter, le véhicule est à drive, donc comme dans tout véhicule automatique, si votre pied n'est pas sur le frein, le véhicule avance. Donc, mettez votre pied sur le frein et ne touchez pas tout de suite au volant. Attendez que je vous le dise avant de commencer.

4. Quand vous conduisez, évitez de faire des mouvements brusques avec le volant. Aussi, essayez de freiner et de prendre les virages doucement pour vous habituer au simulateur.

5. Vous pourriez avoir l'impression que vous roulez à une vitesse plus ou moins élevée par rapport à la réalité. Le but de la simulation est d'être le plus représentatif possible de vos habitudes de conduite habituelles. On vous demande donc de le conduire de la même manière que vous conduisez sur la route. Les règles du Code de la Sécurité routière s'appliquent comme elles le font sur la route.

6. Pour la pratique, vous conduirez sur une route pendant 2 minutes. La pratique vise à vous donner la chance d'apprendre comment utiliser le volant, les freins, l'accélérateur et à vous habituer au siège ainsi qu'à façon dont le simulateur réagit lorsque vous dépassez d'autres véhicules. Prenez le temps de vous familiariser à dépasser le véhicule devant vous.

7. À n'importe quel moment durant la simulation, vous pouvez me demander d'arrêter si vous ne vous sentez pas bien (étourdissement, mal au cœur).

8. L'écran deviendra noir pendant 30 secondes avant que la simulation commence. C'est très important que vous ne touchiez pas au volant puisqu'il bouge brusquement par lui-même.

9. (Quand c'est prêt) : Vous pouvez commencer maintenant.

Maintenant que vous avez fait la pratique, vous êtes prêt à faire les deux tâches. Voici les règles: si vous complétez chaque tâche en 5 minutes ou moins, vous obtiendrez 10 $ de plus.

Conduite 1

1. On va vous demander maintenant de compléter la première tâche de simulation. Cette tâche est censée prendre environ 6 minutes.

2. Si vous avez un accident, la tâche arrêtera temporairement et vous serez remis sur la route après quelques secondes. Cela augmentera le temps qu'il vous faut pour compléter la tâche.

3. Le but est de compléter le parcours le plus rapidement possible.

Conduite 2

1. On va vous demander maintenant de compléter la deuxième tâche de simulation. Cette tâche est censée prendre environ 6 minutes.

2. Si vous avez un accident, la tâche arrêtera temporairement et vous sera remis sur la route après quelques secondes. Cela augmentera le temps qu'il vous faut pour compléter la tâche.

3. Le but est de compléter le parcours le plus rapidement possible.

<u>Déception Étude Suivi</u>

Bien que nous vous ayons dit que vous recevrez une compensation additionnelle de 10 $ si vous complétiez les tâches en 5 minutes ou moins, en fait, tous les participants ont reçu 10$. Nous avons fait cela pour motiver les participants à faire de leur mieux.

Appendix 6: Simulation Task Instructions (EN)

Instructions

Today you are going to drive the simulator three times; the first time will be a practice. The tasks are supposed to take approximately six minutes each. It is important to listen to the instructions carefully and to try to do your best.

Practice

1. The practice will allow you to get used to the driving the simulator.

2. Take your time to adjust your seat and pedals.

3. Everything works like a normal vehicle. The gas is on the right and the brake is on the left. However, it is not necessary to use your blinkers. The simulator is an automatic vehicle. When the practice starts, the vehicle will be in drive, so like in other automatic vehicles, if your foot is not on the brake, the vehicle advances. So, put your foot on the brake and do not touch the steering wheel yet. Wait until I tell you to start.

4. When you drive, avoid making any abrupt movements with the steering wheel. Also, try to brake gently to get used to the simulator.

5. You might have the impression that you are driving at a speed faster or slower than in reality. The goal of this simulation is to be as representative as possible of your usual driving. We therefore ask you to drive in the same way as you drive on the road. The rules of the Code de la sécurité routière apply as they do on the road.

6. For the practice, you will be driving on a road for about 2 minutes. The practice is intended to give you the chance to learn how to use the steering wheel, the break, the accelerator and get used to the seat as well as how the simulator reacts when you pass other vehicles. Take the time to get used to passing the vehicle ahead of you.

7. At any time during the simulation, you can ask to stop if you do not feel well (dizzy, nauseous).

8. The screen will be black for 30 seconds until the simulator starts. It is very important that you do not touch the steering wheel until I tell you that you can start because it moves abruptly on its own.

9. (When it's ready): You can now start.

Now that you have done the practice, you are ready to do the two tasks. Here are the rules: if you complete each task in 5 minutes or less, you will get an additional $10.

Drive 1

1. You will now complete the first driving task. This task is supposed to take approximately 6 minutes.

2. If you crash, the task will temporarily stop and you will be placed back on the road after several seconds. This will increase the time it takes you to complete the task.

3. Your goal is finish this task as quickly and safely as possible.

Drive R

1. You will now complete the second driving task. This task is supposed to take approximately 6 minutes.

2. If you crash, the task will temporarily stop and you will be placed back on the road after several seconds. This will increase the time it takes you to complete the task.

3. Your goal is finish this task as quickly and safely as possible.

<u>Deception Follow Up</u>

Even though I told you that you will get an additional $10 compensation if you completed the tasks in 5 minutes or less, in reality, all participants were given the additional $10. We did this to motivate participants to do their best.

Appendix 7: Description of Simulation Variables

Variable description for overtaking manoeuvres

Simulation variables were calculated by superimposing a 40 cm-ruler to the computer screen (NEC EA231WMI Paysage; 1680 x 1050) on which the simulation videos were analyzed. The right lane's road extends from approximately 15 cm (interior solid yellow line) to 24.5 cm (interior white line to the right), with the center of the road existing at approximately the 20 cm mark.

Number of overtaking manoeuvres

An overtaking manoeuvre in this study refers to a participant crossing the median line, passing the vehicle in front on them and successfully returning to their lane. More specifically, the "start" time of the overtaking manoeuvre (crossing the median into the other "left" lane) occurs when the interior of the solid yellow median line >17.5 cm (pink arrow). The "end" time of the overtaking manoeuvre (crossing the median into the initial "right" lane) occurs when the solid yellow median line = 15 cm (blue arrow). An overtaking manoeuvre only occurs if a truck is passed. It is also possible that participants drive off-road for several seconds while completing their overtaking manoeuvre, which will increase the time it takes to complete their overtaking manoeuvre.