Gender as Moderator of the Relationship Between Impulsivity and Driving After Cannabis Use

par

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Résumé

Les accidents routiers constituent de graves problèmes de santé publique dans le monde et les facteurs humains sont connus pour être le principal facteur d'accidents, impliquant principalement les jeunes adultes. Des études antérieures ont démontré que le genre ainsi que des facteurs liés à la personnalité tels que l'impulsivité sont associés à la conduite après consommation récente de cannabis, cependant, l'interaction de ces prédicteurs est rarement abordée dans la littérature. Pour cette raison, cette étude vise à explorer le processus par lequel une facette spécifique de l'impulsivité interagit avec le genre ou le sexe pour modérer la probabilité de prendre le volant après avoir consommé du cannabis. Des participants de 17 à 35 ans possédant un permis de conduire valide ont été recrutés à partir de Facebook par le biais d'annonces payantes. Ils étaient invités à remplir un questionnaire portant sur leur caractéristique socio-démographique, leur habitude de consommation de cannabis, ainsi que sur les composantes de l'impulsivité. Une analyse de modération a été effectuée pour clarifier la relation entre la recherche de sensations, le genre et la conduite d'automobile à l'aide du SPSS PROCESS. Le modèle proposé inclut la recherche de sensations comme variable exogène directement associée à la conduite après la consommation du cannabis, et cette relation est modérée par le genre ressenti. Effectivement, le genre ressenti des participants semble être une variable modératrice de l'association entre la recherche de sensation et la prise de volant après avoir consommé du cannabis. Les implications de ces résultats seront discutées.

Mots-clés: Cannabis, genre, sexe, masculinité, modération, impulsivité, recherche de sensation

Abstract

Road traffic crashes are a serious public health problem worldwide, and human factors are the most prominent factor of accidents, affecting mostly the young adults. Past studies found that both gender and personality traits such as impulsivity are associated with risky driving, however, the interaction of these predictors is rarely addressed in the literature. To bridge the gap, the present study explores how a specific facet of impulsivity interacts with our hypothesized moderator, gender identification, leads to drug driving using a moderator analysis. We recruited participants from 17 to 35 years old possessing a valid drivers' licence via Facebook advertising. They were invited to complete a questionnaire on their socio-demographic characteristics, cannabis consumption habits and impulsivity scores. A moderator analysis is conducted to disentangle the relationship between sensation seeking, gender and driving after cannabis consumption using SPSS Process. The proposed model contains sensation seeking as an exogenous variable directly associated with driving after cannabis use, and this relationship is moderated by gender identification. The current study provides evidence that sensation seeking and gender identification are not only associated with DACU but also interact to affect driving behaviour. Implications of the study are discussed.

Keywords: Cannabis use, DACU, gender identification, sex, masculinity, moderation, impulsivity, sensation-seeking

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Abbreviation

DACU: Driving after consuming cannabis

SDLP: Standard Deviation Lateral Position

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Gender as Moderator of the Relationship Between Impulsivity and Driving After Cannabis Use

Road traffic crashes are serious public health concern worldwide and one of the leading causes of death in Canada (Beirness & Beasley, 2010). In 2018, Canada recorded a total of 1841 road fatalities that cost 40.7 billion CAD to the society or 2.1% of the GDP (International Transport Forum, 2020). Human factors are known to be the most prominent contributor to accidents, meaning they are entirely preventable (Asbridge, Poulin & Donato, 2005). Risky driving behavior such as speeding, distracted driving and taking the wheel following substance use are all associated with a higher risk of road accidents (Bergeron, Langlois & Cheang, 2014; Richer & Bergeron, 2009). While alcohol was the most problematic substance on the road in the past century, the trend in the number of driver fatalities involving alcohol has been decreasing over the last two decades in Quebec (Perrault, 2016) and greater attention is directed at driving within a time frame after consuming cannabis. Since the legalization of non-medical use of cannabis, there is a growing concern regarding the incidence of driving after using cannabis and road accidents because research shows that cannabis induces impairment in driving performance (Bondallaz et al., 2016). In addition to life costs, vehicle crashes result in considerable medical expenses and property damage, thus highlighting the need for intervention to reduce the incidence of road collisions (International Transport Forum, 2020). When designing effective intervention programs, specific groups of individuals at greater risk of risky driving should be considered. In this context, the present thesis will summarize previous findings on driving after cannabis use (DACU) and propose individual characteristics associated with that risky behavior.

Terminology

In the first place, it is essential to distinguish terminology describing the consequences of cannabis use on driving performance. Non-medical use of cannabis includes using cannabis for pleasure, enjoyment, lifestyle and other non-medical reasons. For instance, detectable presence of cannabis implies being tested positive for cannabis whereas driving under the influence of cannabis means that the driver has used cannabis before taking the wheel and driving is impaired (Capler et al., 2017). THC concentration peaking was observed within two hours after consumption, but it can be detectable in plasma for two to seven days (Sharmas, Murthy, & Bharath, 2012). As such, THC-positive drivers are not necessarily driving while impaired. To avoid making assumptions about driving ability, the present thesis will employ the term driving after cannabis use (DACU) referring to individuals who have operated a vehicle two hours following drug consumption.

There are two common ways of consuming cannabis, inhaling or ingesting. When inhaled, the effects of cannabis begin as soon as a few seconds, peak within 30 minutes and dissipate over the course of the following six hours. On the contrary, the effects of ingested cannabis can be perceived within 30 minutes to two hours of consumption, peak within four hours and feature a duration of roughly 12 hours after use. Both usage routes have a residual effect that lasts up to 24 hours following consumption. The onset, peak and duration also depend on the user's tolerance and daily consumption (Canadian Centre on Substance Use and Addiction, 2019).

Prevalence

Data from self-report survey reveals a high rate of DACU among young adult drivers and that prevalence doubled from 1988 to 2004 in Canada. This represents 4.8% or over one million licenced drivers who report having operated a vehicle within two hours of cannabis intake in the

past 12 months (Beirness & Davis, 2006). More recently, according to the Canadian Cannabis Survey 2020, around 22% of users in the sample report they have driven at least once within two hours of smoking or vaporizing cannabis and 32% in the past 12 months (Health Canada, 2021). Since DACU is not a socially accepted behavior, the numbers in the general population are probably underestimated. Although the reported cannabis use prevalence increased after the implementation of the Cannabis Act, the incidence of reported DACU remained stable (Rotermann, 2020). In terms of demographic group use, the prevalence tends to be higher among young adults and males. Around 15.4% of Canadian cannabis users aged 16-19 report driving a vehicle within two hours of using cannabis in 2019 (Wadsworth & Hammond, 2019). The Canadian Cannabis Survey reports that among people who had used cannabis in the past 12 months, approximately 17% of males reported DACU whereas females represent only 9 % (Health Canada, 2021). Driving after cannabis use is therefore not an uncommon phenomenon on the road, especially among young males who might be an important target for messaging.

In addition to self-report surveys, roadside tests found that drugs are often tested positive in fatally injured drivers and the rate of serious crashes involving cannabis are causes for public concern as they could potentially lead to property damages, injuries and mortality. Specifically, in a sample of 345 cases of fatally injured drivers, 124 were tested positive for alcohol and 107 positive for other drugs in 2002 including cannabis (Dussault et al., 2002). According to a database from Ontario, 5.1% of road collision involves a driver who tested positive for THC in the blood. Among deadly injured drivers who received a toxicological test, 12.9% were tested positive for cannabis for the years 2002-2004 and 15.6% for the years 2011-2013 (Farassi, Gagné & Dubé, 2016). Outside Canada, California researchers obtained oral fluid samples from 1000 drivers and found that 8.5% of them have detectable THC. Nevertheless, the prevalence

should be considered with caution because the presence of THC in the blood does not indicate a recent consumption of cannabis or driving while intoxicated. A meta-review indicates cannabis use is associated with an increase in motor vehicle crashes (Rogeberg & Elvik, 2016), and the risk of collision is doubled after acute cannabis consumption (Asbridge, Hayden, & Cartwright, 2012).

Cannabis and driving performance

Experimental studies demonstrated that the primary psychoactive component of cannabis, THC, reduces specific cognitive abilities deemed necessary for safe driving when consumed at a moderate or greater dose (>18mg) and therefore increases the risk of injury (Ramaekers et al., 2004). Namely, braking latency, road tracking precision and mean headway distance with other vehicles are altered among participants who smoked cannabis five minutes prior to the driving test (Lenne et al., 2010). Even at low doses (6.25mg), cannabis impairs driving skills involving automatic functions such as road tracking (Sewell, Poling, & Sofuoglu, 2009). Driving simulator studies often measure impairment with an index known as Standard Deviation Lateral Position (SDLP), referring to the difficulty of keeping lateral road position within the drivers' lane (Hartman et al., 2015). For instance, an on-road study also measured drivers' performance using SDLP and found an increased impairment following consumption of one dose (10mg or 20mg) of cannabis (Bosker et al., 2012). Further, cannabis alone significantly increases a driver's SDLP in a dose-dependent manner but driving performance is severely impaired in combination with a low dose of alcohol (0.04g/dl). Mixing drugs is associated with more severe impairment in driving performance and greater accident risk (Ramaekers, Robbe & O'Hanlon, 2000). Berghaus et al. (1995) commented that cannabis-induced impairment in driving skills is highest during the first hour following the consumption. Yet, these damaging effects of cannabis may last beyond

the perceived acute intoxication. Heavy chronic users still experience deficits in attention and concentration after an abstinence period of 28 days (Bolla et al., 2002). In addition, imaging of users under the effects of 17mg THC shows alterations in the brain area involved in motor coordination and attention. On the behavioral side, 17mg of THC significantly increased the collision rate during the virtual reality maze task (Weinstein et al., 2008).

With regards to cannabis-related motor vehicle accidents, the general population survey reports increased accident involvement following cannabis intake, after controlling for alcohol use (Watson & Mann, 2016). Based on an extensive review of available literature on vehicle crashes, using cannabis increases the risk of motor vehicle accidents by approximately 20%-30%, and the odd ratio decreases when alcohol use is controlled. The study concluded that cannabis use is significantly associated with a low to medium magnitude increase in motor vehicle crash when controlling for other substance use (Rogeberg & Elvik, 2016). The increased risk estimate is low, nevertheless, it is still considered a meaningful increase (Capler et al., 2017). In another vein of the literature assessing culpability, Ramaekers and colleagues report that drivers who have been tested positive for THC in their blood are three to seven times more likely to be responsible or culpable for the crash than drivers who did not use any substance (Ramaekers et al., 2004). Another more recent study examining driver's culpability did not report a significant effect of cannabis on the risk of being responsible for a crash (Poulsen, Moar & Pirie, 2014). The presence of cannabis is detected among drivers involved in vehicle crashes but whether driving after consuming cannabis raises the risk of being responsible for the accidents remains an unanswered question (Capler et al., 2017).

Predictors of DACU

THC impairs driving skills and contributes to the risk of collision, but there is no evidence that cannabis use in isolation is a better predictor of taking the wheel after consuming cannabis than other characteristics inherent to the users. Other factors related to cannabis users such as socio-demographic characteristics, cognitive factors, and personality traits also play a role in deciding to take the wheel. From a traffic safety perspective, predictive variables of risky driving and under what circumstance this behavior is most likely to occur should be examined to provide key insight into this public health problem.

Socio-demographic characteristics such as younger age, being male and earning an annual income over 30,000$ are factors associated with a greater likelihood of engaging in DACU in Canada (Huynh et al., 2021). According to the Canadian Cannabis Survey, drivers aged between 20 to 24 have the highest prevalence of driving within two hours of smoking cannabis, with more males reporting this behavior in 2020 (Health Canada, 2021). Drivers in the age group 16 to 24 are twice more likely to be tested positive for cannabis than the age group 35 and older (CCSA, 2015). Adolescence is a period of heightened potential for risky behavior due to their flawed reasoning capabilities and poor decision-making skills than older adults (Arnett, 1992). Thus, this group may represent a broad target for risky driving prevention programs.

Risky driving behavior including speeding, negative emotional driving (Richer & Bergeron, 2009), and on-road violation (Blows et al., 2005) are associated with an increased risk of DACU. Further, driving under the influence of alcohol is also positively correlated with DACU (Richer & Bergeron, 2009). Fergusson and colleagues (2008) suggest that those risky behaviors on the road represent a general deviant lifestyle, putting individuals at higher risks of

collision. On the other side, emotional stability and self-reported mindfulness are protective factors against risky driving behavior (Safe States Alliance, 2019).

In terms of cognitive factors, lower expectation of negative effects is associated with DACU (Huynh et al., 2021). Those who believe that cannabis use leads to a depressive mood and loss of control are less likely to engage in DACU. Along the same line, the perceived dangerousness of driving after smoking cannabis is associated with a greater frequency of risky driving (Aston et al., 2016). Thus, the perception of dangerousness and potential risks concerning driving after consuming are likely key contributors to the decision to engage in DACU. In contrast, group norms and attitudes promoting safe driving behavior are considered positive factors that reduce individual vulnerability to risky driving (Safe States Alliance, 2019).

Psychosocial research suggests that individual personality differences are the central determinant of engagement in risky behavior such as driving after consuming psychoactive substances. Given the complication in measuring to what extent driving is impaired when cannabis is consumed, it is, therefore, necessary to examine predictive variables of DACU to target high-risk individuals for preventive purposes. According to Schwebel et al. (2006), a driver's personality is the most critical predictor of their risky driving behavior. Therefore, it is essential to consider those factors when tailoring effective intervention programs and identifying individuals at high risk of engaging in DACU. The following paragraphs will elaborate on the influence of specific personality traits and demographic factors such as gender.

Personality traits and DACU

Among those personality traits, impulsivity is often mentioned by many authors worldwide as a significant contributor to risk taking behavior (Dahlen et al., 2005; Fergusson, Horwood, & Boden, 2008; Richer & Bergeron, 2009; Ryb et al., 2006). Defined as behavior

occurring without reflection or forethought of consequences, impulsivity deals with one's control over thoughts or actions and high impulsivity leads to risk-taking due to the lack of self-control to refrain from dangerous activities (Dahlen et al., 2005). It is also one of the most common diagnostic criteria for many mental disorders including ADHD, conduct disorder, Substance Use Disorder and Antisocial Personality Disorder (American Psychiatric Association, 2013). As such, impulsivity has an essential role in the understanding of deviant and problematic behavior. Richer and Bergeron (2009) compared individuals who exhibited risky driving behavior such as DACU versus those who did not and found that individuals scoring high on specific personality determinant such as impulsivity are more likely to engage in DACU. While other personality traits such as risk-taking and hostility are also predictors of driving under the influence of cannabis, the association is no longer significant when cannabis consumption frequency is being controlled (Bingham, Shope & Zhu, 2008). From a neuroscience point of view, young drivers are more likely to engage in impulsive behavior given that executive brain function such as impulse control is not fully mature until the early adulthood. As such, impulsive individuals who cannot resist the urge will engage in risky behavior even if they understand the possible consequence (Hatfield et al., 2017). Additionally, impulsivity is present in nearly all major personality classification systems (Five-Factor Model, Three-factor model, PEN, and UPPS) and individual difference in this trait is related to socially deviant behavior (Whiteside & Lynam, 2001).

There are conceptual differences in the conceptualization of impulsivity in the literature, but it is now widely accepted that impulsivity is a multi-faceted construct. Multiple related dimensions underlie impulsive action (Dawe & Loxton, 2004). In attempt to identify specific facets of impulsivity across measures, Whiteside & Lynam (2001) integrated previous research and presented a new perspective, labeled the UPPS model of personality, which includes five

distinct facets of impulsivity: positive urgency, negative urgency, sensation-seeking, premeditation and perseverance. The UPPS Impulsive Behavior Scale has become a popular tool for assessing personality traits as it takes into account the heterogeneous nature of impulsivity. According to the model, the facets are not considered as variations of any psychological trait, they are rather discrete psychological processes associated with overt impulsive behavior. For instance, urgency refers to impulsive behavior evoked to reduce negative affect, (lack of) perseverance reflects the inability to concentrate on a task or ignore distracting stimuli, (lack of) premeditation is related to lack of anticipation for consequence and lastly, sensation seeking is defined as the tendency to seek excitement.

Each facet demonstrates specificity in relation to psychopathology (Um et al., 2018). For instance, lack of premeditation and lack of perseverance is correlated with ADHD, whereas negative urgency displays the largest effect size for borderline personality traits (Berg et al., 2015). Sensation seeking is the most documented trait predicting risky driving and driving after substance intake. Notably, the sensation seeking facet has two key features relevant to our subject: a tendency to pursue exciting activities and openness to try dangerous experiences (Whiteside & Lynam, 2001). Although similar, but there is a subtle difference between impulsivity and its facet sensation seeking. Impulsivity is defined as deliberate action without self-control that leads to unplanned behavior whereas sensation seeking refers to the tendency to take risks for stimulating experiences and it appears to underlie different forms of risk-taking behavior (Steinberg et al., 2008). Lydon-Staley, Falk and Bassett (2020) found that participants scoring high in trait sensation seeking engage in a greater diversity of risky behaviors and that finding aligns with the core concept of the trait, the tendency to seek exciting experiences. High sensation seekers are willing to take financial, legal, and social risks to engage in intense

experiences. This facet also predicts disadvantageous decision-making under risk (Bayard, Raffard, & Gely-Nargeot, 2011). Particularly during the transition from adolescence to adulthood, the willingness to seek novel experiences and unbrace uncertainty is expected to be strongest.

In term of risky driving, several researchers found that individuals who score high on sensation seeking drive faster (Machin and Plint, 2010), more aggressively (Dahlen et al., 2005), and more likely to drive while drunk (Van Beurden et al., 2005). Zakletskaia et al. (2009) noted that sensation seeking is a predictor of driving after drinking of alcohol. Among the young adults in the Canadian population, research shows that both sensation-seeking and impulsivity are personality traits predicting driving in the hour following cannabis use (Richer & Bergeron, 2009). After controlling for age and driving experience, sensation seeking is still significantly associated with DACU (Bergeron & Paquette, 2014). Particularly young drivers who are characterized by high sensation seeking may engage in risky driving for the sake of excitement (Paaver et al., 2013). Similarly, a review synthesizing the literature on personality and driving behavior found that 36 out of 40 studies examined report a significant positive relationship between sensation seeking and risky driving. Some studies suggest that individuals with higher sensation seeking levels tend to perceive certain driving behavior as less risky (Asbridge, Hayde, & Cartwritght, 2012).

In sum, those five inter-related but separate facets of impulsivity predict specific aspect of impulsive behavior. Since impulsive behavior is defined broadly, we stress the importance of examining the specificity of each facet in relation to engagement in risky behavior as it may be masked or have it effect sizes diluted when taking the averaged effect of impulsivity (Smith, Fischer, & Fister, 2003). For instance, the averaged effect of the UPPS trait is not significant in

predicting suicidal behavior, however, true effect was found to be masked as negative urgency in specific has a larger and significant effect on this behavior (Berg et al., 2015). Therefore, we speculate that the masking effect may be present across other impulsive behavior, namely DACU. Therefore, the present study aims to examine further the effect of sensation seeking on DACU.

Sex, gender and DACU

Another variable of interest in the present study is the role of sex since the literature linking the difference between sexes to driving behavior is extensive. Males are more likely to engage in driving an hour following cannabis use than females (Richer & Bergeron, 2009; Asbridge, Poulin & Donato, 2005; Capler et al., 2017). According to the Canadian Institute of Health Research (2015), sex refers to the biolofical attributes in humans that is primarily associated with physical and physiological features. Beirness and Davis (2007) found that 76.9% of drivers who took the wheel after consuming cannabis are male, significantly different from all the licensed drivers consisting of only 48% males. A Canadian survey reports that 2.8% of men and 1.5% of women engaged in driving after using cannabis during the last 12 months (Robertson et al., 2017). Men tend to perceive lower risk and show more acceptance of driving after drinking (Navas et al., 2019). However, a Spanish study examining the same behavior did not find a significant sex difference (Alvarez, Fierro & Del Rio, 2007). Although there may be a sex difference in driving behavior, how and why this occurs is unclear. Researchers propose that these relationships appear to be influenced by the social norms on femininity and masculinity rather than biological mechanisms (Özkan and Lajunen, 2005; Sibley & Harre, 2009). Men tend to believe that they have better perceptual-motor skills than women leading them to adopt risky driving behavior (Özkan et al., 2011). The drawback of those studies on sex differences is the

lack of uniformity in the operationalization of sex when designing research. The method of measuring sex is not consistent across the studies thus creating difficulties when reviewing the literature and that methodological difference could potentially contribute to the disparate results. Historically, the terms gender and sex have been defined loosely in the scientific community as well as in the popular press. For instance, some studies include only one question asking participants to choose between either female or male while others did not specifically mention how sex was measured. This type of question will increase the rate of missing data since it does not take into account the diversity of sex and gender identity. Respondents may identify beyond the gender binary since some will have a history of gender transition and others identify with a culturally specific gender thus the gender dimension that is being queried must be clear.

One distinction, gender identification, will be elaborated in the present thesis as it provides a deeper insight into what motivates behavior. Sex and gender identification seem to be closely related and interchangeable, but there are conceptual differences that should be clarified. Some authors argue that gender-related difference in behavior is not necessarily the result of biological sex (Oppenheim et al., 2016; Stets & Burke, 2000). While biological sex is genetically predisposed, gender identification is determined by the way individuals perceive themselves as feminine, masculine, a blend of both or neither given the societal construction of what consists of a man or a woman. The perception of one's gender motivates in turn, gender-related behavior (Oppenheim et al., 2016). Wizemann and Pardue (2001) define sex as a tool for classification based on the reproductive organs derived from chromosomes whereas gender refers to a socially constructed self-identity that influences how people perceive themselves and act accordingly. Beginning at birth, babies develop their gender identity through ongoing interaction with others and by observing parents. Once that identity is established, they are expected to engage in

appropriate behavior shaped by the society instead of biological sex (Stets & Burke, 2000). It is hypothesized that the overrepresentation of males in drug driving is in part affected by the culture. Özkan and Lajunen (2005) propose that drivers who identify themselves as male overestimate their driving skills and perceive "willing to take the risk" as a masculine characteristic. Thus, the mastery of automobiles following substance use is a way of demonstrating power among young males whereas females are less likely to engage in risky driving due to societal pressure on women to be responsible in their decision-making (Farrow & Brissing, 1990). Drug and aggressive driving are socially endorsed strategies among males for achieving dominance whereas women are less likely to engage in socially proscribed behavior (Sibley & Harre, 2009). Considering these findings, gender identification is a promising candidate to predict driving after cannabis use in the present thesis.

A gendered social dynamic regarding drug use is also observed in a systematic review. Young men are more likely to use illicit drug to explore their masculinity in “paradoxical ways” and risk taking is a central form of displaying masculinity. For some men, consuming cannabis in combination with other drugs aligns with the masculine notion of competitive drug-taking, as they take pride in being the last man standing up. The consumption of cannabis, along with the method used, the intensity and the dosage are all opportunities to demonstrate men’s ability to control over their body (Hemsing & Greaves, 2020). Another American study found that adherence to gender-typical behavior is associated with an increased risk for high frequency cannabis use for males and a decreased risk for females (Wilkinson et al., 2018). The authors concluded that substance use represents gender expression for men, so substance use prevention programs may be more effective if they challenge the gender norms.

There is also a gender difference in the facet of impulsivity, that is, men have higher levels of sensation seeking than females (Evans-Polce et al., 2018). In a similar line of work, Zuckerman (1994) found consistent gender variation in sensation seeking with men scoring higher than women in Australia, Canada, and Spain. More recently, researchers found that men score higher on impulsivity than females on sensation seeking and they show a higher frequency of driving under the influence of alcohol (Robertson et al., 2017). Such findings have substantial implications for the current study in determining the potential predictor of DACU. Further, it would be interesting to explore the interaction of gender with impulsivity as previous literature focuses only on the main effects of each predictor.

Gender as moderator of the relationship between impulsivity and DACU

While the main effect of demographic variables on sensation seeking and DACU is of research interest, their interactive effect received less attention. Given that personality trait is relatively stable over time, González-Iglesias, Gómez-Fraguela and Luengo (2014) propose that the effect of sensation seeking on driving behavior may be changed by other variables. Baker and Yardley (2002) reported that the relationship between gender difference, personality, and substance use is more complicated than previous literature suggests. They found that gender has no significant main effect on alcohol use among Canadian adolescents, but it is found to moderate the relationship between sensation seeking and alcohol use when gender enters the regression analysis. It is plausible that gender moderates not only the association between personality and substance use, but also the relationship between sensation seeking and negative outcomes of substance use like DACU. A possible explanation is that those with male gender identification are more likely to engage in risky driving under high sensation-seeking conditions to demonstrate masculinity. Participants who have a female gender identification are less

influenced by sensation seeking due to the social expectation for them to be responsible. Further, a moderated pathway might explain the discrepancies in the literature on gender differences. For the purpose of the current study, we hypothesize that gender identification is associated with DACU, and it may also change the strength of the association between sensation seeking and driving after cannabis use. In the search for an explanation of this effect, the present study will build a moderation model with gender identification as moderator of the relationship between sensation seeking and DACU.

In addition, we have identified three covariates, age, education levels and frequency of cannabis use that are previously reported as potential predictors (Richer & Bergeron, 2014; Adlaf et al., 1995; Baker & Yardley, 2002; Duff & Rowland, 2006). Covariates are variables that explain part of the variability in the outcome on their own, but they are not variables of interest in the present study (Stefanski & Carroll, 1985) therefore adding covariates to our model may increase result accuracy. Increased age was previously associated with a significantly lower openness to drive a vehicle an hour following cannabis consumption in certain situations (Davis et al., 2016). In 2018, the age group 21-25 had the highest prevalence of driving under influence of cannabis followed by the age group 16-20 and decreases gradually with age in the United States (Azofeifa et al., 2019). Next, educational attainment was correlated with the age of cannabis use onset (Horwood et al., 2010) but the extent to which it leads to DACU is understudied in the literature. An Australian study observed that having a formal education is associated with a significantly lower likelihood of drink-driving because drivers have a better understanding of the impairing effect of alcohol on the road (Damsere-Derry et al., 2014). It is plausible that education is a predictive variable of DACU thus we have included educational attainment as our second covariate. Lastly, a moderate to elevated cannabis consumption

frequency is associated with a higher probability of DACU and those who report having an elevated consumption also report having taken the wheel under the influence at least five times in the past month (Bergeron, Langlois & Cheang, 2014; Davis et al., 2016).

Objectives

Although risky driving is a complex behavior and interacting effects contribute to road accidents, research often examines the potential predictor of DACU in isolation. As mentioned above, both sensation seeking and gender are consistently associated with DACU (Richer & Bergeron, 2009; Evans-Polce et al., 2018; Robertson et al., 2017; Zuckerman, 1994), but the interaction of their effect on cannabis-related consequences is understudied. Baker & Yardley (2002) previously suggested that the interaction of predictors should be considered when studying substance use because the effect of one predictor may change depending on the level of the other predictor. To our knowledge, there is no study investigating the interactive effect of gender identification and sensation seeking on DACU in the literature. Thus, to address the gap in the literature, the present study aims to explore specific facet of impulsivity, sensation seeking, and its interaction with the moderator leading to taking the wheel after consuming cannabis.

A moderation analysis with gender identification as moderator will be conducted. Based on the literature, we hypothesize that gender identification and sensation seeking are both predictors of DACU. Furthermore, gender identification could be a significant moderator of the relationship between sensation seeking and driving after cannabis use.

Method

Participants

A total of 1609 participants were recruited via Facebook advertisement targeting primarily young adults who drive following cannabis intake. Given that drug driving concerns

mostly young adults, inclusion criteria require participants to be aged from 17 to 35 years old, consumed cannabis in the past 12 months and they must hold a valid driver's licence. Also, they must be residents of Canada and fluent in French or English. The study does not have other exclusion criteria. The study lasted eight months, from August 2018 to March 2019.

Protocol

When participants clicked on the Facebook advertisement, they were invited to complete an online questionnaire measuring different variables related to the study. They were also informed on the study's protocol, objectives, and confidentiality terms. This survey method was chosen because it has a relatively low cost and reaches the young population more efficiently than the traditional recruitment procedure. In 2017, Facebook and YouTube were the most visited social media among users aged from 16 to 64 (Gruzd et al., 2018). The Facebook advertisement was shared among interest groups on drugs and driving to increase the response rate.

Participants were notified on the confidentiality terms of the study before filling out the questionnaire and collected data will not reveal one's identity. Also, the participation was voluntary, and participants could withdraw at any moment. Once participants have clicked on the case indicating their acceptance of participation, they can start completing the questionnaire anonymously. Participants must answer all the questions before proceeding to the next page, thus reducing missing data. When the questionnaire was completed, a promotional code was sent to their email inbox and participants could use it for online purchases. Data were collected from the site LimeSurvey and all data were kept within Canada to assure confidentiality.

Measurement

In the literature, gender category is often questioned with a single item and two answer options: do you consider yourself as female or male. Nonetheless a single question method does not capture the full range of gender categories as some people experience transgender identity thus posing threat to validity. It is also important to note that experienced gender identity could not match the birth-assigned sex that is based on genital anatomy (Tate, Ledbetter & Youssef, 2013). Given that about 0.24% of the Canadian population is transgender and they face more challenges in responding, researchers are required to include trans-inclusive sex/gender measures in their questionnaire (Statistic Canada, 2021). Therefore, Tate, Ledbetter and Youssef (2013) suggest that gender should be assessed with two questions in addition to expanding response options to capture all transgender spectrum identities. They found that using two question method of assessing gender identities increased statistical reliability by reducing the missing data rate to 0%. Further, accurate classification of transgender respondents offer a better data quality compared to a single question (Tate, Ledbetter & Youssef, 2013). Bauer et al. (2017) further recommend a multidimensional measure to better reflects the diversity of gender identities.

The moderator of our study, gender identification was measured by one self-reported question on how the participants perceive themselves as feminine, masculine, cultural gender or others. The item asks which option best describes the respondent's gender identity as an acknowledgment that the list is not complete and one's specific identity may be not listed. The choice of "cultural gender" was recommended to recognize the existence of the First Nation's traditional gender in Canada. Lastly, the response option "others" includes other gender identities namely non-binary, genderqueer and agender. Biological sex was measured by the sex that participants were born with, the answer options are women, men or undetermined.

With respect to the dependent variable, subjects were surveyed on how often they were involved in driving within two hours following cannabis consumption ranging from 0 to 9 and more in the last 12 months. The two-hours time frame was chosen because studies demonstrate that THC blood level following consumption reaches the peak within 60 minutes and impairment usually occurs in the first few hours after inhalation (Capler et al., 2017). The validity of self-reported cannabis use on the road was reported to have moderate to high validity in 2014 across the United States (Eichelberger, & Kelley-Baker, 2020). Variation in reporting reflects different social norms and legalization of its use, therefore we speculate that the validity of self-reported DACU is not compromised as the study was carried out after the legalization of recreational use of cannabis.

In addiction and risk-taking research, the UPPS model is one of the leading perspectives defining the construct of impulsivity (Cyders et al., 2007). The five facets are the result of a factor analysis of nine frequently used measures of impulsivity in a sample of 437 undergraduates and 47 items were selected to make up five facets from these factors (Whiteside & Lynam, 2001). Given that it provides a clear framework for the conceptualization of impulsivity, the present study uses this scale to measure one of the facets, sensation-seeking. Lynam et al. (2006) created the original UPPS 59 items questionnaire, but participants of our study took the short French version, composed of 20 items measured on a Likert scale of four points (strongly agree, agree, disagree, strongly disagree) (Billieux et al. 2012). The short version has been shown to present psychometric properties such as an internal consistency between 0.70-0.84 and test-rest stability between 0.84-0.92 (Billieux et al., 2012). The facet of interest, sensation seeking, was composed of items 3, 9, 14 and 18.

In addition, we have identified three covariates, age, education levels and frequency of cannabis use that are previously reported as potential confounders (Richer & Bergeron, 2014; Adlaf et al., 1995; Baker & Yardley, 2002). Age was measured by asking participants' age in numerical value but only those aged from 17 to 35 were retained for the study. Response option for education attainment ranks from primary school to Doctorate degree. The frequency of cannabis use in that last 30 days was measured with a series of mutually exclusive indicators of never used, everyday use, once a week, 2-3 times a week, 4-6 times a week, once or twice in a month and less than once in a month. The response option of this variable is coded with 1 being everyday use and 7 being never used.

Statistical analyses

To address the hypothesis of the study, a moderation analysis using the macros written by Andrew Hayes (2019) is conducted to disentangle the relationship between sensation seeking, gender identification and driving after cannabis use. The proposed model contains sensation seeking as the independent variable directly associated with the dependent variable driving after cannabis use, and this relationship is moderated by gender identification. Unlike the independent variable that has a direct effect on the dependent variable, a moderator should change the strength or the direction of the relationship between sensation seeking and DACU. In other words, gender identification specifies conditions under which sensation seeking is related to the likelihood of driving after cannabis use. It also implies interaction since the nature of the relationship between the predictor and the outcome variable changes when the moderator is present. If gender identification is indeed a moderator, then the strength of the relationship between sensation seeking and driving after cannabis use changes as a function of gender identification (Field, 2013). Thus, their interaction is expected to be statistically significant.

A moderation model with biological sex as moderator is also tested. Given that both models produce similar output, and the one containing gender identification is a better fit, only one model is retained for the purpose of the present study.

The goal of the analysis is to estimate the effect of sensation seeking on engagement in risky behavior and the extent to which this effect is contingent on gender identification. Prior to the analysis, data is screened for preliminary assumptions to ensure the validity of the result and interpretation. Next, descriptive statistics of participants are presented, and the result of the moderation analysis is discussed in the last part. Moderation analysis with SPSS PROCESS was performed. The independent variable was centered. Gender identification was coded as a categorical variable and the category of feminine identification was used as the reference group. In parallel, DACU was coded as a binary variable. In all cases, the alpha level of the tests is set at .05.

For the purpose of the present study, the group of cultural gender and others is combined together given that the two groups contain only 1.4% and 3.1% of our sample. The percentage is close to the data provided by Bauer et al. (2017), 4.2% of respondents feel neither male nor female or don't know. The dependent variable driving after cannabis use is dichotomized because it has a U-shaped distribution with 41.9% of the subjects who were never involved in driving after cannabis use and 28.2% who did it nine or more times. The rest of the sample is distributed between one and eight times. For this reason, the independent variable driving after cannabis use (0=No, 1=Yes) is recoded into a dichotomous variable so that subjects are grouped depending on if they have never driven after consuming cannabis or at least once in the past 12 months. Thus, the statistical analysis will be a moderated logistic regression.

Result

Assumptions

Basic assumptions for conduction logistic regression include normality of continuous variable, independence of observation and errors, linearity of independent variable with the dependent variable and absence of multicollinearity (see appendix A). The data satisfies all required assumptions.

The assumption for normality of the variable sensation seeking has been met given that the histogram displays approximatively normally distributed and bell-shaped data. Also, the scatter on the Q-Q plot shows no drastic deviation away from the normality line.

It is unlikely to find the dependence of observations given that the order of items is randomized for each subject and only one questionnaire can be submitted for each participant. According to the assumption of independence of errors, the scatterplot of the residuals should not display patterns and that is also satisfied because points are equally distributed above and below zero on both axes.

Finally, there is no correlation between two variables above the critical value of 0.70 suggesting the predictors are independent from each other (Steven, 1992). Also, absence of multicollinearity is checked with the VIF value below 10 indicating the assumption is met.

Sample Characteristics

Respondent' (n=1609) demographic characteristics are summarized in Table 1. Given that we only included the young adults, the respondent's age is evenly distributed between 17 to 35. With regard to educational attainment, approximately 40.3% of them completed high school, 37.4% report having either Cegep, professional studies or college certificates, 16.2% obtained a bachelor's degree and 5.2% completed graduate studies. Among cannabis users, most of them

report consuming cannabis once or twice per month, followed by less than once per month and two to three times a week. With respect to gender identification, 49% of respondents have a feminine gender, 46.5 masculine gender and 4.5% others. About 58.1% admitted having driven after consuming cannabis and 41.9% never did so in the past 12 months.

There is no missing data as participants are required to answer all questions before proceeding to the next section of the questionnaire. Participants will be excluded if the questionnaire is not completed. Following data checking and cleaning, 1609 participants were included in the final sample.

Moderation in PROCESS

The macro command set estimated the logistic regression model containing gender identification as moderator. First, there is main effect of sensation seeking. Result indicates that greater sensation seeking level is associated with a higher likelihood of DACU (b= 0.07, p = 0.02). Second, the output (table 2) states that the difference in gender identification between women and men b = 0.55, 95% CI [0.31, 0.78], z = 4.52, p < 0.01 is significant but no such difference is found when comparing women to other groups b = -0.42, 95% CI [-0.92, 0.09], z = -1.61, p = 0.11. The interaction between sensation seeking and gender identification is statistically significant, $\chi^2(2) = 7.29$, p = 0.03 indicating the presence of moderation. In other words, the relationship between sensation seeking and the likelihood of engaging in driving after cannabis use is contingent on gender identification. Precisely speaking, the interaction of the difference between women and men by sensations seeking is significant b = 0.11, 95% CI [0.02, 0.21], z = 2.36, p = 0.02 but not significant interaction is found in other groups. In terms of covariates, only frequency of cannabis use seems to covary with sensation seeking b = -0.55, 95% CI [0.48, 0.62], z = 15.85, p < 0.01.

The interaction is probed by testing the conditional effects of sensation seeking at three levels of gender identification. As shown in table 2, sensation seeking is only related to driving after cannabis use among participants who identify themselves as either male $b = 0.18$, 95% CI [0.11, 0.25], $z = 5.02$, $p < 0.01$ or female $b = 0.07$, 95% CI [0.01, 0.13], $z = 2.27$, $p = 0.02$. Among these groups, higher sensation seeking predicted more likelihood of driving after cannabis use. When participants consider themselves as "others," no such effect is found. Figure 1 further demonstrates that the slope of mean driving after cannabis use for men is significantly higher and steeper than the others two groups at all levels of sensation seeking. Taken together, sensation seeking is positively associated with sensation seeking at all levels of gender identification, however, this association is only statistically significant among men and women.

Table 1.

Descriptive statistics of variables

Variables	n	Percent	Mean	S.D.
Sensation-Seeking	1609		10.33	2.62
Gender identification	1609		1.55	0.58
Feminine	794	49.35		
Masculine	734	45.62		
Others	81	5.03		
DACU	1609		0.58	0.49
Yes	1152	58.1		
No	830	41.9		
Age	1609		25.16	5.50
Education	1609			
Primary	12	0.7		
Secondary	634	39.4		
Professional	288	17.9		
Cegep	200	12.4		

College certificate	120	7.5
Baccalaureate	263	16.3
Masters	67	4.2
Doctorate	25	1.6
Cannabis consumption frequency	1609	
Everyday	523	32.5
4 to 6 times/week	262	16.3
2 to 3 times/week	183	11.4
Once a week	197	12.2
1 to 2 times/month	222	13.8
Less than once/month	216	13.4
Never	6	0.4

Table 2.

Model summary

Variables	*b*	S.E.	Z	*p*	Lower CI	Upper CI
Sensation seeking	0.07	0.03	2.27	0.02*	0.01	0.13
W1: women vs men	0.55	0.12	4.52	<0.00*	0.31	0.78
W2: women vs others	-0.42	0.26	-1.61	0.11	-0.93	0.09
W1 X Sensation seeking	0.11	0.05	2.36	0.02*	0.02	0.21
W2 X Sensation seeking	-0.07	0.09	-0.75	0.45	-0.25	0.11
Education	-0.03	0.04	-0.99	0.32	-0.10	0.03
Age	-0.00	0.01	-0.17	0.86	-0.02	0.02
Frequency of cannabis use	-0.55	0.03	-15.85	<0.00*	-0.62	-0.48

*p<0.05

Table 3.

Conditional effect of gender identification on driving after cannabis use

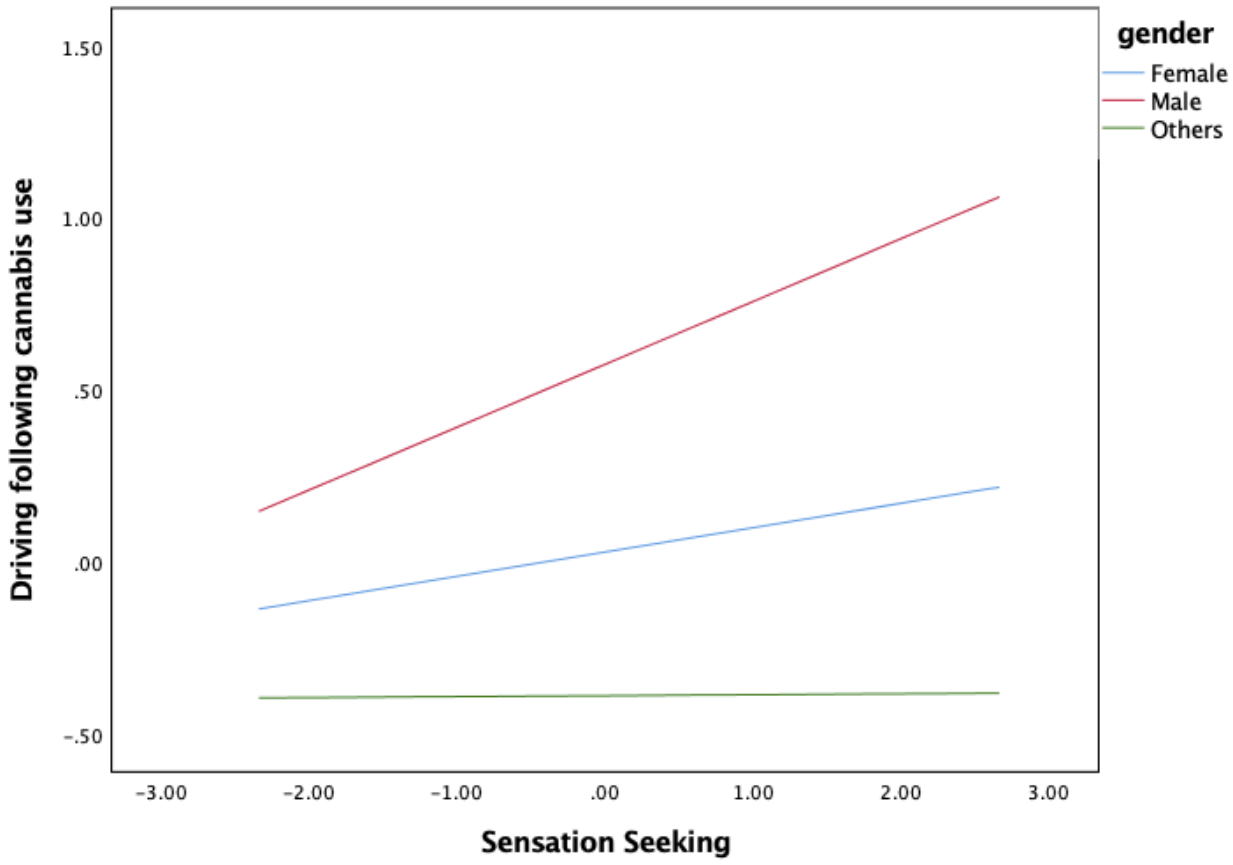
Gender Identification	*b*	S.E.	p
Female	0.07	0.03	0.02*

Male	0.18	0.04	0.00*
Others	0.00	0.09	0.97

*$p<0.05$

Figure 1.

line graph depicting the relationship between sensation seeking and mean DACU at different levels of gender identification.



Discussion

The goal of this study is to determine whether gender identity moderates the relationship between sensation seeking and driving after cannabis use among young adults in Canada. The result from moderation analysis confirmed such a statistical pattern and lends support for the initial hypothesis. After controlling for covariates age, education and cannabis use frequency, it

appears that the association between sensation seeking and DACU changes depending upon gender identification.

Main Findings

First, sensation seeking is positively correlated with DACU indicating that high sensation seekers are more likely to engage in risky driving. As expected, this finding reaffirmed the conclusion drawn from comparable studies that explored the association between personality dimensions related to sensation seeking and DACU. Self-reported seeking is positively correlated with willingness to take the wheel following cannabis consumption suggesting that our results are in accordance with the literature trend (Asbridge, Poulin & Donato, 2005; Bergeron & Paquette, 2014; Capler et al., 2017; Richer & Bergeron, 2009). The strength of the association (b= 0.07) is also similar to the result reported by Richer and Bergeron (b = 0.08) in 2009 as well as mentioned by Bergeron and Paquette (b = 0.09) in 2014. Individuals scoring high on that trait may perceive less risk in dangerous situations and show an elevated likelihood of DACU to seek intense sensation (Bergeron & Paquette, 2014). While previous studies emphasize mostly the effect of impulsivity, the present study further demonstrates that the specific facet of that personality trait, sensation seeking, should be considered as the contributor to risky driving.

Second, the nature of the relationship between sensation seeking and DACU changes as gender identification changes. Specifically, sensation seeking predicted DACU only when respondents have a male or female gender identification, and that association is stronger among males. In other gender identification groups, sensation seeking and driving after cannabis use are not associated. Although personality and gender are important variables in understanding driving after substance use, the pattern of their association has been partially overshadowed in the literature. To our knowledge, this is the first study that investigates the moderating role of gender identification on the association between sensation seeking and DACU. Previous studies only

examined the main effect of sensation seeking on driving behavior, but our finding specifies further under which conditions the predictor is related to the outcome. Thus, the present study reinforces the role of gender identification in moderating the relationship between sensation seeking and driving behavior, DACU. Given that drug driving is a complex behavior, examining interaction may be of theoretical interest. We suggest that risk factors such as personality and gender identification do not contribute directly to driving after cannabis use, but they interact to affect driving behavior.

Past studies that examined predictors of risky driving as a function of sex difference among young adults produced mixed results and used driving under the influence of alcohol as their outcome variable, making it difficult to draw comparative conclusion. For instance, Navas et al. (2019) found a significant interaction between sensation seeking and sex on driving under the influence of alcohol, but the association is uniquely present for women. On the other hand, Fernandes, Job, & Hatfied (2007) found a medium to a high association in both females and males while others did not find any association for any sex (Brown et al., 2015). The methodological difference can explain part of these disparate results given that those studies did not specify their assessment methods or used biological sex as moderator. However, we believe that taking an interactional approach to the analysis may be the key to disentangling the associations among variables because using only partial correlations may not reveal interactional influences on these relationships. Particularly when no main effect is present, interaction of moderating variables should be examined.

Gender Norms and Sex

A noteworthy finding is that driving behavior is predicted by gender identification, a socially constructed distinction between men and women that could be different from one's

biological sex. In our sample, masculine gender identification predicted the likelihood of engaging in drug driving, and that association converges with the finding from a study undertaken by Oppenheim and colleague (2016) who argues that gender role identification is a more valid predictor of driver's behavior than sex because the way individuals identify themselves is a source of motivation for gender-related behavior. For instance, a woman may identify herself as masculine and therefore she would probably engage in competitive, dominant and aggressive driving behavior (Özkan & Lajunen, 2005). These behaviors could be further exacerbated after consuming psychoactive drugs. Those who adhere to feminine gender norms are less likely to demonstrate their capability in handling risky driving. Therefore, the way individuals act and behave depends on the conceptualization of femininity and masculinity that they adopt from their culture. While previous studies use biological sex, we support the idea that gender role should be considered when investigating risk-taking differences within groups of drivers. Gender could be an interesting variable to examine in the context of driving after drug use.

Historically, the use of the term sex is not specified in the methodology or defined inappropriately sometimes because birth-assigned sex could be different from genetic sex. For instance, an individual's genetic sex could not match phenotypic sex due to genetic mutation or illnesses that occurred during their lifetime. Further, some of the transgender respondents are seeking hormonal augmentation for physical transition and very few have undergone genital surgeries (Wizemann & Pardue, 2001). It is important to point out that biological sex could provide little insight into what motivation for risky behavior. In contrast, gender identity refers to the difference that originates from social environment and it is more likely to influence behavior. Most importantly, gender identity could be easily assessed by asking how participants self-

identify instead of investigating biological sex at the cellular level, complicating the methodology. We recommend in addition a measurement that provides a wider range of possible answers to include trans identity respondent.

That being said, we also ran another moderation with biological sex and the model is significant as well (See appendix B). The result is consistent with the findings provided by Oppenheim et al. (2016) who found that the interaction of both gender identification and biological sex with sensation seeking is significant but the former is a better predictor of risky driving. We speculate that possibly the majority of the participants identify themselves accordingly to their biological sex thus the result of the two models came out similar. Only 1.6% of our sample are born with male biological attributes but identify themselves as women. About 1.3% of participants born with female biological attributes and identify themselves as men. Given that the majority of participants are cis-gender individuals in the present study, a larger sample size is needed to assess the adherence to gender norms among subgroups. A key next step is the consideration of understudied population in engagement in DACU, and we believe that including gender diverse people will provide a richer view on driving behavior. Overall, findings speak to the fact that interactions among predictors should be taken into account to predict DACU and that the overrepresentation of males in DACU could be partially determined by social norms. Further research is warranted to confirm such exploratory findings.

These pattern and trend in DACU highlight the need to attend to gender norms that emphasizes risk-taking behavior among young men. And possibly the adherence to feminine norms could be a protective factor against DACU so integrating gender norms and their behavioral implication into prevention effort could be more effective than discouraging drug

driving. As Wilkinson and colleagues (2018) suggest, breaking the link between masculinity and its gender typical behavior should be taken into account when designing intervention program.

Limitations and future direction

The result illuminates several shortcomings. First, we have recruited our sample from Facebook for convenience, so the generalizability of our study could be compromised as the older population who do not have access to social media and cannot be reached. Not to mention the possibility that respondents with biases may self-select themselves into our study. Second, gender identification should be measured along a continuum because it refers to the degree people perceive themselves thus categorical question would limit the variety of responses. The distribution of gender categories is uneven since we only have four response options. Lastly, the current study asked about the incidence of taking the wheel two hours following cannabis use and not driving while impaired, so we are not certain if the driving performance was affected by cannabis within this time frame. Especially the length of impairment could be different according to consumption method (inhalation and ingestion). Future research could specify in the methodology the route of administration. Also, self-report questionnaires are subject to recall and social desirability biases. Further, studies on the effect of repeated doses on driving skills are limited, thus we do not know if users adapt to the effect of cannabis as result of tolerance (Ramaekers et al., 2004). Therefore, our outcome variable may be a biased estimate of accident involvement.

Another interesting future direction would be implementing strategies and interventions addressing risk factors and strengthening protective factors to reduce risky driving behavior in the target group. Researchers, public health professionals, and policymakers could collaborate to evaluate educational and preventive programs at the local level.

Implication

The current research aims to provide a framework for understanding predictors of drug driving within the Canadian context where cannabis use has been recently legalized. Past studies have shown that DACU could potentially lead to road accidents, yet we are uncertain if cannabis consumption is the only predictor of engagement in DACU or the role of other factors such as gender and personality of the user that contribute to risky behavior. The results highlight the pertinence of interactional research.

To ameliorate prevention programs designed to reduce driving with cognitive impairment, investigating what motivates the decision to drive intoxicated could be beneficial. Although our results do not suggest a causal relationship, they can shed light on specific groups of individuals targeted for preventive intervention and political decisions and education programs on cannabis use. We stress the importance of examining gender from the social context so that policymakers could gain some insight into behavior influenced by social norms on masculinity rather than simply emphasizing on men. Educational programs should also aim to teach young adults the knowledge and skills such as mindfulness practice to make a responsible decision and reduce risky behavior.

Conclusion

The major conclusion from this thesis can be summarized as follow. First, our result highlights the importance of considering personality trait such as sensation seeking when targeting a group of individuals at high risk of DACU. Second, the current study provides some evidence that sensation seeking and gender identification are not only associated with DACU, but the interaction of these variables demonstrates the complexity of their relationship. While previous studies investigate the direct association between driver's characteristics and the likelihood of engaging in risky driving, the focus here is to find out the presence of a moderation

effect and how it can be traced to gender identification. Lastly, a masculine gender identification, rather than simply being male in terms of biological sex, might be the source of risky behavior.

Ethic Statement

The research protocol has been approved by Comité d'éthique de la recherche – Dépendances, Inégalités sociales et Santé publique (DIS-1920-24).

References

Adlaf, E. M., Ivis, F. J., Smart, R. G., & Walsh, G. W. (1995). Ontario student drug use survey, *Addiction Research Foundation of Ontario*, 1977–1995.

Alvarez F.J., Fierro I. & Del Río M.C. (2007). Cannabis and driving: Results from a general population survey. *Forensic Science International, 170*(2), 111–116.

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM–5-TR)*. https://doi.org/10.1176/appi.books.9780890425596

Arnett, J. (1992). Reckless behavior in adolescence: A developmental perspective. *Developmental Review, 12*(4), 339–373. https://doi.org/10.1016/0273-2297(92)90013-R

Asbridge, M., Hayde, J., & Cartwritght, J. L. (2012). Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis. *British Medical Journal, 344*(536), 1–9.

Asbridge, M., Poulin, C., & Donato, A. (2005). Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada. *Accident Analysis and Prevention, 37*, 1025–1034.

Azofeifa A, Rexach-Guzmán, B. D., Hagemeyer, A. N., Rudd, R. A., & Sauber-Schatz, E. K. (2019). Driving Under the Influence of Marijuana and Illicit Drugs Among Persons Aged ≥16 Years — United States, 2018. *Morb Mortal Wkly Rep, 61*, 1153–1157.

Baker, J. R., & Yardley, J. K. (2002). Moderating effect of gender on the relationship between sensation seeking-impulsivity and substance use in adolescents. *Journal of Child & Adolescent Substance Abuse, 12*(1), 27–43. https://doi.org/10.1300/J029v12n01_02

Bauer G.R., Braimoh, J., Scheim, A.I., Dharma, C. (2017). Transgender-inclusive measures of sex/gender for population surveys: Mixed-methods evaluation and recommendations. *PLoS ONE 12*(5), 1–28

Bayard, S., Raffard, S., & Gely-Nargeot, M. C. (2011). Do facets of self-reported impulsivity predict decision-making under ambiguity and risk? Evidence from a community sample. *Psychiatry research*, *190*(2-3), 322–326. https://doi.org/10.1016/j.psychres.2011.06.013

Beirness D.J. & Beasley E.E. (2010). A roadside survey of alcohol and drug use among drivers in British Columbia. *Traffic injury prevention, 11*(3), 215–221.

Beirness, D. J., & Davis, C. G. (2007). Driving after drinking in Canada: findings from the Canadian Addiction Survey. *Canadian journal of public health = Revue canadienne de sante publique*, *98*(6), 476–480. https://doi.org/10.1007/BF03405442

Berg, J. M., Latzman, R. D., Bliwise, N. G., & Lilienfeld, S. O. (2015). Parsing the heterogeneity of impulsivity: A meta-analytic review of the behavioral implications of the UPPS for psychopathology. *Psychological Assessment, 27*(4), 1129–1146. https://doi.org/10.1037/pas0000111

Bergeron, J., Langlois, J., & Cheang, H. S. (2014). An examination of the relationships between cannabis use, driving under the influence of cannabis and risk-taking on the road. *Rev. Eur. Psychol. Appl., 3*(64), 101–109.

Bergeron, J., & Paquette, M. (2014). Relationships between frequency of driving under the influence of cannabis, self-reported reckless driving and risk-taking behavior observed in a driving simulator. *Journal of Safety Research, 49*, 19–24.

Berghaus, G., Scheer, N., & Schmidt, P. (1995). Effect of cannabis on psychomotor skills and driving performance—a meta-anlysis of experimental studies. *Drugs and Traffic Safety*, 403–409.

Billieux, J., Rochat, L., Ceschi, G., Carré, A., Offerlin-Meyer, I., Defeldre, A. C., Khazaal, Y., Besche-Richard, C., & Van der Linden, M. (2012). Validation of a short French version of the UPPS-P Impulsive Behavior Scale. *Comprehensive psychiatry*, *53*(5), 609–615.

Bingham, C. R., Shope, J. T., & Zhu, J. (2008). Substance-involved driving: predicting driving after using alcohol, marijuana, and other drugs. *Traffic injury prevention*, *9*(6), 515–526. https://doi.org/10.1080/15389580802273698

Blows, S., Ameratung, S., Ivers, R.Q., Lo, S.K., & Norton, R. (2005). Risky driving habits and motor vehicle driver injury. *Accident Analysis and Prevention 37* (4), 619–624.

Bolla, K.I., Brown K., Eldreth, D., Tate, K., & Cadet, J.L. (2002) Dose-related neurocognitive effects of marijuana use. *Neurology, 59,* 1337–1343.

Bondallaz, P., Favrat, B., Chtioui., Fornari, E., Maeder, P., & Giroud C. (2016). Cannabis and its effects on driving skills. *Forensic Science International, 268,* 92–102.

Bosker, W.M., Kuypers, K.P., Theunissen, E.L., Surinx, A., Blankespoor, R.J., Skopp, G., Jeffery, W.K., Walls, H., Leeuwen, C.J., & Ramaekers, J.G. (2012). Medicinal Δ9-tetrahydrocannabinol (dronabinol) impairs on-the-road driving performance of occasional and heavy cannabis users but is not detected in Standard Field Sobriety Tests. *Addiction, 107*(10), 1837–1844.

Brown, T.G., Ouimet, M.C., Nadeau, L., Tremblay, J., & Pruessner, J. (2015). Sex differences in the personality and cognitive characteristics of first-time DWI offenders. *J. Stud. Alcohol Drugs, 76*, 928–934.

Canadian Center on Substance Use and Addiction. (2015). *Cannabis, Driving and Implications for Youth*. Retrieved from https://ccsa.ca/sites/default/files/2019-04/CCSA-Cannabis-Driving-Implications-for-Youth-Summary-2015-en.pdf

Canadian Center on Substance Use and Addiction. (2019). *Cannabis: Inhaling vs Ingesting [infographic]*. Retrieved from https://www.ccsa.ca/cannabis-inhaling-vs-ingesting-infographic

Canadian Institutes of Health Research. (2015). *Definition of Sex and Gender*. CIHR. Retrieved from https://cihr-irsc.gc.ca/e/47830.html

Capler, R., Bilsker, D., Pelt, K. V., & MacPherson, D. (2017). *Cannabis Use and Driving: Evidence Review*. Canadian Drug Policy Coalition. Retrieved from https://drugpolicy.ca/wp-content/uploads/2017/02/CDPC_Cannabis-and-Driving_Evidence-Review_FINALV2_March27-2017.pdf

Cyders, M.A., Smith, G.T., Spillane, N.S., Fischer, S., Annus, A.M., & Peterson, C. (2007). Integration of impulsivity and positive mood to predict risky behavior: development and validation of a measure of positive urgency. *Psychol. Assess., 19* (1), 107–118.

Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2005). Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. *Accident Analysis & Prevention, 37*(2), 341–348. Doi: 10.1016/j.aap.2004.10.006

Damsere D. James., Afukaar, F., Gavan, P., & King, M. (2014). Determinants of drink-driving and association between drink-driving and road traffic fatalities in Ghana. *The International Journal of Alcohol and Drug Research*, *3*(2), 135–141.

Davis, K. C., Allen, J., Duke, J., Nonnemaker, J., Bradfield, B., Farrelly, M. C., Shafer, P., & Novak, S. (2016). Correlates of Marijuana Drugged Driving and Openness to Driving While High: Evidence from Colorado and Washington. *PloS one*, *11*(1), 1–13 https://doi.org/10.1371/journal.pone.0146853

Dawe, S., & Loxton, N. J. (2004). The role of impulsivity in the development of substance use and eating disorders. *Neuroscience and biobehavioral reviews*, *28*(3), 343–351. https://doi.org/10.1016/j.neubiorev.2004.03.007

Duff, C., & Rowland, B. (2006). 'Rushing behind the wheel': Investigating the prevalence of 'drug driving' among club and rave patrons in Melbourne, Australia. *Drugs: Education, Prevention and Policy, 13,* 299–312. doi:10.1080/09687630600625946

Dussault, C., Brault, M., Bouchard, J., & Lemire, A.M. (2002). *The Contribution of Alcohol and Other Drugs Among Fatally Injured Drivers in Quebec: Some Preliminary Results* [conference] 16th International Conference on Alcohol, Drugs and Traffic Safety, Quebec.

Eichelberger, A. H., & Kelley-Baker, T. (2020). Measuring Drug Use Among Drivers: How Accurate Is Self-Reported Use?. *Journal of studies on alcohol and drugs*, *81*(1), 104–114.

Evans-Polce, R. J., Schuler, M. S., Schulenberg, J. E., & Patrick, M. E. (2018). Gender- and age-varying associations of sensation seeking and substance use across young adulthood. *Addictive Behavior, 84*(2018), 271–277. Doi: 10.1016/j.addbeh.2018.05.003

Eysenck, H. J., & Eysenck, S. B. G. (1968). *Manual of the Eysenck Personality Inventory*. Educational and Industrial Testing Service.

Farassi M., Gagné M-A, Dubé P-A. (2016). *Présence de psychotropes dans les prélèvements biologiques des conducteurs décédés au Québec de 2002 à 2013*. Institut national de santé publique du Québec.

Farrow, J. A., & Brissing, P. (1990). Risk for DWI: a new look at gender differences in drinking and driving influences, experiences, and attitudes among new adolescent drivers. *Health education quarterly*, *17*(2), 213–221. https://doi.org/10.1177/109019819001700207

Fergusson, D. M., Horwood, L. J., & Boden, J. M. (2008). Is driving under the influence of cannabis becoming a greater risk to driver safety than drink driving? Findings from a longitudinal study. *Accident Analysis and Prevention, 40*, 1345–1350.

Fernandes, R., Job, S., Hatfield, J., (2007). A challenge to the assumed generalizability of prediction and counter measure for risky driving: different factors predict different risky driving behaviors. *J. Safety Res. 38*, 59–70.

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics: And Sex and Drugs and Rock "N" Roll,* (4th Edition), Sage.

González-Iglesias, B., Gómez-Fraguela, J. A., & Luengo, M. Á. (2014). Sensation seeking and drunk driving: the mediational role of social norms and self-efficacy. *Accident; analysis and prevention*, *71*, 22–28. https://doi.org/10.1016/j.aap.2014.05.006

Gruzd, A., Jacobson, J., Mai, P. & Dubois, E. (2018). The State of Social Media in Canada 2017. Version: 1.0. *Ryerson University Social Media Lab*. Doi:10.5683/SP/AL8Z6R.

Hartman, R.L., Brown, T.L., Milavetz, G., Spurgin, A, Pierce, R.S., Gorelick, D.A., Gaffney, G, & Huestis, M.A. (2015). Cannabis effects on driving lateral control with and without alcohol. *Drug and alcohol dependence, 1*(154), 25–37.

Hatfield J., Williamson A., James K. E., & Prabhakharan, P. (2017). An examination of the relationship between measures of impulsivity and risky simulated driving amongst young drivers, *Accident Analysis & Prevention, 103*, 37–43.

Hayes, A.F. (2019). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. (Second Edition). New York, NY: Guilford Press

Health Canada. (2021). *Canadian Cannabis Survey 2020: Summary*. Government of Canada. Retrieved from https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2020-summary.html

Hemsing, N., & Greaves, L. (2020). Gender Norms, Roles and Relations and Cannabis-Use Patterns: A Scoping Review. *International journal of environmental research and public health*, *17*(3), 947. https://doi.org/10.3390/ijerph17030947

Horwood L.J., Fergusson, D.M., Hayatbakhsh, M.R., Najman, J.M., Coffey, C., Patton, G.C., Silins, E., & Hutchinson, D.M. (2010). Cannabis use and educational achievement: findings from three Australasian cohort studies. *Drug Alcohol Depend, 110*(3), 247–253.

Huỳnh, C., Beaulieu-Thibodeau, A., Fallu, J.-S., Bergeron, J., Flores-Aranda, J., Jacques, A., & Brochu, S. (2022). Risk Factors Associated With Driving After Cannabis Use Among Canadian Young Adults. *Journal of Drug Issues*, *52*(2), 144–167. https://doi.org/10.1177/00220426211049359

International Transport Forum. (2020). *Detailed Country Profile for Canada*. Retrieved from https://www.itf-oecd.org/sites/default/files/canada-road-safety.pdf

Lenne, M.G., Dietze, P. M., Triggs, T.J., Walmsley, S., Murphy, B., & Redman, J.R. (2010). The effects of cannabis and alcohol on simulated arterial driving: influences of driving experience and task demand. *Accid. Anal. Prev., 42* (3), 859–866.

Lydon-Staley, D. M., Falk, E. B., & Bassett, D. S. (2020). Within-person variability in sensation-seeking during daily life: Positive associations with alcohol use and self-defined risky

behaviors. *Psychology of Addictive Behaviors, 34*(2), 257–268. https://doi.org/10.1037/adb0000535

Lynam, D. R., Smith, G. T., Whiteside, S. P., & Cyders, M. A. (2006). The UPPS-P: Assessing five personality pathways to impulsive behavior. *West Lafayette, IN: Purdue University*, *10*.

Machin, M.A., & Plint, J.E., (2010). Understanding the unique contribution of aversion to risk taking in predicting drivers' self-reported speeding. Driver Behaviour and Training. *Human Factors in Road and Rail Transport, 9,* 61–73.

Navas, J. F., Martín-Pérez, C., Petrova, D., Verdejo-García, A., Cano, A., Sagripanti-Mazuquín, O., Perandrés-Gómez, A., López-Martín, A., Cordovilla-Guardia, A., Megías, A., Perales, J. C., & Vilar-López, R. (2019). Sex differences in the association between impulsivity and driving under the influence of alcohol in young adults: The specific role of sensation seeking. *Accident Analysis & Prevention, 124*, 174–179.

Oppenheim, I., Oron-Gilad, T., Parmet, Y., & Shinar, D. (2016). Can traffic violations be traced to gender-role, sensation seeking, demographics and driving exposure. *Transportation Research Part F, 43*(8), 387–395. Doi: 10.1016/j.trf.2016.06.027

Özkan, T., & Lajunen, T. (2005). Why are there sex differences in risky driving? The relationship between sex and gender-role on aggressive driving, traffic offences, and accident involvement among young Turkish drivers. *Aggressive Behavior, 31*(6), 547–558.

Özkan, T., Lajunen, T., Chliaoutakis, J.E., Parker, D., & Summala, H. (2011). Cross-cultural differences in driving skills: A comparison of six countries. *Accident Analysis & Prevention, 38*(5), 1011–8.

Paaver, M., Eensoo, D., Kaasik, K., Vaht, M., Mäestu, J., & Harro, J. (2013). Preventing risky driving: A novel and efficient brief intervention focusing on acknowledgement of personal risk factors. *Accident; analysis and prevention*, *50*, 430–437.

Perrault, S. (2016). *Impaired driving in Canada, 2015*. Canadian Centre for Justice Statistics.

Poulsen, H., Moar, R. & Pirie, R. (2014). The culpability of drivers killed in New Zealand road crashes and their use of alcohol and other drugs. *Accident Analysis and Prevention, 67*, 119–128.

Ramaekers, J. G., Berghaus, G., van Laar, M., & Drummer, O. H. (2004). Dose related risk of motor vehicle crashes after cannabis use. *Drug and alcohol dependence*, *73*(2), 109–119. https://doi.org/10.1016/j.drugalcdep.2003.10.008

Richer, I., & Bergeron, J. (2009). Driving under the influence of cannabis: Links with dangerous driving, psychological predictors, and accident involvement. *Accident Analysis and Prevention 41*(2), 299–307

Ramaekers J.G., Berghaus G., van Laar M., & Drummer O.H. (2004). Dose related risk of motor vehicle crashes after cannabis use. *Drug and alcohol dependence, 73*(2), 109–119.

Ramaekers, J.G., Robbe, H.W., & O'Hanlon, J.F. (2000). Marijuana, alcohol and actual driving performance, *Hum. Psychopharmacology, 15* (7), 551–558.

Robertson R.D., Mainegra H. M., Pashley C.R., Brown S.W., & Vanlaar W.G.M. (2017). Prevalence and trends of drugged driving in Canada. *Accident Analysis & Prevention, 99*(2), 236–241. doi: 10.1016/j.aap.2016.12.008.

Rogeberg O, & Elvik R. (2016). The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction, 111*(8), 1348–59.

Rotermann, M. (2020). *What has changed since cannabis was legalized? Statistics Canada*. https://www150.statcan.gc.ca/n1/pub/82-003-x/2020002/article/00002-eng.htm

Ryb, G. E., Dischinger, P. C., Kufera, J. A., & Read, K. M. (2006). Risk perception and impulsivity: Association with risky behaviours and substance abuse disorders. *Accident Analysis and Prevention, 38*(3), 567–573.

Schwebel, D., Severson, J., Ball, K., & Rizzo, M. (2006). Individual difference factors in risky driving: The roles of anger/hostility, conscientiousness, and sensation-seeking. *Accident Analysis & Prevention, 38*(4), 801–810. doi:10.1016/j.aap.2006.02.004

Sewell R.A., Poling J., & Sofuoglu M. (2009). The effect of cannabis compared with alcohol on driving. *J. Addict. 18*(3) 185–193.

Sibley, C. G., & Harre, N. (2009). A gender role socialization model of explicit and implicit biases in driving self-enhancement. *Transportation Research Part F Traffic Psychology and Behaviour 12*(6), 452-461.

Sharma, P., Murthy, P., & Bharath, M. M. (2012). Chemistry, metabolism, and toxicology of cannabis: clinical implications. *Iranian journal of psychiatry*, *7*(4), 149–156.

Smith, G. T., Fischer, S., & Fister, S. M. (2003). Incremental validity principles in test construction. *Psychological assessment*, *15*(4), 467–477. https://doi.org/10.1037/1040-3590.15.4.467

Statistics Canada (2020). *A statistical portrait of Canada's diverse LGBTQ2+ communities*. Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/210615/dq210615a-eng.htm

Stefanski, L. A., & Carroll, R. J. (1985). Covariate Measurement Error in Logistic Regression, *Annals of Statistics, 13*, 1335–1351.

Steinberg, L., Albert, D., Cauffman, E., Banich, M., Graham, S., & Woolard, J. (2008). Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: evidence for a dual systems model. *Developmental psychology*, *44*(6), 1764–1778. https://doi.org/10.1037/a0012955

Stets, J. E., & Burke, P. J. (2000). Femininity/masculinity. *Encyclopedia of Sociology* (Revised Edition, pp. 997-1005). Macmillan.

Stevens, J. (1992). *Applied multivariate statistics for the social sciences* (2nd ed.). Lawrence Erlbaum Associates, Inc.

Tate, C. C., Ledbetter, J. N., & Youssef, C. P. (2013). A Two-Question Method for Assessing Gender Categories in the Social and Medical Sciences, *The Journal of Sex Research, 50*(8), 767–776, DOI: 10.1080/00224499.2012.690110

Um, M., Hershberger, A. R., Whitt, Z. T., & Cyders, M. A. (2018). Recommendations for applying a multidimensional model of impulsive personality to diagnosis and treatment. *Borderline personality disorder and emotion dysregulation*, *5*, 6. https://doi.org/10.1186/s40479-018-0084-x

Van Beurden, E., Zask, A., Brooks, L., & Dight, R. (2005). Heavy episodic drinking and sensation seeking in adolescents as predictors of harmful driving and celebrating behaviors: implications for prevention. *J. Adolesc. Health, 37*, 37–43.

Watson, T. M. & Mann R. E. (2016). International approaches to driving under the influence of cannabis: A review of evidence on impact. *Drug and Alcohol Dependence, 169*, 148–155. Doi: 10.1016/j.drugalcdep.2016.10.023

Wadsworth, E., & Hammond, D. (2019). Differences in patterns of cannabis use among youth: Prevalence, perceptions of harm and driving under the influence in the USA where non-

medical cannabis markets have been established, proposed and prohibited. *Drug and alcohol review*, *37*(7), 903–911. https://doi.org/10.1111/dar.12842

Weinstein, A., Brickner, O., Lerman, H., Greemland, M., Bloch, M., Lester, H., Chisin, R., Mechoulam, R., Bar-Hamburger, R., Freedman, N., & Even-Sapir, E. (2008). Brain imaging study of the acute effects of Delta9-tetrahydrocannabinol (THC) on attention and motor coordination in regular users of marijuana, *Psychopharmacology, 196* (1) 119–131.

Wilkinson, A. L., Fleming, P. J., Halpern, C. T., Herring, A. H., & Harris, K. M. (2018). Adherence to gender-typical behavior and high-frequency substance use from adolescence into young adulthood. *Psychology of Men & Masculinity, 19*(1), 145–155.

Wizemann, T.M. and Pardue, M.-L. (2001). *Exploring the Biological Contributions to Human Health: Does Sex Matter?* The National Academies Press, Washington DC.

Whiteside, P., & Lynam, D. R. (2001). The Five Factor Model and impulsivity: using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30*(4), 669–689. Doi: 10.1016/S0191-8869(00)00064-7

Zakletskaia, L. I., Mundt, M. P., Balousek S. L., Wilson, E. L., & Fleming, M. L. (2009). Alcohol-impaired driving behavior and sensation-seeking disposition in a college population receiving routine care at campus health services centers, *Accident Analysis & Prevention, 41*(3), 380-386,

Zuckerman, M. (1994*). Behavioral expressions and biosocial bases of sensation seeking*. Cambridge University Press.

Appendix A

Variable	1	2	3	4	5	6
1. Sensation seeking	-					
2. Gender identification	0.10	-				
3. DACU	0.15	0.16	-			
4. Age	-0.16	0.06	0.01	-		
5. Education level	-0.06	-0.07	-0.16	0.18	-	
6. Cannabis use frequency	-0.05	-0.18	-0.47	-0.10	0.24	-

Appendix A. Correlations between variables

Appendix B

	b	*S.E.*	Z	*p*	LowerCI	UpperCI
Sensation Seeking	.0743	.0299	2.4827	.0130	.0157	.1330
W1: Women vs Men	.6281	.1185	5.2988	.0000	.3958	.8605
W2: Women vs others	-1.4228	.7348	-1.9363	.0528	-2.8630	.0174
W1 X Sensation	.0991	.0464	2.1360	.0327	.0082	.1900
W2 X Sensation	-.6006	.2789	-2.1535	.0313	-1.1472	-.0540
Age	-.0954	.1200	-.7951	.4265	-.3306	.1398
Scolarity	-.0304	.0351	-.8640	.3876	-.0992	.0385
Cannabis use frequency	-.5490	.0345	-15.9052	.0000	-.6166	-.4813

Biological sex	*b*	*S.E.*	*p*
Female	0.07	0.03	0.02*
Male	0.17	0.04	0.00*
Undetermined	-0.53	0.28	0.97

*$p<0.05$

Appendix B. Model summary with biological sex as moderator