Specific biomarkers of internalizing and externalizing characteristics among first-time driving while impaired offenders

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Abstract

Background
Studies have described the externalizing (e.g., antisocial propensity) and internalizing (e.g., anxiety, depression) characteristics of driving while impaired (DWI) recidivism. However, the respective contribution of those characteristics to recidivism risk and their underlying mechanisms are still unknown. Cortisol, a stress hormone, is a biomarker underlying various high-risk characteristics. Studies have found that first-time DWI (fDWI) offenders and recidivists have lower cortisol reactivity (CR) than non-DWI drivers. In other high-risk populations, internalizing characteristics has been positively correlated to cortisol basal levels (CBL). To disentangle the distinct recidivism trajectories in the fDWI offender population, this study explored whether cortisol measures were markers of externalizing and internalizing characteristics.

Aims
Hypotheses 1: CR is lower among fDWI offenders with higher versus lower externalizing propensity (driving violations, criminal arrests, antisocial tendency, sensation seeking, impulsivity); 2: CBL is higher among fDWI offenders with higher versus lower internalizing propensity (anxiety, depression).

Methods
Male fDWI offenders (n = 126) were recruited and submitted to the following protocols: Millon Clinical Multiaxial Inventory (antisocial tendency, anxiety, depression); Addiction Severity Index (major driving violations, criminal arrests); Sensation Seeking Scale; Barratt Impulsivity Scale and salivary cortisol measured after a psychosocial stress task and during a resting day. Cluster analyses and ANOVA were performed.

Results
fDWI offenders with higher externalizing propensity have a lower CR compared to offenders with lower propensity (F(1, 124) = 5.85, p = .017). Moreover, CBL is higher among offenders with higher versus lower internalizing propensity (F(1, 124) = 5.55, p = .020).
Discussion and conclusions
The current study revealed dissimilar associations between cortisol measures and externalizing and internalizing propensity among fDWI offenders. These results suggested that externalizing and internalizing characteristics, two high-risk dimensions associated to DWI recidivism, involved in specific underlying mechanisms. Increasing knowledge on these underlying mechanisms may more precisely explain the various etiological pathways to DWI recidivism.

Introduction
Road traffic injuries represent the ninth leading contributor to the burden of disease and injury (World Health Organization, 2004). Approximately one third of first-time driving while impaired (fDWI) offenders will recidivate (Impinen et al., 2009), with recidivists responsible for a disproportionate number of accidents involving alcohol (Nochajski & Stasiewicz, 2006). In order to improve traffic safety, a better understanding of the propensity of engaging in high-risk behaviour by fDWI offenders is needed.

High-risk propensity: externalizing and internalizing characteristics
Various studies have identified high-risk characteristics associated to driving while impaired (DWI) recidivism risk. Externalizing characteristics, as defined by criminal and antisocial behaviours, have been frequently linked to recidivism (LaBrie, Kidman, Albanese, Peller, & Shaffer, 2007). Attention has more recently turned to internalizing characteristics (i.e., depression, anxiety) in DWI. For example, a study investigating various personality and mental health characteristics among severe DWI offenders (BAC ≥ 0.10%) has shown that the only significant predictor of DWI relapse, over a two-year period, was depression (Hubicka, Källmén, Hiltunen, & Bergman, 2010). Furthermore, a high anxiety subgroup had instigated more at-fault crashes over the past three years and had more DWI episodes during the preceding year compared to low and medium anxiety subgroups (Dula, Adams, Miesner, & Leonard, 2010). Externalizing and internalizing characteristics seems associated with different pathways to fDWI behaviour (Schlauch, O'Malley, Rounsaville, & Ball, 2012). Still, the association between externalizing and internalizing characteristics and high-risk driving behaviours has not always been consistent (Ulleberg & Rundmo, 2003), suggesting that behavioural indices may be inadequate for disentangling the different trajectories to DWI. To reconcile these inconsistencies, one strategy is to shift focus onto neurobiological markers of behavioural risk.

Underlying neurobiological mechanisms of externalizing and internalizing characteristics
Investigators have suggested to incorporate biological and genetic factors for an improved understanding of DWI recidivism propensity (Eensoo, Paaver, Harro, & Harro, 2005). After exposure to a psychological or physiological stress, a cascade of hormones is activated from hypothalamic-pituitary-adrenal (HPA) axis with cortisol released from the adrenal cortex in the last stage of this process. Cortisol excretion follows a circadian rhythm that fluctuates throughout the day. As such, cortisol may be measured as cortisol basal level (CBL) or as reactivity (CR) to a stressful situation. The relationship between HPA axis, alcohol abuse and delinquent behaviour, led Brown and colleagues (2005) to posit that dysregulation of the HPA axis might be at play in DWI offenders as well.
Some studies showed that CBL or CR may be related differently to externalizing and internalizing characteristics. For now, some externalizing characteristics have been investigated in relation to CR of DWI offenders. First, Brown and colleagues (2005) found that CR of DWI offenders, measured by sampling saliva during a challenging neuropsychological assessment, was inversely correlated to the frequency of previous DWI convictions, a relationship especially marked in recidivists and significantly independent from alcohol abuse severity. Second, recidivists (Couture et al., 2008) and fDWI offenders (Couture et al., submitted) had a reduced CR than non-DWI controls. Finally, compared to fDWI offenders with higher CR to stress, offenders with lower CR were more likely to show lower educational achievement, exhibit greater impulsiveness, and smoke cigarettes. In these studies, stress reactivity was considered as the difference between pre-stress and post-stress cortisol measures. As such, lower CR seems related to various externalizing characteristics among DWI offenders, although CBL did not seem significant. In other populations, internalizing characteristics have been usually linked to CBL. Among adolescents, internalizing characteristics were associated to morning levels of cortisol (Ruttle et al., 2011). In addition, healthy young men with higher trait anxiety were associated to higher CBL but not to CR (Takahashi et al., 2005). Moreover, patients with major depressive disorders had higher CBL in the afternoon than controls, but no effect was found for CR (Burke, Davis, Otte, & Mohr, 2005). Even among healthy young adults, depressive symptomology was linked to higher CBL during waking hours (Pruessner, Hellhammer, Pruessner, & Lupien, 2003). To date, no studies conducted with DWI offenders have considered the association between internalizing characteristics and CBL.

In order to improve our understanding of DWI recidivism risk, the present study aimed to increase knowledge on how dissimilar HPA axis dimensions might be linked to higher externalizing and internalizing propensity. The study tested two hypotheses: 1) CR is lower among fDWI offenders with higher than those with lower externalizing propensity (driving violations, criminal arrests, antisocial tendency, sensation seeking, impulsivity); 2) CBL is higher among fDWI offenders with higher than those with lower internalizing propensity (anxiety, depression).

**Methods**

The current study, part of a longitudinal study, was conducted at the Douglas Mental Health University Institute, a McGill University affiliated facility located in Montreal, Quebec, Canada. Male fDWI offenders \( (n = 126) \) were recruited from ethics approved newspaper advertisements, posters and invitation letters displayed in public addiction treatment centers and company certified to install mandated interlock devices. Inclusion criteria: 1) age between 18 and 44 years; 2) minimum of a 6\(^{th}\) grade education; 3) access to official driving records from 2002 to 2016; and 4) fDWI conviction within the past 24 months. Exclusion criteria: 1) female sex, 2) medical conditions that could interfere with normal HPA, and 3) risk of alcohol withdrawal (assessment scale and physician examination) or alcohol consumption (blood alcohol concentration > 0.01% or visible substance-induced impairment) on testing day. Participants were invited to three sessions on separate days. The first session involved psychosocial and neuropsychological questionnaires. The next two sessions measured cortisol level with nine saliva samples. One session comprised of a resting period and the other, a stress task. The stress task comprised of answering mathematical questions under a time constraint for a monetary prize.

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Measures
For this study, the antisocial predisposition, anxiety and depression were assessed with the Millon Clinical Multiaxial Inventory III (Piotrowski, 1997). Sensation seeking was measured with the Sensation Seeking Scale form V (Zuckerman, 1994), and impulsivity was measured using the Barratt Impulsivity Scale version 11. Moreover, non-DWI major driving violations and non-DWI criminal arrests since the age of 18 (dichotomised as absence = 0 or presence = 1) were measured with the legal section of the Addiction Severity Index questionnaire (McLellan et al., 1985). Sociodemographic information was gathered from a combination of the Composite International Diagnostic Interview version 2.1 (World Health Organization, 1997), and specific questions regarding age, years of education, income, and kilometres driven during past 12 months. Cortisol level (µg/100 ml) was assessed with cotton swabs Salivette® devices. Using the nine samples from the rest session, CBL was calculated with the “area under the curve with respect to ground” formula (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). CR was considered as the difference between the sample before and after the stress task and during the stress session.

Analyses
Two step clusters were performed, with forced two classes, to classify fDWI offenders with higher and lower externalizing (driving violations, criminal arrests, antisocial tendency, sensation seeking, impulsivity) and internalizing (anxiety, depression) propensity, respectively. CR and CBL, as independent variables, were then entered in a one-way ANOVA for both cluster groupings (higher or lower externalizing and internalizing propensity).

Results
Participants had a mean age of 27.9 years (SD = 6.8), 14.1 years of education (SD = 2.6) and drove 10 937.7 kilometres during the past year (SD = 13 575.4). As expected in the first hypothesis, fDWI offenders with higher externalizing propensity had lower CR (M = .04, SD = .17) compared to offenders with lower externalizing propensity (M = .19, SD = .37; F(1, 124) = 5.85, p = .017, partial η² = .05). Finally, second hypothesis was also supported, more precisely, fDWI offenders with higher internalizing propensity had higher CBL (M = 73.87, SD = 86.11) than offenders with lower internalizing propensity (M = 46.86, SD = 42.20; F(1, 124) = 5.55, p = .020, partial η² = .04). Additional analysis suggested that fDWI offenders with higher or lower externalizing propensity were not differently distributed on higher or lower internalizing propensity (χ²(1) = 0.54, p = .548).

Discussion and conclusions
To date, studies of DWI offenders’ characteristics have rarely considered externalizing and internalizing characteristics simultaneously (Schlauch, et al., 2012) and their respective neurobiological underpinning. Though, such an approach may improve the inherent limits of descriptive research by understanding the fundamental mechanisms involved in DWI recidivism risk. In the current study, the consideration of two neurobiological markers (i.e., CR and CBL) seemed useful to identify two distinct ways offenders might get to DWI recidivism.

The two hypotheses of the present study were supported. The CR was lower among fDWI offenders with higher versus lower externalizing propensity, and the CBL was higher among
those with higher versus lower internalizing propensity. As such, even among the same fDWI offender sample, both externalizing and internalizing characteristics were present and linked differently to HPA axis dimensions. As seen among other populations, externalizing and internalizing characteristics were associated to different HPA axis dimensions. For example, among adolescents, externalizing characteristics were associated to diurnal cortisol slope (i.e., the amount of cortisol decline during the day) and internalizing characteristics were associated to morning levels of cortisol (Ruttle, et al., 2011). Still, the non-distinctiveness between externalizing and internalizing propensity grouping underlined the high comorbidity between these two distinct high-risk dimensions. To improve our understanding of DWI recidivism risk, the investigation of these two distinct, but highly linked, characteristics is warranted.

This cross-sectional study had some inherent limitations. First, it is impossible to attest whether CR or CBL predated or resulted of externalizing and internalizing characteristics. In addition, it is too early to speculate the reason why these characteristics were linked to different HPA axis dimensions. Still, it will be interesting to investigate, with the longitudinal part of the study, if these two different pathways are linked to future high-risk driving behaviours. Secondly, the study may not generalize to female fDWI offenders. In fact, female fDWI offenders have less externalizing and more internalizing characteristics compared to male fDWI offenders (Lapham et al., 2001).

To conclude, determination of subgroups with genetic/biological, physiological and behavioural endophenotypes may help better understand the various risk factors related to the development of high-risk behaviours (Hines, Ray, Hutchison, & Tabakoff, 2005). Accordingly, the current study added to this research area by improving knowledge on the various pathways to DWI recidivism risk.

References


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