Putative Mechanisms Underlying Risky Decision-Making in High Risk Drivers

Samantha Ashley Wells\textsuperscript{1,2}, Thomas Gordon Brown\textsuperscript{1,2}
Psychiatry Department, McGill University
Psychiatry Department, Douglas Hospital Research Centre

Abstract

Introduction
The Iowa Gambling Task (IGT) is a neuropsychological task that measures two types of decision-making: i) under risk, and ii) under ambiguity. Investigations using the IGT in groups of high risk drivers (HRDs) consisting of driving while impaired (DWI) offenders suggest that a deficit in decision-making under risk is present in HRDs. However, the IGT may be measuring broader cognitive dimensions other than decision-making. Validation of these findings is needed with more direct measurement of decision-making under risk in a more representative sample of HRDs. It is hypothesized that: 1. HRDs will perform worse than Controls (CTLs) on a task that measures decision-making under risk alone, the Game of Dice Task (GDT); and 2. Decision-making under risk via the IGT will be significantly associated to the GDT.

Methods
Male HRDs are included if they are between 19-40 years old, possess at least three moving violations (i.e., speeding) in the previous two years or ≥ 2 DWI convictions. CTLs have none of the above. Participants (n = 43 recruited of n = 45 targeted) complete the IGT, the GDT and questionnaires.

Results
In preliminary analyses, HRDs (n = 27; mean age = 29) did not differ from CTLs (n= 15; mean age = 25.0) in their scores for decision-making under risk on the IGT or the GDT. Additionally, scores on the IGT were not significantly correlated to scores on GDT. Exploratory analyses after dividing HRDs according to DWI involvement (i.e., Y/N) were done. Results suggest that HRDs who have not been convicted of DWI perform better on the IGT and GDT compared to CTLs and HRDs who have been convicted of DWI, who are comparable.

Conclusion
Preliminary findings do not support hypotheses. Given the heterogeneity of HRDs in this study, investigation of HRDs based on DWI involvement may better elucidate the role, if any, that decision-making plays in HRD.

Background
Road traffic safety is major global health concern. In 2004, road traffic crashes (RTC) accounted for 1.3 million deaths and were ranked as the 9\textsuperscript{th} most important burden on global health ("Global Burden of Disease 2004 Update," 2008). Numerous human factors contribute to the large number of road traffic fatalities, including lack of seatbelt use, excess speed, and drunk driving, also known as Driving While Impaired (DWI) by alcohol. Based on findings from epidemiological data, researchers and licensing program administrators are increasingly focused on a relatively small but particularly dangerous subgroup of the driver population,
known as high risk drivers (HRD). One operationalization of HRD signals drivers who have either: 1) three or more distinct 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 a two year period; or 2) been convicted for a first impaired driving offence (DWI) at BAC >0.16, refused to provide a breath sample, or have committed repeated DWI offences (Vezina, 2001). HRDs, compared to normal drivers, are over four times more likely to be implicated in deadly RTCs. A greater understanding of what leads some individuals to repeatedly engage in high risk driving behaviour is clearly needed.

Deficits in decision-making appear to underlie risky driving behavior (Lev, Hershkovitz, & Yechiam, 2008). The Iowa Gambling Task (IGT) is a widely used neuropsychological task measuring decision-making. The IGT is a complex task that measures decision-making under ambiguity (outcome probabilities unknown) in the first part of the task and decision-making under risk (outcome probabilities known) in the later part of the task. In previous studies in our laboratory as well as others, groups of HRDs consisting for the most part of DWI recidivists, show marked impairment in the last blocks of the task, suggesting a deficit in decision-making under risk (Kasar, Gleichgerrcht, Keskinilic, Tabo, & Manes, 2010; Maldonado-Bouchard, Brown, & Nadeau, 2012; Yechiam, 2008). One important facet about the IGT is that it relies on the integrity of diverse cognitive processes, such as reversal learning and working memory (Busemeyer & Stout, 2002; Fellows & Farah, 2005). In order to accurately investigate impaired decision-making as a cognitive pathway to HRD, it is important to determine whether impaired performance on the IGT is due to a deficit in decision-making under risk or to some other impairment. To do this, use of a well-validated task that measures decision-making under risk alone is needed. The Game of Dice Task (GDT), which has successfully identified impaired decision-making under risk in a variety of clinical populations (Brand, Labudda, & Markowitsch, 2006; Brand, Recknor, Grabenhurst, & Bechara, 2007; Labudda et al., 2008), seems well suited for this purpose.

In summary, preliminary evidence suggests that HRDs have a marked impairment in decision-making under risk, which may represent a neurocognitive pathway leading to HRD behaviors. Given the complexity and lack of ecological validity inherent in the tasks used to date, validation of these findings using more appropriate measures of decision-making under risk is needed.

Aims

The purpose of this study is to use two neuropsychological tasks to elucidate deficits in decision-making under risk as a putative mechanism underlying risky decision-making in HRDs. The main objectives of the current study are to (1) investigate decision-making under risk in a broader sample of HRDs and (2) validate the use of the IGT for this purpose using a more pure measure of decision-making under risk, the GDT.

Two hypotheses are tested: Hypothesis 1- HRDs will exhibit a deficit in decision-making under risk as measured by both the IGT and the GDT; Hypothesis 2 - decision-making under risk as measured by the IGT (Blocks 3-5) will be significantly associated to the GDT.

Methods

Recruitment
A total of 45 male participants aged 19-40 are targeted for recruitment in the current study (30 HRDs and 15 controls) through advertisements in local newspapers as well as databases and other research studies in the Addictions Research Program at the Douglas Mental Health University Institute in Montreal, Quebec, Canada. Individuals who are interested in participating in the study complete a preliminary telephone screening and if eligible, are assigned an appointment at their convenience. Upon arrival at the laboratory, participants are asked to provide proof of their identity and driving record, undergo a Breathalyzer® test to determine study eligibility (BAC 0.00 mg/dl) as well as read and sign the informed consent form. They then proceed to the study session, which consists of two counterbalanced neuropsychological tasks (IGT and GDT) and several questionnaires that assess alcohol and drug intake, driving behaviors and attitudes as well as sociodemographic information. After their participation, participants are debriefed about the study and are given $50 compensation for their time and effort.

**Measures**

The Iowa Gambling Task (IGT) and the Game of Dice Task (GDT) will be used to measure decision-making. In the IGT, the participant must choose between four decks of cards, two of which lead to higher immediate wins but long term losses (disadvantageous) and two of which lead to lower immediate wins but long term gains (advantageous). Adaptive performance on the IGT requires participants to pick from advantageous decks more than disadvantageous decks. The first two blocks of the IGT measure decision-making under ambiguity and the last three blocks of the IGT measure decision-making under risk. IGT scores are calculated based on five blocks of 20 trials each (100 trials total). For each block, the total number of selections from disadvantageous decks is subtracted from the total number of selections from advantageous decks. The IGT Total Score is the sum from all the decks, IGT under ambiguity is the mean score from blocks 1 and 2 and IGT under risk is the mean score from blocks 3-5.

In the GDT, participants bet on the outcome of several thrown dice. Advantageous betting decisions involve three or four number combinations (i.e. betting $100 that a 1, 2 or 3 will be thrown) as they are the most likely to occur and involve low gains/losses whereas disadvantageous betting decisions involve one or two number combinations (e.g. betting $1000 that a 1 will be thrown) as they are the least likely to occur but involve high gains/losses. Because the outcome probabilities of rolling a dice are known (the chances of rolling a 6 for example, is always 1/6 while the chances of rolling a 3,4,5 or 6 is always 4/6), the GDT measures decision-making under risk. The GDT Total Score is derived from subtracting the total number of disadvantageous betting decisions from the total number of advantageous betting decisions. A series of questionnaires are also administered to collect sociodemographic data, data regarding the participant’s alcohol and drug consumption as well as driving attitudes and behaviours.

**Results**

**Progress**

To date, 43 of the 45 study participants have been recruited and tested. Data from 42 of the tested participants have been processed and are used for the analyses here.

**Testing of Primary Hypotheses** (see Table 1 below)
**Hypothesis 1:** Mann-Whitney U independent samples test was performed using the aggregate scores from blocks 3-5 of the IGT as well as the aggregate scores of the GDT to compare HRDs and CTLs. Hypothesis 1 was not supported. CTLs were not found to have significantly lower scores for decision-making under risk as measured by the IGT or the GDT.

**Hypothesis 2:** A bivariate correlation was performed for Hypothesis 2 using the aggregate scores from blocks 3-5 of the IGT as well as the aggregate scores of the GDT. Hypothesis 2 was not supported. Aggregate scores for decision-making under risk as measured by the IGT (blocks 3-5) were not found to be significantly correlated to the GDT.

**Exploratory Results** (see Table 2 below)

Given that the majority of the preliminary data regarding decision-making deficits in HRDs were conducted with samples of DWI offenders, the HRD group was divided according to whether or not they had ever been convicted of a DWI offence. Though not reaching significance (possibly due to the small sample size), a consistent pattern based on the IGT and GDT scores emerged. For decision-making under risk (measured by blocks 3-5 of the IGT as well as the GDT), alcohol-related HRDs performed similarly to controls while both groups were outperformed by the alcohol-unrelated HRDs.

**Discussion and conclusions**

Preliminary data analysis does not support the hypothesis that decision-making under risk underlies the risky behaviour of HRDs as a whole. Furthermore, concurrent validation of the IGT data (specifically blocks 3-5) using the GDT was not supported. The majority of research into decision-making in high risk drivers, however, has been conducted using samples of DWI offenders. Exploratory analysis in this study suggests that looking at subgroups within the broader HRD sample may provide a more thorough understanding of the role that decision-making plays in high risk driving. Supplementary data analysis using the full range of variables available in the dataset as well as a more varied statistical repertoire will better elucidate decision-making in high risk drivers.
Table 1
Sociodemographic characteristics, substance use, Iowa Gambling Task (IGT) scores and Game of Dice (GDT) scores for High Risk Drivers (n=27) and Controls (n=15)

<table>
<thead>
<tr>
<th></th>
<th>High Risk Drivers</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age</td>
<td>29.04</td>
<td>5.02</td>
</tr>
<tr>
<td>Education</td>
<td>13.96</td>
<td>2.59</td>
</tr>
<tr>
<td>AUDIT</td>
<td>7.91</td>
<td>5.46</td>
</tr>
<tr>
<td>MAST*</td>
<td>11.61</td>
<td>11.07</td>
</tr>
<tr>
<td>DAST</td>
<td>1.70</td>
<td>1.26</td>
</tr>
<tr>
<td>Self-report DWI current</td>
<td>1.87</td>
<td>0.82</td>
</tr>
<tr>
<td>Self-report DWI lifetime</td>
<td>2.96</td>
<td>1.22</td>
</tr>
<tr>
<td>Age at first drink</td>
<td>13.61</td>
<td>2.84</td>
</tr>
<tr>
<td>Age at first intoxication</td>
<td>14.87</td>
<td>3.29</td>
</tr>
<tr>
<td>IGT Total Score</td>
<td>149.04</td>
<td>14.97</td>
</tr>
<tr>
<td>IGT Ambiguity Score</td>
<td>29.83</td>
<td>3.27</td>
</tr>
<tr>
<td>IGT Risk Score</td>
<td>31.09</td>
<td>4.99</td>
</tr>
<tr>
<td>GDT Total Score</td>
<td>39.30</td>
<td>8.67</td>
</tr>
</tbody>
</table>

AUDIT: Alcohol Use Diagnostic Identification; DAST: Drug Abuse Screening Test; MAST: Michigan Alcohol Screening Test; IGT: Iowa Gambling Task; GDT: Game of Dice Task

*significant at p < .05

Table 2
Iowa Gambling Task (IGT) scores and Game of Dice (GDT) scores for Alcohol-Unrelated HRDs (n=10), Alcohol-Related HRDs (n=17) and Controls (n=15)

<table>
<thead>
<tr>
<th></th>
<th>Alcohol-Related HRDs</th>
<th>Alcohol-Unrelated HRDs</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>IGT Total Score</td>
<td>149.13</td>
<td>15.56</td>
<td>149.20</td>
</tr>
<tr>
<td>IGT Ambiguity Score</td>
<td>28.35</td>
<td>3.54</td>
<td>26.60</td>
</tr>
<tr>
<td>IGT Risk Score</td>
<td>30.35</td>
<td>3.95</td>
<td>32.63</td>
</tr>
<tr>
<td>GDT Total Score</td>
<td>37.41</td>
<td>10.19</td>
<td>43.00</td>
</tr>
</tbody>
</table>

IGT: Iowa Gambling Task; GDT: Game of Dice Task
References


