IMPULSIVITY, CANNABIS USE, RISK TAKING BEHAVIOUR AND PERFORMANCE ON VIGILANCE, ATTENTION AND DECISION MAKING TASKS

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ABSTRACT

IMPULSIVITY, CANNABIS USE, RISK-TAKING BEHAVIOUR AND PERFORMANCE ON VIGILANCE, ATTENTION, AND DECISION MAKING TASKS

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This study aimed to explore relationships between impulsivity scores, cannabis use, and performance on vigilance, attention, and decision making tasks. We also investigated whether cannabis use related to self-reported risk taking behaviours, including risky driving, openness to engage with cryptocurrency markets, or gambling behaviour. The regular recreational cannabis users had significantly higher impulsivity scores and tendency to use other substances than non-users. The regular cannabis users had better performance efficiency than non-users for hit targets on the vigilance task, but not the other two target trial types. The regular cannabis users made significantly fewer errors than non-users on the verbal Stroop task. There were no significant performance differences on the Iowa Gambling Task between the regular recreational cannabis users and non-users. None of our other hypotheses explorations yielded statistically significant results.

Keywords: impulsivity, cannabis, vigilance, cryptocurrency, Stroop, gambling.

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TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	v
LIST OF TABLES	vi
LIST OF ABBREVIATIONS	vii
OVERVIEW	viii
INTRODUCTION	1
HYPOTHESES	22
METHOD	24
Participants	24
Procedure	24
Measures	25
RESULTS	32
DISCUSSION	48
Limitations and Future Directions	55
Conclusion	57
REFERENCES	60
APPENDIX	
A In-Lab Task Instructions	69
B Data Tables	70
C Canadian Cannabis Use in the Past 12 Months, by Sex and Age Group, 2018 to 2022	89
D A Brief History of Cryptocurrency	90
E Part One Survey Participant Screening Process	93
F Part One Qualtrics Survey Items	94

LIST OF FIGURES

Figure 1. Appearance of the Vigilance Task
Figure 2. Appearance of the Stroop Task
Figure 3. Appearance of the Iowa Gambling Task
Figure 4. Canadian Cannabis Use in the Past 12 Months, by Sex and Age Group, 2018 to 2022

LIST OF TABLES

Table 1.	Descriptive Statistics of Sample Demographics
Table 2.	Self-Reported Social Acceptability Beliefs of Substance Use, Comparing Frequency of Use and Method of Intake
Table 3.	Self-Reported Perceptions of the Degree of Risk of Harm from Various Substance Use
Table 4.	Self-Reported Perceptions of the Impacts of Cannabis Use, Comparing Responses of Cannabis Users and Non-Users
Table 5.	Belief Statements About Cannabis Use
Table 6.	Cannabis Use Patterns in Our Whole Sample
Table 7.	Comparing Rates of Other Substance Use in Cannabis Users and Non-Users
Table 8.	Self-Reported Cannabis Use Patterns and Preferences Over the Past 12 Months
Table 9.	Self-Reported Frequencies of Mixing Cannabis Use with Other Substances
Table 10.	Self-Reported Driving-Related Behaviours
Table 11.	Comparing Drinking and Driving Behaviour in Cannabis Users and Non-Users
Table 12.	Comparing Risky Driving Behaviours in Cannabis Users and Non-Users
Table 13.	Cryptocurrency Beliefs & Engagement Scale
Table 14.	Cryptocurrency Engagement Willingness, Comparing Cannabis Users and Non-Users
Table 15.	Participant Estimates About What Percentage of the Canadian Population Owns Cryptocurrency
Table 16.	Self-Reported Gambling Behaviour
Table 17.	Gambling Behaviour Changes Since Covid
Table 18.	Comparison of Reaction Times Between Congruent and Incongruent Stroop Trials

LIST OF ABBREVIATIONS

CBD	Cannabidiol
IGT	Iowa Gambling Task
THC	Delta-9 tetrahydrocannabinol

Impulsivity, cannabis use, risk-taking behaviour and performance on vigilance, attention, and decision making tasks

Overview

We were interested in exploring the relationships between impulsivity scores, cannabis use, and performance on a variety of cognitive tasks tapping attention, executive function, and decision making (a target surveillance task, a Stroop task, and an Iowa Gambling Task). We were also interested in exploring whether impulsivity scores or cannabis use would relate to self-reported risk taking behaviours, including: risky driving, openness to engagement with cryptocurrency markets, or gambling behaviour.

Impulsivity, cannabis use, risk-taking behaviour and performance on vigilance, attention, and decision making tasks

Prior to the legalisation of cannabis, cannabis use could have been considered a risk-taking behaviour, given that possession or use of the drug could have negative legal consequences, which in turn could have cascading detrimental impacts on prospective employment opportunities or stigmatisation within the community. Cannabis research over recent decades (to be discussed in this introduction) has examined how cannabis use is associated with risk-taking and impulsivity, however, with changes in the legalisation of cannabis, the use of cannabis is no longer illegal in some jurisdictions, which may change the relationships between its use and other risk-taking behaviours or impulsivity scores. Decades if research has yielded inconclusive support for the "gateway hypothesis," which theorises that use of cannabis is a gateway to further, other drug use (Public Health Ontario, 2019). One of the major aims of this study was to explore in the contemporary context of cannabis legalisation how cannabis use would relate to impulsivity scores and risk-taking behaviour.

A Background of Vigilance Research

Vigilance, a term coined by neurologist Sir Henry Head in 1923 is a state when "mind and body are poised in readiness to respond to any event external or internal" (Head, 1923). In the context of attention research, it involves maintaining a watchful state of attention for sometimes relatively long stretches of time so that one is ready to detect and respond at any time to critical changes in the environment (Siddle, 1972). In vigilance research, an important distinction is made between tasks that fall under the taxonomic categories of either *successive* or *simultaneous judgement* procedures (Parasuraman, 1979; See et al., 1995; Warm, Parasuraman & Matthews, 2008). In successive tasks, participants are typically required to keep a target stimulus in working memory and compare this memorial representation against multiple trials of other stimuli, determining whether those trials contain that same target stimulus or not. In simultaneous tasks, a sample of the target is available for reference on all trials and participants must decide whether the simultaneously presented set of stimuli contain any matches to the original available target.

A common approach in vigilance studies has been to use surveillance tasks, which generally involve detection of visual or auditory targets over long periods of time. Seminal vigilance research emerged out of Information Theory, Signal Detection Theory, Communication Theory, and necessity within the military during WWII to identify human factors that affected radar and sonar surveillance performance. Specifically, failure to detect airborne or submarine threats had potentially severe consequences for both human life and financial loss (Hancock, 2013; Warm, Parasuraman & Matthews, 2008). For a laboratory analog of military radar systems, Mackworth created the “Clock Test” surveillance task, in which participants were instructed to sustain attention on a rotating clocklike display and to report rare double-jumps of the clock’s hand (Hancock, 2017). The criterion variable in early vigilance studies was generally the frequency of “hits” or the probability of successful detection of a critical occurrence – or, in Mackworth’s early Clock test studies, the successful detection of a double-jump of the clock hand.

From the pioneering days of vigilance research, several factors have been identified that influence reaction time and detection accuracy in vigilance tasks (Baker, 1960; Bevan, Avant & Lankford, 1966), including: (a) the rate of the critical target’s appearance (the more frequent the signals, the faster the average reaction time); (b) the inter-signal interval (the more regular/consistent the intervals between signals, the more accurate general signal detection); (c) the signal to noise ratio (the stronger the magnitude of the target stimulus in relation to background noise, the more probable it will be detected); (d) knowledge of results (if participants are provided feedback whether they hit/miss a target, performance is better than without that feedback); (e) environmental factors (environmental distractions such as background noise or high room temperature are theorised to compete for attention and impair performance); (f) knowledge of signal location (performance is better if participants are cued to where the signal may appear); and (g) the length of the vigil (performance declines with increased vigil time).

Vigilance Decrement

A recurring finding throughout studies of vigilance is the phenomenon of vigilance decrement, which is defined as a gradual decrease in detection performance over time (See et al., 1995) and can begin as early as 5 to 10 minutes after the onset of a vigilance task (McCarley & Yamani, 2021; Warm, Parasuraman & Matthews, 2008). Vigilance decrement is a decrease in performance over time in vigilance-type tasks, and is an umbrella term that includes multiple forms of performance decrement, including an uptick in misses (failure to detect) or false alarms (false positives), or a delay in responding. Vigilance decrement is a term used to describe a decrease in performance and does not necessarily implicate the failure of attentional mechanisms, it is merely a recurring pattern that has been observed in research using vigilance-type tasks and can be attributed to a combination of factors. Meta-analysis has revealed that vigilance decrement occurs more rapidly in successive vigilance tasks that have a high event rate, which the meta analysts defined as 24+ rapidly occurring trials per minute (See, Howl, Warm, Dember, 1995).

There have been multiple theories to account for the occurrence of vigilance decrement. An early explanation was that a response bias may emerge over time across trials/blocks in a surveillance task. More specifically, participants shift towards responding more cautiously/reluctantly over time in vigilance tasks (Broadbent & Gregory, 1965). The researchers discovered this by observing that not only does the probability of accurate detection of targets decrease across the blocks of a vigilance task, but so too does the frequency of false alarms. This decrease in false alarm rate suggests that participants become more conservative in their decision-making over time in a vigilance task, becoming less “trigger-happy”. Essentially, the overall responding rate declines. Research suggests that vigilance tasks using either low signal rates or simultaneous tasks that do not require participants to retain the target stimulus in their memory are particularly susceptible to this conservative shift in response (Parasuraman, 1979).

Another common proposed explanation is that participants merely experience a decline in internal sensitivity (Parasuraman, 1979; Warm, Parauraman & Matthews, 2008), which is purportedly caused by a systemic overload, or depletion of attention resources. According to this theory, over time the accumulated tiredness from the demands of sustained attention undermines the ability to maintain a steady, high level of vigilance and a decline in performance results from this physical and cognitive fatigue. High signal rates and successive (memory-involved) vigilance tasks have been identified as likely to produce a decline in sensitivity (Parasuraman, 1979). Other design factors that make vigilance tasks more cognitively demanding include having irregularly occurring signals, spatial uncertainty about where/when the signal will occur, and whether multi-tasking is involved (Warm, Parasuraman, & Matthews, 2008).

Within the framework of cognitive resource depletion explanations, there are several proposed mechanisms for this decline. According to the *resource depletion model*, the cognitive demandingness of vigilance tasks causes stress that gradually wears down participants' capacity for further information processing; alternatively, the *resource control model* explains that over time, participants' executive control wanes, which gives way to task-irrelevant, mind wandering and irrelevant thought (McCarley & Yamani, 2021). Both models suggest that participants are less sensitive to targets following cognitive taxation imposed by the vigilance/surveillance tasks. McCarley and Yamani (2021) provided support for three other explanations for vigilance decrement: a response bias shift wherein participants respond more conservatively, a drop in sensitivity, and also attentional lapses. Of these three explanations, however, they identified the conservative shift in responding as the strongest contributor towards vigilance decrement.

Conversely, Hancock (2013) proposed that the vigilance decrement observed in lab settings may actually reflect the inadvertent systemic flaws with the monotonous tools used to measure vigilance in artificial in-lab environments. Hancock believes the artificial nature of in-lab vigilance tasks which typically constrain participants to focus narrowly on repetitive signals for extended periods, are taxingly boring. Therefore, participants become increasingly invigilant as they tire of the task at hand, rendering the decrement in performance observed to be iatrogenically induced by the task's boring and low-stakes nature. Unlike real-life demands for vigil that can potentially be threatening situations with real-life consequences, in a research context there lacks true consequences for failure, and this undermines motivation to maintain vigil. Throughout the arduous externally-imposed vigilance in-lab tasks, participants become increasingly invigilant and show a decline in performance, which Hancock believes reflects the strain of the nonoptimal nature of the vigilance tasks used in research, rather than one's capacity to sustain vigil if required in the real world. In an effort to study the decrement, researchers have found ways to exacerbate it.

Neuroimaging research has indicated that vigilance decrement corresponds with changes in cerebral hæmovelocity.With the use of Doppler sonography, technology that uses ultrasonic waves to measure real-time metabolic changes as cerebral activation byproducts (such as carbon dioxide) dilate the blood vessels that moderate blood flow, researchers are capable of capturing images indicative of cerebral activity (Warm, Parasuraman, & Matthews, 2008). Greater levels of activation byproducts are interpreted as indicative of greater cognitive effort/load. Transcranial Doppler sonography has revealed the underlying physical concurrence of cerebral hæmovelocity shifts and vigilance decrement as participants actively engage with a vigilance task - there is a correspondence between a decrease in cerebral blood flow as vigilance decrement occurs behaviorally.

Cannabis Use in Canada

With the legalisation of recreational cannabis trending upward across Western countries, use of the drug is on the rise. In Canada recreational use was legalised in October 2018, and according to the Canadian Cannabis survey conducted by Statistics Canada in 2018, 22% of surveyed Canadians aged 16+ reported having used cannabis at least once over the previous 12 months. In a survey of young Canadians, 36% of the sample aged 16 to 19 and 44% of Canadians surveyed between 20 and 24 years old reported use in the previous 12 months (Statistics Canada, 2018). Results from the 2022 Canadian Cannabis Survey indicate a significant increase in cannabis consumption, with an overall rate of 27% of survey participants aged 16+ reporting cannabis usage in the previous 12 months (Statistics Canada, 2022). Reported cannabis usage in the 2022 survey remained higher in younger Canadian cohorts, with 37% aged 16 to 19 and 50% aged 20 to 24 reporting cannabis usage in the previous 12 months (Statistics Canada, 2022). Appendix C includes a visualisation produced by Statistics Canada indicating the significant increases in cannabis consumption over the years between 2018 and 2022. The increase in cannabis consumption is concerning, for with it comes physiological effects to be explored in this paper. In fact, in a recent Canadian press release regarding the National Drug Driving Study 2024, results of blood tests taken within six hours following car accidents between 2018 and 2023 indicated that 16.6% percent of the drivers tested positive for cannabis in their blood, which was slightly higher than the 16% prevalence rate of alcohol (Ramsay, 2024). Also recently, the Ontario Drug Driving Study 2024 Progress Report, which analysed the data of collected blood samples from motor vehicle accident drivers at three trauma centres in Ontario within six hours of their crash, likewise indicated that 15.3% of drivers tested positive for THC in their blood (Brubacher et al., 2024).

Physiological and Cognitive Effects of Cannabis

Humans have an innate homeostasis-regulating endocannabinoid system that entails CB1 and CB2 receptors, the endocannabinoids that activate them, as well as the enzymes that synthesise and break down endocannabinoids (Holland, 2010). The body's CB1 receptors are located within the central nervous system, concentrated within the brain and spinal cord; the CB2 receptors are concentrated within the immune system and peripheral tissues (Manzanares, Urigüen, Rubio, & Palomo, 2004). While our bodies have naturally occurring cannabinoids that interact with our endocannabinoid systems (such as anandamide, a neurotransmitter involved in appetite and memory), cannabis usage brings an influx of exogenous cannabinoids, resulting in altered physiological and psychological states. Chinese medical records document the use of cannabis for its therapeutic physiological effects as far back as 5000 years ago, however it became a widespread medicine in postcolonial Britain in the 19th century following a medical publication in 1842 registering cannabis as an antiemetic, analgesic, anticonvulsant and antispasmodic (Manzanares, Urigüen, Rubio, & Palomo, 2004). Not to be confused as a positive panacea, cannabis use has also been associated with psychological disorders including substance dependence, anxiety, depression, and psychosis (Manzanares, Urigüen, Rubio, & Palomo, 2004).

Concerningly, there has been an influx of widely varying synthetic cannabinoids (which also activate CB1 and CB2 receptors) that are marketed as an alternative to cannabis and recent research suggests its use has been associated with more negative outcomes, such as greater unemployment levels and poorer mental health compared against counterpart users of regular cannabis in the study (Cengel, Bozkurt, & Evren, 2021). These poorer outcomes from synthetic cannabis use might be explained by finding that synthetic cannabinoids have between 2 and 100 times the pharmacological effects and more intense psychoactive effects compared against natural cannabis (Castaneto et al., 2014). Also concerningly, cannabinoid receptors seem to activate and respond to synthetic cannabinoids at lower dosages than they do for natural cannabis (Castaneto et al., 2014), possibly increasing the likelihood of the risk of its users overdosing.

Delta-9 tetrahydrocannabinol, colloquially referred to as THC, is one of over 104 cannabinoids that have been identified in cannabis and is by far the most widely studied (Borgan, Beck, Butler, et al., 2019). THC is a psychoactive cannabinoid that binds to CB1 receptors in the brain and produces psychological effects. Notably, cannabis seems to have varying impacts on different people, with some being susceptible to detrimental effects while others do not experience that same negative impact, possibly explained by different gene compositions and/or personality characteristics (Atakan, 2012). One possible explanation for differential effects of cannabis is that different cannabis strains have different ratios of THC to cannabidiol (CBD), and since CBD may serve as a neuroprotective force, users that more regularly use strains higher in CBD may benefit from its possible protective effects that would otherwise be missing for users that typically use high THC and to low CBD ratio strains (Demirakca et al., 2011). Psychological research has discovered significant differences between cannabis users and non-users in multiple domains of cognition, including divided attention, information processing, and fluid intelligence (McCartney, Arkell, Irwin, & McGregor, 2021). Under the acute influence of THC, participants have demonstrated impaired immediate and delayed recall on memory tasks, as well as poorer performance on verbal learning tasks (Borgan et al., 2019). The cognitive impairment associated with acute cannabis intoxication has been shown to subside within five to seven hours if it is ingested via inhalation, but can last longer if ingested orally or in an exceptionally high dosage (McCartney et al., 2021).

Given that cannabis use is associated with negative cognitive effects, the longevity of the physiological impacts is an important consideration. There are contentious findings about the longevity of cognitive impairment associated with cannabis use following a period of abstinence – for example, in the domain of memory, some studies indicate improvement after 28 days of abstinence meanwhile others have found lingering impairment 28 to 60 days since the onset of abstinence (Borgan et al., 2019). It is important for scientists to ascertain the temporal length of lingering cognitive impacts associated with cannabis use, for these findings could have implications for labour policies in regards to drug-testing for jobs wherein sharp cognitive skills are essential for safety.

While some researchers focus on delineating the longevity of cannabis impairment, other researchers have discovered that cannabis intoxication could have impacts on the perception of time itself. Perhaps intuitively this proposition seems sensible, given that there is a proliferation of CB1 receptors in the prefrontal cortex and cerebellum, areas of the brain involved in the perception of time (Fontes et al., 2016). Could the influx of exogenous cannabinoids in these brain regions concentrated with CB1 receptors influence time perception? Recent research indicates that the phenomenological experience of time perception may vary in cannabis users while they are acutely intoxicated (Ogden & Faulkner, 2022; Sewell, Schakenberd, Enander et al., 2012). Sewell et al. (2012) cleverly used two types of tasks to explore time perception - a time estimation task, and a time production task. In the time estimation task, the participants were requested to count the number of letter B's that flashed on the screen while ignoring the other letters - this served as a distractor to prevent participants from counting the total number of seconds in the trial, which was the actual variable of primary interest (the participants' estimation of how long the task was). By contrast, in the time production task participants were instructed to press down on a mouse button and hold it down for an assigned number of seconds (varying from 5 to 30 seconds) before releasing it.

Prior to measurement, participants were administered THC in either a low dosage (0.01-0.02mg/kg), medium dosage (0.03-0.04mg/kg), or high dosage (0.05mg/kg) (Sewell, Schakenberd, Enander et al., 2012). Remarkably, regardless of dosage, under the influence of THC participants overestimated the passage of time in the time estimation task and underproduced time intervals in the time production task compared to both their baseline and placebo performance (Sewell et al., 2012). This finding is consistent with other research that has found cannabis users overestimate the passage of time on time estimation tasks (Paasche, Weibel, Wittman, & Lalanne, 2019) and suggests that time may feel as if it is passing more slowly to cannabis users. Notably, Sewell et. al (2012) concluded there was not a significant difference in the baseline scores on either the time estimation nor time production task between the frequent (8+ uses in the past month) and infrequent (<2 uses per week) cannabis users, suggesting there are not long-lasting effects of chronic, frequent cannabis usage on time perception. The researchers theorised that THC might increase our internal clock speed, creating the phenomenological perception of time passing more quickly than in reality it is – in essence, a standardised block of time may feel longer under the influence of THC than it would at baseline. More recent research indicates that varying strains of cannabis could have differential impacts on time perception, for example, indica strains may have stronger impacts on distorting time-perception than sativa or hybrid strains (Muro, Cladellas, & Corstellà, 2021). This highlights the importance of not considering cannabis as a unitary drug, for by grouping together the impacts of different strains, some important effects of certain strains could be masked by others should they have opposing effects.

The research outlined above has several important implications for the present thesis. The pattern of vigilance decrement occurring in lab-lased vigilance tasks and the changes in time perception and attention associated with cannabis use as discussed above contribute to the rationale for the study documented below. Specifically, performance accuracy over time has been discussed. Should cannabis users have an altered perception of time in that it feels more elongated, does that mean cannabis users might bore more quickly when doing a surveillance-type task and begin to show declines in performance earlier in the surveillance block than non-users? This is one of our major research questions, and we hypothesise cannabis users might demonstrate an earlier descent in their surveillance-task performance curve than non-users. Such a finding would open the questions of whether any decline discovered in cannabis users might be attributable to physiological or psychological fatigue, mind wandering, response criterion shifts, increased or decreased phenomenological time passage which could affect the experienced inter-target interval or duration of the vigil.

One of the documented impacts of cannabis is that it can slow reaction time (McCartney et al., 2021; Brooks-Russel et al., 2024). Slower reaction time is concerning as sometimes a difference in milliseconds can make a magnitude of difference in outcomes – in driving, for example, immediate responsiveness in a potentially dangerous, high speed situation could make the difference between getting into a collision and not, especially on congested highways wherein drivers are not respecting the "keep two chevrons apart" advisory.

Impulsivity and Risk-Taking

Impulsivity is a wide-ranging concept that comprises several facets such as sensation-seeking and risky behaviours, difficulty in delaying gratification, and aloofness to long-term consequences (O'Donnell et al., 2021). In essence, it is a myopic tendency to make rash decisions. Elevated impulsivity scores have been associated with risky-behaviour, including drug abuse (Perry & Carroll, 2008), gambling (Navas et al., 2017), and unplanned pregnancy (Godiwala, Appelhans, Moore Simas et al., 2016). Of the multitude of factors that contribute towards risk-taking behaviour, impulsivity is one of the most closely connected to risk-taking behaviour (Megías-Robles, Cándido, Maldonado, S. Baltruschat, & Catena, 2022). Impulsivity is one of the variables we measure in our research, employing the Dickman Reduced Impulsivity Scale.

The Iowa Gambling Task (IGT) is a widely used lab procedure that psychologists use to assess risky decision making. Decision making is a behaviour that involves surveying potential options and selecting a choice between those potential options to execute (O'Donnell, Skosnik, Hetrick, & Fridberg, 2021). For the IGT, participants select amongst four card decks, with each deck preset by the experimenter to have a different win:loss ratio, and participants must integrate the financial consequences associated with those outcomes to guide their ongoing decisions (O'Donnell et al., 2021). Suhr and Hammers (2010) explored whether psychological variables (personality, intellect, executive function) related to performance on the IGT. They additionally measured cerebral oxygenation via near-infrared spectroscopy to assess potential differences in cortical activation between groups that either made money or lost money on the IGT. The particular focus was on whether those who lost money on the IGT scored higher on impulsivity-related sensation seeking behaviours. There was a moderate effect-size in the data (Cohen's D = .48) indicating a connection between poor IGT performance and impulsivity, and while this finding did not reach statistical significance, the researchers attributed that to low statistical power (only 58 participants were involved). Executive function findings were mixed. Two tasks tapping executive function were used in this study. The Wisconsin Card Sorting Test showed no significant group differences, however the N-back Test did find there were significantly more commission errors made on average in the poor IGT-performance group. The near-infrared spectroscopy results revealed there was less activation in the right frontal cortex in the poor IGT performance group than the high IGT performance group, which was consistent with prior research

(Suhr & Hammers, 2010). These findings are relevant to our research question because substance use has been associated with differences with both impulsivity and executive function in non-users.

Another relevant study that employed the IGT explored whether there were any interactions between risky decision making, impulsiveness, and smoking behaviour – in this study, the researchers were curious whether there would be differences in these measures between groups of young tattooed versus non-tattooed women (Kurtman, Kagan, Lapidus, & Weizman, 2013). The tattooed group self-rated themselves significantly higher on all scales of the Barratt Impulsivity Scale II and performed significantly poorer on the decision making IGT compared with the non-tattooed group (Kurtman, Kagan, Lapidus, & Weizman, 2013). This finding supports other research that has found body modification (in the form of piercings) to be significantly positively correlated with impulsivity and hyperactivity scores (Glans, Nilsson, & Bejerot, 2024). Curiously, Kurtzman et al. (2013) found that the tobacco smoking rate was five times higher within the tattooed, generally more impulsive group versus the non-tattooed, generally lower in impulsivity group. Together these findings suggest that high impulsivity may be predictive of an inclination towards engaging in risky behaviours.

There is a growing field of research delving into the relationship between impulsivity and substance use. O'Donnell et al. (2021) explored whether there was a connection between cannabis usage and decision making as well as impulsivity (the Barratt Impulsiveness Scale was used for measuring impulsivity). In their study they compared cannabis users (defined as using cannabis a minimum of once per week and no other illicit substance use within the past three months) against a group that had never used cannabis. They concluded that there was an association with impaired decision making and elevated scores of impulsivity in their cannabis using group compared against the group of non-users. Other research using the Barratt Impulsiveness Scale II has indicated even higher levels of impulsivity on all subscales in patients with synthetic cannabinoid use disorder compared against a group of participants with cannabis use disorder (Sengel, Bozkurt, & Evren, 2021).

Consistent with their findings of elevated self-reported impulsivity in the cannabis using group, the cannabis users in O'Donnell et al. (2021) indicated a preference for immediate, smaller rewards rather than delayed, larger rewards and made less beneficial decisions on the Iowa Gambling decision making task compared with non-users. On average it took the cannabis-using group significantly longer (into the final, third block of 50 trials) than the non-using group to shift their selection pattern towards the more advantageous decks, suggesting either a lag in learning or potential forgetting of earlier outcomes (O'Donnell et al., 2021). Given that CB1 receptors are densely concentrated in cerebral regions associated with decision making (including the amygdala, hippocampus, prefrontal cortex, cingulate cortex, dorsal striatum, cerebellum, and ventral tegmental area), perhaps it is unsurprising that a surge in exogenously sourced cannabinoids in cannabis users could influence decision making behaviour (O'Donnell et al., 2021).

Other recent research has compared impulsivity scores and problems arising from substance use in regular users of non-synthetic cannabis to those that use synthetic cannabis (Cengel, Bozkurt, & Evven, 2021). Synthetic cannabis, which is typically billed as an alternative to cannabis that is more difficult to detect in urine also interacts with CB1 and CB2 receptors, however it often has a longer half-life and can produce 4 to 100 times the pharmacological effects (Cengel, Bozkurt, & Evven, 2021). Natural cannabis contains cannabidiol, which works as both an antipsychotic and anxiolytic substance whereas synthetic cannabis does not, which might partly explain why synthetic cannabis has increased toxicity, worse side effects, and worse withdrawal symptoms post-cessation compared to natural cannabis. Researchers found that in their comparison of 54 synthetic cannabis users against 45 natural cannabis users that the synthetic use group scored higher on all impulsivity subscales on the Barratt Impulsiveness Scale II (Cengel, Bozkurt, & Even, 2021). Quite often psychologists will consider the degree to which a concern impacts day-to-day life function in everyday tasks in evaluating its severity. In this particular study, 51.9% of the synthetic cannabis using group was unemployed, versus 8.9% of the natural cannabis using group – this contrast alone could be considered significant.

Executive Function and Stroop Performance

A widely-used tool to study executive function is the Stroop task, which demands that participants selectively attend to one visual characteristic of a multi-featured stimulus, ignoring the other characteristics. In a Stroop task it is the participant's role to identify the colouring of a word (the colour of the text) and ignore what the word says (often the word is a colour name). Trials are either congruent (when the word says "RED" and its colouring is red) or incongruent (when the word says "BLUE" but its colouring is red). Participants are quicker to respond and less error-prone in congruent blocks than incongruent blocks – a phenomenon labelled 'the Stroop effect.' Altering the physical intensity of the presented stimuli, such as the hue or intensity of the colours presented, can influence how difficult it is to discern those stimuli, which can increase reaction time in relation to increasing difficulty (Callaghan, 1984).

Research suggests that the Stroop effect magnitude can be influenced by altering the congruent:incongruent trial ratio, revealing a greater Stroop effect when the majority of the Stroop trials are congruent compared to when incongruent trials outnumber the congruent ones (Schmidt & Besner, 2008). Participants can implicitly learn contingencies that can amplify the Stroop effect, for example, if there are proportionately more congruent trials (high contingency congruent) than incongruent trials (low contingency incongruent), participants learn to have biassed expectancies that shift them towards responding faster in the more commonly presented trial type, serving as a form of response strategy (Schmidt & Besner, 2008).

Neuroimaging research suggests that with increasing proportions of Stroop trials that are incongruent, there may be greater cognitive load demands. The use of fMRI neuroimaging has revealed a positive linear relationship with increasing proportions of incongruent trials and activity in the anterior cingulate cortex (Mitchell, 2010). For our purposes, we are aiming to compare performance (measuring reaction time and error frequency) between regular recreational cannabis users and non-users on a spoken response computer based Stroop task. We wanted half of our Stroop trials (n = 96) to be cognitively challenging incongruent trials to increase the probability participants making errors on our Stroop task. However, we did not want to load the number of incongruent trials as we did not want a response bias to begin to occur if participants begin expecting trials to be incongruent and strategically filter out the word presented to focus more narrowly on the font colour. For these reasons we chose to equally balance the ratio of congruent and incongruent trials.

Gambling, Cryptocurrency

Cryptocurrency, a rapidly expanding market, is an encrypted digital currency that can be exchanged anonymously between parties without the intermediary involvement by a financial institution. It is an emerging asset class with a notorious reputation for its volatility. For a condensed summary of the history of cryptocurrency, see Appendix D. Unlike some forms of investment that have guaranteed, government insured financial returns such as Treasury bills and GICs, cryptocurrencies operate more similarly to stocks and often have rapid, wide fluctuations in their value. Like the traditional stock market, the cryptocurrency market has a combination of experienced and new traders that make buy and sell orders that operate via digital trading systems/exchanges. However, unlike the traditional stock market, cryptocurrency is (a) far more volatile in its sometimes extremely rapid value fluctuations, (b) its trading platforms operate 24/7, and (c) its value is harder to evaluate, often stemming from its potential use-case or reputation (Delfabbro, King, & Williams, 2021). Cryptocurrency engagement can be considered more akin to gambling than saving. The Oxford English Dictionary defines gambling as "exposing (something valuable) to risk or danger in the hope of gaining some advantage, benefit, or success" (Oxford English Dictionary, n.d.). Given the volatile context of the cryptocurrency market, the purchase of cryptocurrency can be considered gambling due to the potential risk of losing the definite value of one's speculative monetary investment should the cryptocurrency of choice decrease in value from the time of its acquisition. Research has indicated an association between gambling behaviour and the use of cannabis (Punia, DeVillaer, MacKillop, & Balodis, 2020). This introduction has highlighted a connection between cannabis use with a tendency towards impulsivity, risk-taking, and gambling behaviours. Considering these already documented associations, we were curious to explore whether cannabis users might have more favourable attitudes about or openness to purchasing cryptocurrency than non-users, given that opting into the cryptocurrency market could be considered an inherently risky form of gambling.

A recent gambling-related study by Kocher, Lucks, & Schindler (2018) explored the influence of psychological variables (including self-control and risk attitudes) upon trading behaviour in stock markets and to examine whether there would be a relationship between self-control and overpricing in financial markets. In the study, the researchers attempted to experimentally lower some participants' self control, which they defined as a "person's capacity to refrain from acting upon undesired behavioural tendencies/impulses." To accomplish this they utilised a 5-minute Stroop task, designed to be loaded in more challenging incongruent trials for the "low self-control" condition – while the researchers did not make reference in their paper to the resource depletion model previously discussed in this thesis, this implementation of the Stroop task for the purpose of deliberately wearing down participants' self-control relates to this model. Cleverly, the researchers had participants return to the lab for multiple visits to compare differences across low and high self-control conditions in a within-subjects design. In this study a computerised simulated experimental market was used wherein participants were provided experimental cash and assets with which to trade (posting bids/asks and also accepting offers on their assets). In total there were ten trading periods that each lasted two minutes. The researchers concluded that the lower self-control condition prior to engagement with the experimental market resulted in significantly higher market overpricing and the participants being significantly more inclined to buy assets at excessively inflated prices (Kocher, Lucks, & Schindler, 2018). Given the similarity in construct between self-control and impulsivity, these findings are significant as people with higher impulsivity might be at greater risk of making financially imprudent decisions in financial markets and scorching their pockets by impulsively buying in at inflated prices well above the fundamental value.

Other research related to impulsivity and cryptocurrency involvement was explored in a recent survey that had the inclusion criteria of its participants being both 18+ and holders of Bitcoin cryptocurrency in a cryptocurrency wallet, researchers found that day-traders were far more likely to engage in temporal discounting than long-term traders (Haj & Moustafa, 2023). Temporal discounting occurs when people select smaller but more immediate rewards instead of distant, larger rewards and performance on temporal discounting tasks can be used as a predictor of impulsivity. A separate impulsivity-related recent study that surveyed adults that had been trading cryptocurrency for a minimum of six months (albeit unfortunately 96.7% of their participants were male so generalisation is to be taken with caution) found that frequent cryptocurrency and day traders as a group scored higher in motor impulsivity (Sonkurt & Altinoz, 2021). Impulsivity-related scores are relevant as they could potentially be used as predictors for those at greater risk of engaging in the risk-fraught realm of cryptocurrency.

Research has explored whether there is any association between gambling behaviour in regular gamblers (those that have gambled a minimum of once per month over the past year) and engagement with cryptocurrency markets (Mills & Nower, 2019). The researchers discovered that cryptocurrency trading frequency was significantly positively correlated with all other forms of gambling measured within the survey (from scratch tickets, to skill-based casino-type games, to high risk stock trading). Shockingly, 53% of their sample had engaged in the cryptocurrency market within the past year, and, less shockingly, those with moderate to high risk for problematic gambling were significantly more inclined to have been involved with the cryptocurrency market (Mills & Nower, 2019). Other survey research exploring potential connections between gambling and cryptocurrency trading found significant positive correlations between cryptocurrency trading and greater excessive gambling, online gaming, and excessive alcohol consumption (Oksanen, Manter, Vuorinen, & Savolainen, 2022). Among Mills and Nower's sample that were involved with high-risk stock trading, 75% of them were also cryptocurrency traders (2019). The study added support to a recurring finding that cryptocurrency trading is more common among younger, higher income earning males (Mills & Nower, 2019; Oksanen, Manter, Vuorinen & Savolainen, 2022). Given that the sample to be studied in our study is young, university students (likely to become higher income earners post-graduation), these research findings in regards to cryptocurrency and risk taking behaviours may be directly relevant to our target sample and participation may be beneficial to them for this reason should these pertinent findings be brought to their awareness as a consequence of involvement with this study.

The Present Study

The research literature above has highlighted connections between cannabis use and risky behaviour. We aimed to explore the connection between cannabis use and risky behaviour further by asking participants about their engagement in real-world potentially risky scenarios, including risky driving behaviours and involvement in cryptocurrency markets. Furthermore, we were curious to explore whether the cannabis users in our sample would more frequently select risky card decks in an imitation gambling game, the Iowa Gambling Task.

The association between substance use and higher impulsivity scores has been discussed in the introduction above. If cannabis users as a group are higher in impulsivity we would expect them to be more rash in their actions, taking less time to process their thinking. With that in mind, we would expect the cannabis users to make more frequent judgement errors, which is something we will look for in the frequency of errors using both a Stroop task and a target surveillance vigilance task.

Hypotheses

Online Survey

Hypothesis 1: The recreational cannabis users in our sample would score significantly higher in impulsivity scores measured by the Reduced Dickman Scale used in our survey.

Hypothesis 2: Recreational cannabis users would be significantly more likely to report "yes" to both having purchased cryptocurrency in the past and "yes" to being willing to purchase cryptocurrency in the future.

Hypothesis 3: That the recreational cannabis users in our sample would be significantly more likely to use other substances (alcohol and tobacco) than the non-users.

Vigilance Task

Hypothesis 4: There would be a significant difference in performance on the vigilance signal detection task between regular recreational cannabis users and non-users. Specifically I predicted that cannabis users would not perform as well as the non-users, making more mistakes in target selection.

Hypothesis 5

H5: There would be a negative correlation between impulsivity scores and performance efficiency on the vigilance task (the higher the impulsivity score, the lower the participant's performance).

Hypothesis 6: The recreational cannabis users would have significantly higher estimates about the duration of the vigilance task than non-users.

Stroop Task

Hypothesis 7: There would be a significant difference in the numbers of errors on the Stroop task between regular recreational cannabis users and non-users. Specifically I predicted that cannabis users would make errors in significantly more trials than non-users.

Hypothesis 8: The cannabis users in our sample would have slower reaction time on the Stroop task and have a significantly larger Stroop Effect magnitude than non-users, calculated as Reaction Time for Incongruent trials minus Reaction Time for Congruent trials.

Hypothesis 9: There would be a positive correlation between impulsivity scores and the frequency of errors on the Stroop task.

Hypothesis 10: That the recreational cannabis users would estimate that there were significantly more Stroop trials than non-users.

Iowa Gambling Task

Hypothesis 11: The regular recreational cannabis users in our sample would select from the two risky card decks significantly more frequently than the non-users. This would result in a much higher probability of ending with a lower financial balance. I predicted that the recreational cannabis users would end the IGT with significantly lower balances than the non-users.

Hypothesis 12: There would be a negative relationship between impulsivity scores measured on the Reduced Dickman Scale and the frequency of selecting cards from the risky card decks. Relatedly, I predicted a negative correlation between the participants' total impulsivity scores and their final financial balance.

Method

Participants

Our study was initially launched via SONA exclusively to internal Trent students who were enrolled in Psychology courses and received bonus credit towards their course grade for their participation. In total 818 Trent students enrolled in a psychology course were included as participants in Part One of our study. After three months of running our procedure we launched the study to English-speaking adults within the local community of the Durham campus hoping to collect data from adults that would expand our sample beyond that of just young university students and also to increase our sample size. However, despite a widespread distribution of 100 flyers within the local community, only one external participant contacted the researcher and enrolled in the study. Our total eligible *N* for Part One was 819 participants.

A total of 76 participants completed Part Two of our study (75 Psychology course enrolled students and 1 external participant). Our sole external participant was given $20 in exchange for their time (for completing both Parts One and Two of our study together).

Procedure

Our in -lab participants either did the Part One survey online separately in advance or did both parts together in-lab, depending on when they enrolled. Over the 2024 spring and summer semesters the research portal SONA would only allow online course students to participate in online survey research and on-campus students to participate in on-campus lab research. With our study being split between online and in-lab measures we were forced to bring our online component to occur in-lab so that those same participants were eligible to partake in our in-lab research, as per rigid SONA summer guidelines.

Apparatus

Our in-lab component was completed by participants on a desktop computer running Linux 6.1.52., with an in-house trial runner programmed in Python (Version 3.9.17, https://www.python.org/) using PsychoPy Version 2-23.2.2 (Pierce et al., 2019) for the vigilance, Stroop, and IGT tasks. The computer had an AMDFX/8658 at 2.7GHz CPU and a NVIDIA GForce GTX1060 3GB GPU driving BENQ ZOWIE XL LCD XL2730 monitor at a resolution of 2560 horizontal and 1440 vertical pixels. The refresh rate was 144 Hz. Manual responses were made via a standard USB keyboard.

Spoken responses in the Stroop task were recorded via two dynamic microphones through an M-AUDIO mixer to improve the probability/quality of the audio recording properly. Further, a 20ms 2000Hz tone which was synchronised with the vertical-refresh onset of the colour/word combination for each trial, was included in the audio track so stimulus onset to spoken response latency could be determined . A 20 ms 1200Hz tone synchronised to the stimulus offset was also recorded. The audio was recorded as 44.1kHz, 16 Bit flac files.

These audio files were post-preprocessed with WhisperX (which uses intelligent adaptive speech detection) to extract the spoken words and timings (Bain, Huh, Han, & Zisserman, 2023). The time measurement tools in Audacity Version 3.3.3 (Audacity Team, 2014) were used to verify the WhisperX report.

Measures

Part One

Part One consisted of an online, anonymous 98 item survey that participants completed at a time and setting of their choice. A copy of the survey included in Appendix The survey comprised of seven subscales: demographics (7 items), substance beliefs (14 items), substance use (27 items), risky driving (11 items), cryptocurrency beliefs (17 items), gambling behaviour (5 items), and a Reduced Dickman Impulsivity scale (10 questions). Additionally, there were 7 lie-detecting items used to screen for non-serious surveyors or those that were not attentively reading the questions (for example: “This question is meant to find out if you are thoroughly reading each item. Select "Mars" if you are”). Following participation in that initial survey, participants had the option to participate in Part Two, the in-lab component if they registered for it via SONA for Psychology course research participation credit. The screening process used to filter eligible participants is outlined in Appendix E.

We grouped eligible participants into our recreational cannabis user and non-user groups for analyses based on their responses to items SU1 and SU10. Participants that responded “No” to our SU1 question about whether they had ever used cannabis for non-medicinal purposes in their life as non-users (n=250). Participants were classified as recreational cannabis users if they indicated in SU10 that they use cannabis on average at least once or twice per week or more (n=170).

Part Two

Part Two began with a brief survey with a variety of questions pertaining to cannabis use. This data was used to split our in-lab participants into two groups based on substance use (recreational cannabis users and non-users). Those that reported cannabis use a minimum of one or times per week were included in our regular recreational cannabis user group. Next participants serially completed three in-lab cognitive tasks, which always appeared in the same order: a surveillance/vigilance task, a Stroop task, and an Iowa Gambling task (IGT), which cumulatively take approximately 50 minutes to complete. To read the exact instructions provided to participants before each of the in-lab cognitive tasks, see Appendix A.

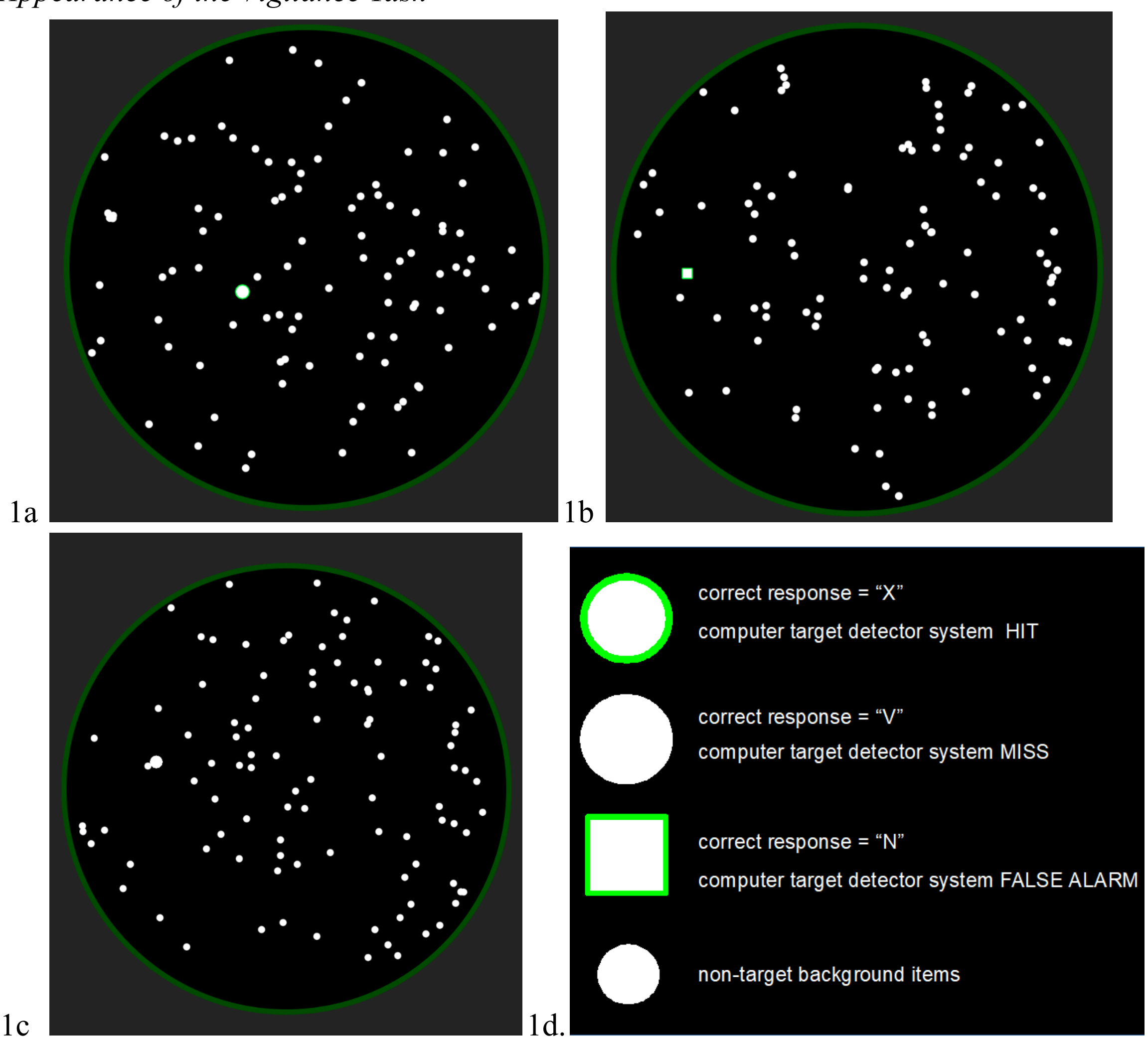
*Vigilance Task***.** For the vigilance task (approximately 29 minutes), the participants' task was described as checking the accuracy of the target/non-target classifications made by a computer target detector system. The participants had to assess whether it had accurately classified (a) hits, (b) misses, or (c) false alarms based on the appearance of the targets. Participants saw a large circular window frame presented on the computer screen in front of them with approximately 100 regenerating small, round white dots moving outwards until they disappeared along the edge of the circle frame. Figure 1 includes screenshots of how this task appeared on the computer monitor. Three target types appeared at random intervals amidst the small circular white dots: large white dots highlighted in green outlining (hits), large white unhighlighted dots (miss), or small white squares highlighted in green outlining (false alarm). The participants were tasked with clicking one of three designated buttons on a standard computer keyboard ('X', 'V', or 'N'), depending on the observed target's appearance, as quickly as possible. For visual reference, a small legend was taped below the keyboard identifying which of three keys to press depending on the target's appearance.

Our dependent variables were the participants' reaction time and accuracy in identifying the targets, as well as their total number of missed targets and false alarms. A trial was recorded as a "hit" if the participant accurately selected the correct key that aligned with the target type presented on the screen (e.g., the participant selected 'V' when an uncircled large white dot appeared on the screen). A "false alarm" was recorded if a participant inaccurately pushed a key suggesting a particular target was on the screen (e.g., the participant selected 'V' when the appropriate button to have pushed would have been an 'N'). A "miss" was recorded if a target appeared on the screen and that participant failed to press a key before the target reached the edge of the screen. While the duration of the vigilance task was equal for all participants, those that were faster and/or more accurate responders could have been exposed to more target trials, for one target trial would not end until the correct target classification was selected.

Signal detection tasks that involve detecting rare visual targets have been widely used by many researchers examining vigilance, and we were interested in comparing our findings to those reported in the existing literature. Depicted below is a screenshot of what the task looked like.

Figure 1

Appearance of the Vigilance Task



Note. Figure 1a depicts a "hit" target, a larger white circle highlighted with green. Figure 1b depicts a "false alarm" target, a small white circle highlighted with green. Figure 1c depicts a "miss" target, a large white circle that is unhighlighted. The vigilance task screenshots were cropped and shrunk for insertion here.

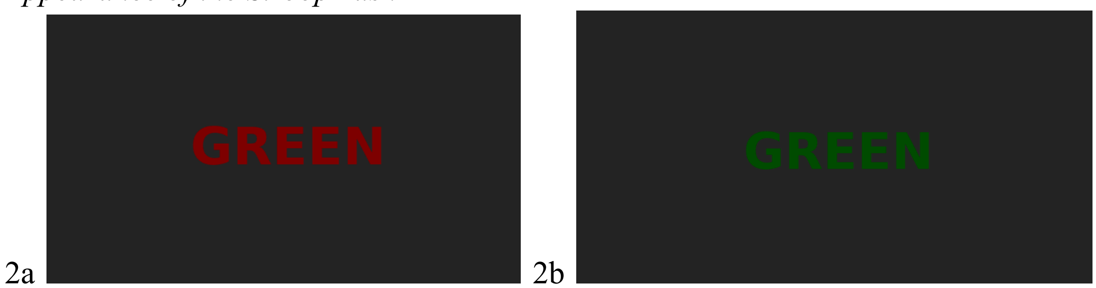
Figure 1d is a depiction of a legend indicating the correct response for each trial type, based on the target's appearance.

Stroop Task. For the Stroop task (12 minutes in length), participants saw colour words (either: "GREEN", "BLUE", or 'RED') presented on the screen and were required to state the colour of the font on the screen into the microphones, regardless of what the written word was. Figure 2 includes screenshots of how this task appeared on the computer monitor. For each trial there was a 20ms 2000 Hz tone presented simultaneously with the trial word to mark the onset of the colour/word. Each word was presented for two seconds, followed by a concluding 20ms 1200 Hz tone, which marked the offset of the colour/word. The screen appeared black until the next trial. For half of trials the colouring of the font was congruent with the written word (for example, "RED" was presented with red-coloured font), and on the other half of the trials the colouring was incongruent (for example, the word 'BLUE" was presented with red-coloured font). In total there were 192 trials, with a randomised order of congruent and incongruent trials – the colour combinations were also randomised. Participants' speech was recorded for subsequent analysis of error frequency and response latency, which was to be compared between groups based on cannabis use.

We measured the frequency of errors, which we defined as any response that deviated from a correct response (correct response = the participant's initial response was to state the colour of the font for that trial). Because errors that occur in the latter half of the task duration could be indicative of vigilance decrement, we calculated total errors for the first and second half of the Stroop block. An error was recorded if the participant's response deviated in any way from the correct expected response, including: (a) a lack of response for a trial, (b) an error wherein the participant stated the text of the word presented and not the font colour in incongruent trials, or (c) a response that included a self-correction that began with an erroneous response (e.g., “gr… red”).

Figure 2

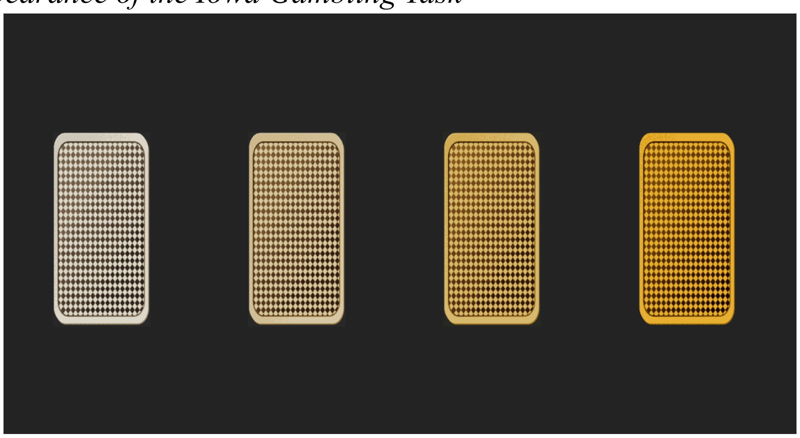
Appearance of the Stroop Task



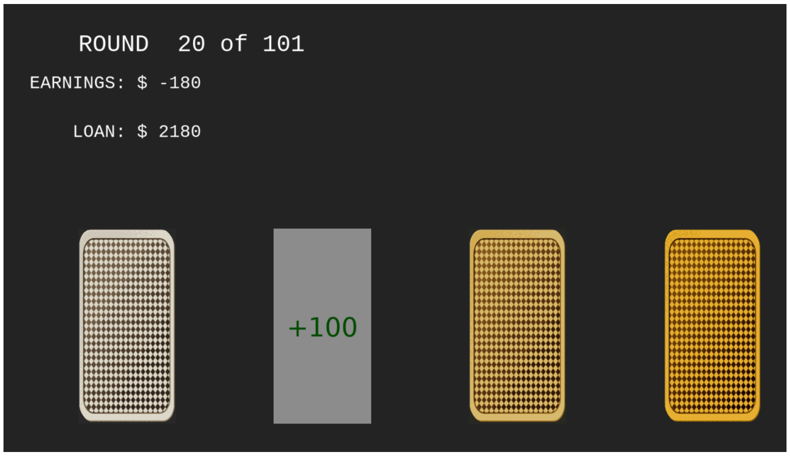
Note. Figure 2a depicts an incongruent trial and Figure 2b depicts a congruent trial. These Stroop screenshots were cropped and shrunk for insertion here. In our study the font appeared amidst a black background screen.

Iowa Gambling Task. The Iowa Gambling Task (IGT) was designed to assess participants’ decision-making pertaining to risks versus rewards. Figure 3 includes screenshots of how this task appeared on the computer monitor. This task took participants approximately 5 minutes as they selected 101 cards total (one per trial), from decks A, B, C, or D. All participants began the task with a pretend loan balance of $2000 – the fluctuating balance of their loan remained visible on the screen throughout the tasks. Decks C and D were rigged to be advantageous while decks A and B were rigged to be disadvantageous. There were ten possible outcomes for each card of the four decks which were randomized until all ten were used within each deck, then they were rerandomized for the next ten selection cycle (if selected). Possible outcomes for (disadvantageous) Deck A were +100, +100, +100, -75, -75, -75, -75, -75, -75, -75. Possible outcomes for (disadvantageous) Deck B were +100, +100, +100, +100, +100, +100, -175, -200, -225, -225. Across ten selections from the disadvantageous Decks A or B would, the participant would have a resultant loss of 225. Possible outcomes for (advantageous) Deck C were +50, +55, +50, +55, +50, +50, -20, -20, -20, -25. Possible outcomes for (advantageous) Deck D were +55, +55, +55, +55, +50, +50, +75, +65, -120, -115. Across ten selections from the advantageous Decks C or D, the participant would have a resultant gain of 225. In order to detect a potential between-groups difference, we compared differences in IGT performance between the self-reported cannabis-users and non-users in our sample. We also plotted the deck selection choices over time between the two groups to see whether there were differences between cannabis users and non-users in how early they may have detected the pattern of which decks were more advantageous and begun to select the advantageous decks. We hypothesised that the cannabis-using group would make lower gains on the IGT compared to the non cannabis-using group.

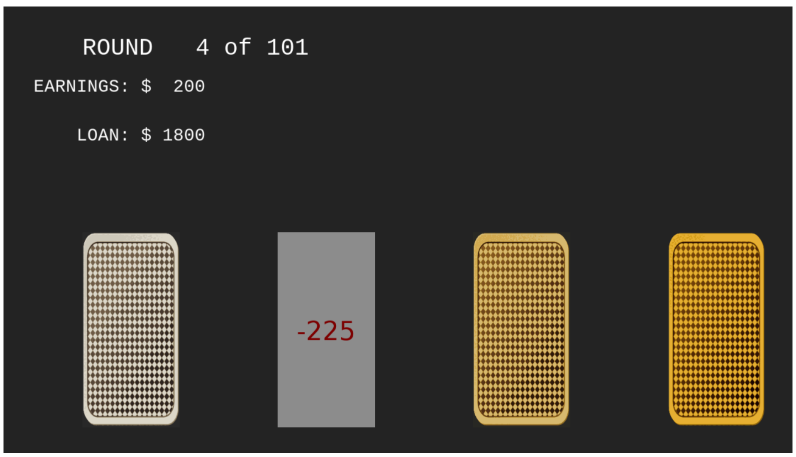
Figure 3
Appearance of the Iowa Gambling Task



3a



3b



3c

Note. Figure 3a depicts what the IGT looked like at its onset. Figure 3b depicts how a sample winning trial appeared. Figure 3c depicts how a sample losing trial appeared (which based on the severe $225 loss was from one of the two disadvantageous decks). On the monitor screen the colour appearance of the decks were (left to right): white, beige, tan, and mustard coloured, increasing in saturation intensity as they progressed from left to right. The background of the screen was black and the font was white.

Results

Part One - Online Survey

Demographics

A total of 819 participants were included in the analyses for our Part One survey. Amongst our sample 698 (85.54%) were female and 118 were male (14.4%). The mean age was 20.57 (*SD* = 5.28, *range* = 17-54 years of age). Overall, our participant pool rated their physical health as better than their mental health, with a total of 716 participants (87.4%) that reported “good” or better physical health, compared with only 55.6%

reporting “good” or better mental health. Concerningly, only 32 participants (3.9%) reported “excellent” mental health while 43.5% (n = 357) reported either “fair” or “poor” mental health. Socially our sample seemed generally content, with a combined total of 670 participants (81.8%) rating their social lives as “good” or better. English was the primary language of 90.23% of our participants. Additional descriptive statistics about our sample are included in Table 1 in Appendix B.

Substance Beliefs

There was quite the discrepancy in belief statements when comparing occasional versus regular use of substances, with participants more favourably believing occasional use to be more acceptable than regular usage across all substances. For reference, see Table 2. By far, the occasional use of alcohol was most commonly believed to be “completely acceptable” to participants (66.91%) than other substance use, including occasional tobacco use (27.07%) or smoking cannabis (40.24%). Interestingly, the perceived degree of social acceptability of substance use varied with their method of intake – for example, with tobacco, when we specified the use of vaped tobacco, 29.9% of participants viewed regular use as “completely acceptable”, which was rated much higher in socially acceptability than the preceding question about social acceptability beliefs about tobacco use generally, with only 9.9% viewing regular tobacco use as “completely” acceptable. Similarly, both regularly vaping cannabis or consuming cannabis edibles was rated as “completely acceptable” far more frequently (27.34% and 25.74%, respectively) than regularly smoking cannabis (4.67%). When asked directly whether occasional use of cannabis is safer than chronic use, 89.60% of the sample responded “Yes.”

In a similar vein, the participants perceived there to be greater risks of substance use-related harm when they are used regularly compared to using them once in a while. For example, few people believed there was "great risk" involved in drinking alcohol once in a while (0.05%), however, the majority of participants (60.25%) perceived there to be "great risk" in drinking alcohol on a regular basis. Table 3 summarises participants' perceptions of risk about occasional versus regular use of a variety of substances, along with varying forms of intake method. By far, more participants perceived there to be "no risk" involved with alcohol use, either once in a while (44.99%) or regularly (30.81%) than other substance use. The next closest runner up of perceived "no risk" substance use amongst our sample was the use of cannabis edibles, both in the occasional use (12.26%) and regular use (3.88%) categories.`

There were massive group discrepancies in belief statements about how harmful the occasional use of cannabis is when we separated the regular recreational cannabis users and non-users apart in our sample. The majority of recreational cannabis users (58.82%) "strongly agreed" that the occasional use of cannabis is non-harmful, compared with a slim minority of the non-users (7.60%). As a whole our sample leaned towards "strongly" (38.83%) or "somewhat" (36.63%) agreeing that there are short-term cognitive effects associated with cannabis use. Similarly, our sample as a whole leaned towards "strongly" (40.29%) or "somewhat" (41.51%) agreeing that cannabis has long-term impacts on cognitive abilities. Only 21.76% of the regular recreational cannabis users in our sample "strongly" agreed that there are long-term cognitive effects associated with cannabis use while 52.80% of non-users strongly agreed that there are. By contrast, a greater proportion of the recreational cannabis users either "strongly" (40.59%) or "somewhat" (41.18%) agreed there are short-term cognitive impacts compared to the non-users in our sample (32.80% and 35.80%, respectively). Only 1.18% of the non-users "strongly disagreed" that there are short-term cognitive effects associated with cannabis use while 10.40% of the recreational cannabis users "strongly disagreed." Table 4 depicts the participants' beliefs about the harmfulness of occasional and daily use of cannabis, as well as their perception of short-term and long-term cognitive effects associated with cannabis use.

The vast majority of our sample (86.79%) believe that "yes" cannabis impairs driving ability, though the regular recreational cannabis users far more frequently reported "it depends" (20.12%) in regards to potential impairment than the non-users (1.60%). Less than 1% of our surveyed believe it is safe to operate a vehicle immediately after consuming cannabis. The most common response for our question about how long after consuming cannabis it takes for it to be safe to drive was "8+ Hours" (35.70%), however, the cannabis users in our sample more frequently reported sooner intervals until it is safe to drive after using cannabis than the non-users in our sample. See Table 5 for a complete breakdown about these post-cannabis consumption driving safety beliefs.

Our sample as a whole indicated they believe that cannabis can be habit forming (97.41%), regular recreational users (98.80%) and non-users (95.95%) alike.

Substance Use

The majority (68.78%) of our sample had used cannabis in their lifetime, with 9.42% reporting having just used it once and 59.36% having used it more than once, as indicated in Table 5. The mean age of participants the first time they used cannabis was 16.87 (*SD* = 2.83, *range* = 12-41). Some participants reported having used cannabis for medicinal purposes, either with a prescription (0.86%), or, more commonly, without one (14.46%). Over the previous year, 54.7% of our sample had used cannabis for non-medicinal (recreational) purposes. Amongst those that have used cannabis, 49.33% of them reported that they use it both socially and on their own, while 44.17% use it only socially, and very few (6.50%) reported using it only on their own.

Amongst those that had used cannabis for recreational purposes over the past year (n = 562), the majority of those people use it infrequently, with 36.87% using it less than once per month, 9.93% using it once per month, and 15.45% using it two or three times per month. Cumulatively, 20.88% of our total sample use cannabis a minimum of once or twice per week, with 6.83% of our total sample reporting daily use. Table 8 summarises the self-reported cannabis use patterns in the participants that reported having used cannabis in the previous year.

Almost a third (34.47%) of the participants that had used cannabis in the previous year were unaware of which level of THC they prefer, and even more of them did not indicate a preference for CBD level (42.53%). The pattern of being undiscerning was also apparent in regards to their preferred cannabis strain preference (indica, sativa, or a blend of both), with 40.76% reporting no preference. Additional preference statistics are reported in Table 8.

The most common reported settings for cannabis use within the prior 30 days included in the participants' home (89.29%), an outdoor public place (40.91%), or at school/university (24.35%). Their employers will be reassured to know that amongst those that have used cannabis in the previous year, 70.18% reported that they had never used cannabis within two hours of going to work within the past 12 months.

The more common methods of cannabis consumption in the prior 12 months were smoking it (77.08%), vaping it in an epen (64.27%), and via eating cannabis edibles (55.96%). Amongst those that reported having used cannabis in the previous year, some experienced a strong urge to use cannabis daily (17.45%), or weekly (11.41%). Roughly over just one third (37.14%) never experienced this strong desire to use cannabis. More details into this inquiry are available to be seen in Table 8.

Table 9 indicates the self-reported frequency that those that have used cannabis within the previous year have mixed cannabis use with other substances. The commonly combined substances used alongside cannabis within the past year were alcohol 76% and tobacco 44.82%. The regular recreational cannabis users (n = 170) in our sample were far more inclined than non-users (n = 250) to smoke tobacco (20.45% vs. 0.80%), vape tobacco (26.79 vs. 0.00%), and drink alcohol (92.35% vs. 49.20%). When asked to type the number of days that they used cannabis at least once within the past 30 days for recreational purposes, the mean reported number of days was 18.81 (SD = 9.74) amongst the regular recreational cannabis users in our sample.

Risky Driving-Related Behaviours

Driving-related behaviour items are summarised in Tables 10, 11, and 12, A total of 70.33% of our surveyed sample drive a vehicle. Across our whole sample of drivers, when it comes to risky driving practices, rolling stop signs was more commonly reported (M = 3.60, SD = 1.28) than breaking 50km/hr speed limits by more than 10km/hr (M = 2.83, SD = 1.29), breaking 90-100km/hr speed limits by more than 10km/hr (M = 2.51, SD = 1.38), or changing lanes across solid white lines (M = 1.41, SD = 0.69). The regular recreational cannabis users in our sample reported engaging risky driving practices slightly less frequently than the non-users in our sample, including rolling stop signs (M = 3.39, SD = 1.26 versus M = 3.78, SD = 1.22), breaking 50km/hr speed limits by more than 10km/hr (M = 2.69, SD = 1.25 versus M = 3.12, SD = 1.27, breaking 90-100km/hr speed limits by more than 10km/hr (M = 2.24, SD = 1.28 versus M = 3.08, SD = 1.44, and changing lanes across solid white lines (*M* = 1.37, *SD* = 0.58 versus *M* = 1.38, *SD* = 0.71). Since the pandemic, participants reported that their risky driving tendencies have largely "remained the same" in regards to breaking speed limits (82.35%) and doing rolling stops (87.61%).

Only about half of the sample (49.14%) reported "no" to having been a passenger in a vehicle within two hours of the driver having used cannabis, with the remaining participants reporting either "yes" (15.89%) or that were "not sure" (34.95%). When asked whether they had driven a vehicle over the past year within two hours of using cannabis, the vast majority reported "no" (90.46%), while some answered "yes" (7.58%) or that they "prefer not to disclose" (1.95%).

The rates of reportedly driving a vehicle over the past year within two hours of consuming two or more alcoholic beverages was slightly lower than the cannabis statistics, with 93.75% reporting "no." When we repeated the same examination with a separation of groups between the regular recreational cannabis users and non-users, 6.47% of the cannabis users reported driving within two hours of consuming two alcoholic beverages while only 1.6% of non-users did.

Cryptocurrency Beliefs

Responses to our cryptocurrency-related questions are summarised in Tables 13, 14 and 15. While the majority (87.99%) of our sample had heard of cryptocurrency before, few (10.74%) had heard of the underlying blockchain technology upon which cryptocurrency operates. Further cryptocurrency questions were only asked to participants that indicated "yes" that they had heard of cryptocurrency before. The cryptocurrency-aware participants greatly underestimated how many cryptocurrencies exist. While there are well over 10 000 cryptocurrencies, only 26.30% of participants correctly estimated that there were “10 000+” cryptocurrencies – all other respondents underestimated the number of cryptocurrencies on the market (1 crypto: 5.94%; 2-10 cryptos: 14.99%; 11-99 cryptos: 22.45%; 100-1000 cryptos: 24.32%; 1001- 10 000 cryptos: 15.98%).

Only 5.91% of our cryptocurrency-familiar participants reported that they have purchased cryptocurrency before, with an additional 6.89% stating that they “yes” would purchase some in the future, and another 34.60% stating “maybe” they would purchase some in the future. Of those that had heard of cryptocurrency before, many participants (41.21%) reported that they know someone that is involved with cryptocurrency and few reported that they know someone involved with cryptocurrency mining (13.40%). Just under a third (30.85%) of our cryptocurrency-familiar participants have been encouraged by someone to purchase cryptocurrency. When the cryptocurrency-familiar participants were asked about what percentage of the Canadian population they believe owns cryptocurrency, the most common response choice was 10 to 19% (27.16%). Other response estimate frequencies can be seen in Table 15.

Only 20.53% of cryptocurrency-familiar participants believe that cryptocurrency is not a real currency, with 24.33% believing that it is a real currency, and the remaining 55.13% were unsure. Only 23.23% of cryptocurrency-familiar participants believed that “yes” cryptocurrency has practical value. Cryptocurrency was commonly perceived to be a “considerably risky” (49.50%) endeavour, with only 0.08% believing the market is “not risky”. Only 9.32% of our cryptocurrency-familiar participants perceived sending cryptocurrency as “not risky.” More detail about these findings can be seen in Table 13.

Gambling Behaviour

Gambling-related behaviour statistics are summarised in Tables 16 and 17. Only 28.36% of our sample purchases lottery tickets, without much of a between-groups difference between the regular recreational cannabis users (72.36%) and non-users (75.10%). The second most common self-reported frequency of lottery ticket purchasing after "never" (67.54%) was less than once per month (27.65%). Few of our participants self-reported that they attend the casino (14.77%), with low casino attendance in both the regular recreational cannabis user (11.76%) and non-user (7.20%) groups.

The participants' self-reported gambling behaviour has not changed since the pandemic. The vast majority (93.83%) reported "no change" in their lottery ticket spending since Covid. While 4.56% reported "more spending" on lottery tickets since the pandemic, given the age of the participants, the change in their behaviour is likely indicative of a change in legal age. When asked whether the frequency of their visits to the casino has changed since the pandemic, 66.94% reported it has remained the same, while 28.93% reported their visits to the casino have increased.

Part Two - In Lab Study

Demographics

Much fewer participants signed up for our in-lab Part Two study than our Part One online survey. A total sample of 76 participants completed Part Two. Of these participants, 13 qualified as recreational cannabis users (reporting non-medical use of cannabis a minimum of once or twice per week over the past three months) and 31 classified as non-users (no use of cannabis over the past three months).

Stroop Task

We collected usable Stroop data from 69 participants, which provided us audio files that gave us their spoken word responses and reaction times for both congruent and incongruent trials. These sound files were pre-processed through WhisperX and then verified using Audacity. Stroop data from 7 participants was excluded due to not following the instructions properly (consistently just reading the words instead of telling us the colour of the font, $n = 5$, or for obvious use of a cell phone during the task, $n = 2$).

Of the valid data collected from the 69 participants (69 participants x 192 trials = 12448 reaction times), a total of 12804 reaction time measures remained after trials with either no or unintelligible responses were removed. Of those remaining valid trials, 208 (<11.63%) were rejected by the outlier removal routine (Van Selst & Jolicoeur, 1994).

Consistent with the renowned Stroop effect, participants as a whole had faster reaction times (measured in milliseconds) in the congruent trials ($M = 708.16$, $SD = 124.98$) compared against the incongruent trials ($M = 808.36$, $SD = 147.33$). Proportionately, out of an equally balanced 96 congruent and 96 incongruent trials, the participants has nearly double the rate of errors in the incongruent trials (3.83%) compared to the congruent trials (1.59%), a difference which was significant, $F(1,67) = 32.585$, $p < .01$.

Overall, amongst all of the usable 68 participants with valid audio files, there was a significant difference in errors made between the congruent and incongruent trials, with about double the rate of errors in the congruent trials (3.83%) than the congruent trials (1.59%), $F[1,76] = 32.485$, $p < .001$. This is consistent with the well-documented Stroop effect.

Iowa Gambling Task

Hypothesis 1

H1: The recreational cannabis users in our sample would score significantly higher in impulsivity scores measured by the Reduced Dickman Scale used in our survey.

A Welch's two sample t-test revealed that there was a significant difference in mean total Impulsivity scores between our sample of regular recreational cannabis users ($M = 2.96$, $SD = 2.39$) and non-users ($M = 2.20$, SD = 2.34), $t(358.1) = 3.235$, $p = .001$. Our hypothesis was confirmed, the recreational cannabis users had significantly higher impulsivity scores.

Hypothesis 2

H2: Regular recreational cannabis users would be significantly more likely to report "yes" to both having purchased cryptocurrency in the past and "yes" to being willing to purchase cryptocurrency in the future.

A Pearson's chi-squared test for independence revealed that the regular recreational cannabis users (3.40%) were not significantly more inclined than the non-users (6.91%) to have purchased cryptocurrency in the past as similar proportions of each group reported that they had $X^2(1, N = 364) = 1.459$, $p > .05$. Considering that our sample comprised of young university students that as a group are likely under financial strain, it is perhaps unsurprising that very low proportions of our sample had purchased cryptocurrency.

Similarly, in regards to their willingness to purchase cryptocurrency in the future, roughly equivalent proportions of regular recreational cannabis users (7.48%) and non-users (7.83%) stated that they would or might in the future (32.65% and 32.58%, respectively), $X^2(2, N = 364) = 0.033$, $p > .05$. We failed to reject the hypothesis on both accounts.

Hypothesis 3

H3: That the recreational cannabis users in our sample would be significantly more likely to use other substances (alcohol and tobacco) than the non-users.

We did two Pearson chi square tests for independence to examine this hypothesis, one for alcohol use and one for tobacco use, comparing yes/no proportions in regular recreational cannabis users and non-users. The proportions of reported tobacco use were not equal, with significantly more of the regular cannabis users reporting that they smoke tobacco (20.24%) than the non-users (0.80%), $X^2(1, N = 418) = 45.797$, $p < .001$.

Similarly, proportions of reporting “yes” to alcohol use significantly varied from equal in regular cannabis users (92.35%) and non-users (49.20%), $X^2(1\ N = 420) = 82.865$, $p < .001$). The cannabis users were more inclined to be alcohol drinkers than were the non-users.

Vigilance Task

Hypothesis 4

H4: There would be a significant difference in performance on the vigilance signal detection task between regular recreational cannabis users and non-users. Specifically I predicted that cannabis users would not perform as well as the non-users, making more mistakes in target selection.

Performance differences on the vigilance signal detection task varied by type of target (the higher the mean efficiency score, the better the performance was). The worst performance occurred during “miss” target trials. There was not a statistically significant difference in target identification accuracy between the regular recreational cannabis users and non-users, however, in the opposite direction of our hypothesis, the cannabis users performed slightly better ($M = 0.84$, $SD = 0.18$) on the “miss” trials than the non-users ($M = 0.76$, $SD = 0.24$), $t(27) = 1.059$, $p > .05$. This means that as a group, the regular cannabis users in our sample were less frequently inclined to push erroneous responses on the lab keyboard in reaction to the miss targets presented on the screen.

The participants overall had slightly higher accuracy/efficiency for the “false alarm” target trials, and again, though the difference was insignificant, the regular recreational cannabis users (*M* = 0.88, *SD* = 0.15) slightly outperformed the non-users (*M* = 0.76, *SD* = 0.29), $t(37.51) = 1.642$, $p > .05$. There was a significant difference between groups on the “hit” target trials, with the regular recreational cannabis users performing better (*M* = 0.91, *SD* = 0.12) than the non-users (*M* = 0.75, *SD* = 0.30), $t(40.73) = 2.610$, $p = 0.012$.

Hypothesis 5

H5: There would be a negative correlation between impulsivity scores and performance efficiency on the vigilance task (the higher the impulsivity score, the lower the participant’s performance).

To examine this hypothesis, we compared whether impulsivity scores were associated with performance efficiency for each of the three types of targets. We found a significant negative correlation between impulsivity scores and “false alarm” target performance, $r(58) = -0.373$, $p < .01$. There was also a significant correlation between impulsivity scores and “miss” target trial performance, $r(58) = -0.381$, $p < .01$. While there was a negative correlation between impulsivity and performance on “hit” vigilance trials, the relationship was not significant, $r(58) = -0.178$, $p > .05$.

Hypothesis 6

H6: The recreational cannabis users would have significantly higher estimates about the duration of the vigilance task than non-users.

One participant (P#24, non-user) was excluded from this analysis for having an outlier, unrealistic estimate of only “1 minute” on this measure. While the recreational cannabis users in our in-lab sample did estimate a longer duration of the vigilance task (*M*

= 21.25, *SD* = 9.32) than the non-users (*M* = 19.53, *SD* = 5.32), the difference was not significant, *t*(14.07) = 0.600, *p* > .05. Note we only had 12 users compared against 31 non-users and that having much larger group sizes would have increased our statistical power.

Stroop Task

Hypothesis 7

H7: There would be a significant difference in the numbers of errors on the Stroop task between regular recreational cannabis users and non-users. Specifically I predicted that cannabis users would make errors in significantly more trials than non-users.

There was a significant difference in the number of Stroop errors made between the regular recreational cannabis users (M = 1.17, SD = 2.81) and non-users (M = 2.97, SD = 1.11) in our in-lab participants, t(41.91) = 3.01, *p* = < .05. Contrary to our hypothesis, the regular cannabis users in our sample made fewer errors on the Stroop task than the non-users, forcing us to reject our hypothesis.

Hypothesis 8

H8: The cannabis users in our sample would have slower reaction time on the Stroop task and have a significantly larger Stroop Effect magnitude than non-users, calculated as Reaction Time for Incongruent trials minus Reaction Time for Congruent trials.

On the Stroop task the regular recreational cannabis users did have slower reaction time (*M* = 757.36, *SD* = 141.74) than the non-users (*M* = 702.37, *SD* = 115.82). However, the slightly longer reaction times of the cannabis users compared to the non-users was not found to be significant, *t*(17.40) = 1.19, *p* = >.05, forcing us to reject this hypothesis. There was not a significant difference in the magnitude of the Stroop effect between regular cannabis users (*M* = 83.12, *SD* = 46.80) and non-users (*M* = 67.56, *SD* = 187.23) in our sample, $t(35.06) = -0.417$, $p > .05$.

Hypothesis 9

H9: There would be a positive correlation between impulsivity scores and the frequency of errors on the Stroop task.

While there was a slight positive correlation between impulsivity scores and the frequency of errors on the Stroop task, the association was not significant, $r(56) = 0.107$, $p > .05$. Note that we had very low statistical power with our small sample size.

Hypothesis 10

H10: That the recreational cannabis users would estimate that there were significantly more Stroop trials than non-users.

There was not a significant difference in the estimated number of trials on the Stroop task between the regular recreational cannabis users (*M* = 97.00, *SD* = 65.27) and non-users (*M* = 93.71, *SD* = 59.94) in our in-lab participants, $t(18.63) = 0.15$, p = > .05. On average, the regular cannabis users estimated there were a similar number of Stroop trials as the non-users.

Iowa Gambling Task

Hypothesis 11

H11: The regular recreational cannabis users in our sample would select from the two risky card decks significantly more frequently than the non-users. This would result in a much higher probability of ending with a lower financial balance. I predicted that the recreational cannabis users would end the IGT with significantly lower balances than the non-users.

In preparing these results , first the total number of advantageous deck choices (decks C & D) for each participant were summed and the total number of disadvantageous deck choices (decks A & B) were subtracted from that previous total. Higher scores indicate more frequent advantageous deck selections. In contrast to our hypothesis, the regular recreational cannabis users selected from the advantageous decks more frequently ($M = 15.67$, $SD = 17.76$) than the non-users ($M = 14.51$, $SD = 15.97$), however, this difference was not statistically significant, $t(18.31) = 0.371$, $p > .05$. We thought that if allegedly cannabis users were more impulsive and inclined to make risky decisions as a group that they might be more inclined to take chances on the high reward (but also high penalty) decks, however, we failed to support this hypothesis. Also in contrast to our hypothesis, the regular recreational cannabis users ended on average with higher monetary balance ($M = 2717.92$, $SD = 723.84$) than the non-users ($M = 2577.67$, $SD = 599.83$), though the difference was not statistically significant $t(17.38) = 0.594$, $p > .05$.

Hypothesis 12

H12: There would be a negative relationship between impulsivity scores measured on the Reduced Dickman Scale and the frequency of selecting cards from the advantageous card decks. Relatedly, I predicted a negative correlation between the participants' total impulsivity scores and their final financial balance.

We found that there was a slight negative correlation between impulsivity scores and the frequency of card selections from the advantageous card decks, though the finding was statistically insignificant, $r(58) = -0.124$, $p > .05$. There was also a slight negative though statistically insignificant correlation between impulsivity scores and final monetary balance on the IGT, $r(58) = -0.194$, $p > .05$.

Discussion

As expected, the regular recreational cannabis users scored higher in impulsivity than the non-users. This adds to a growing body of literature indicating that there is a generalised pattern of substance users scoring higher on impulsivity measures than non-users, even in the current context with the legalisation of cannabis. To be both impulsive and a substance user could for some people be a potentially jeopardising combination, as some individuals may lack the self-control to resist an impulsive desire to use intoxicants in disadvantageous contexts, which could, in some instances, result in negative consequences (such as the substance use impacting one's performance in the workplace). Amongst those that reported having used cannabis in the previous year, some reported a strong urge to use cannabis daily (17.45%), or weekly (11.41%), which suggests that cannabis use may give some of its users a lingering psychological desire to reuse it, a draw that could have potential implications for the development of addiction. Only just over one third (37.14%) reported that they never experienced a strong desire to use cannabis.

There was absolutely no difference in the proportion of regular recreational cannabis users and the non-users who had either purchased cryptocurrency in the past nor in their willingness to purchase cryptocurrency in the future. Cryptocurrency engagement was considered to be a real-world, applied instance of risk-taking behaviour. We hypothesised that the regular recreational cannabis users might be more prone to risk-taking behaviour in general, so specifically wanted to examine whether there would be any differences between them and the non-users in openness to engage with cryptocurrency markets. However, given that the majority of our sample was composed of young university students, our sample was probably in general too young and financially insecure to be examined on this variable, which some might consider to be a form of investment. Additionally, one must be 18 years of age to use a cryptocurrency exchange, so our young sample had a very small window of opportunity to have been able to purchase cryptocurrency. It would be worth exploring whether findings might be different comparing regular cannabis users against non-users in employed, older adults that are not in the financially strained position that many university students are.

We were unsurprised to confirm our hypothesis that the regular recreational cannabis users in our online survey sample also reported that they used more other substances than the non-users. The regular recreational cannabis users in our Part One sample were far more inclined than non-users to smoke tobacco (20.45% vs. 0.80%), vape tobacco (26.79 vs. 0.00%), and drink alcohol (92.35% vs. 49.20%). These findings are consistent with other research, and it makes sense that some might have a general openness to explore various substance use while others might be inclined to reject substance use across the board. Note that while we did not examine religious beliefs, there were almost certainly participants surveyed that, for religious or cultural reasons, are not permitted to use substances like alcohol (Muslims for example are prohibited from using alcohol, but there is no proscription regarding cannabis). That said, of course those that obediently follow such religious doctrine would report “no” to some of our substance use questions. Some cultural practices (e.g. Hindu and Rastafari) may even encourage the use of cannabis in their ceremonies . It would have been relevant to ask some questions about religious or cultural background as these variables do have bearing on substance use. Perhaps as young people transition between adolescence and adulthood in cultures wherein alcohol is prohibited, cannabis use may be more common or its usage patterns might be differ.

Our findings in regards to social acceptability perceptions of tobacco use highlight the importance of specifying substance intake method in substance use research. When asked generally about tobacco use, only 9.7% reported regular use as “completely acceptable” – however, when we specifically asked about vaped tobacco, 27.9% reported regular use as completely acceptable. This finding also alludes to bias in tobacco use perception – when asked generally about the social acceptability of tobacco use, the association of perceiving tobacco as a smoked substance must be stronger in our sample’s tobacco schemas than the vaped method, as they were quick to view tobacco use generally in a more unacceptable light until we provided the vaping lens to their evaluation. It was surprising to discover that a greater proportion of participants rated the regular use of vaped tobacco as “completely acceptable” than the regular use of alcohol.

It was surprising that the cannabis users outperformed the non-users on the vigilance task in identifying all three target appearance types, even though the differences were statistically significant for only one of the three target types (hit trials). These findings suggest no cannabis-related impairment in regards to watchful vigilance. Perhaps people that have careers requiring maintaining watchful vigil over surveillance-type displays can be assured that recreational cannabis use may not have lingering impacts on their job performance (assuming they are not acutely intoxicated by this substance on the job).

Participants were asked to provide an estimate about how long they believe the duration of the vigilance task was. We asked this question as an extension of past, limited research that suggests that time perception may slightly be modulated by cannabis use (Sewell, Schakenberd, Enander, et al., 2012). Based on others’ findings we hypothesised that the cannabis users would on average provide longer duration estimates. We did find that the regular recreational cannabis users as a group on average perceived the task to be about two minutes longer (21.25 minutes) than the non-users (19.53 minutes), however, the gap between these group means was not statistically significant. We expect that if we had done an experiment with ethics approval to provide a dosage of cannabis so that the users in our sample were acutely intoxicated, that there would be a more dramatic difference between the actively intoxicated cannabis users and the non-intoxicated non-users on this measure.

On our in-lab Stroop task, there was a significant difference in the number of errors made on the task made by the regular recreational cannabis users and non-users. However, the significant difference was in the opposite direction than hypothesised, with the cannabis users making less than half of the number of errors (1.17) compared to non-users (2.97). The Stroop task, during incongruent trials, requires a degree of self-control to prevent oneself from uninhibitedly blurting out whatever word appears on the screen, and instead demands some mental processing to decipher the colour of the font. Our result of the cannabis users outperforming the non-users is surprising, even considering that the substance users demonstrated as a group to also be more impulsive on the Reduced Dickman Scale, we hypothesised poorer performance in filtering out erroneous responses to incongruent trials.

In our reaction time measures of the Stroop task, the regular recreational cannabis users had slower reaction time (757ms) than the non-users (702ms), however, the difference was not statistically significant. Note that our sample size was extremely small, and that had we had a larger pool of participants we could have had great statistical power for running this analysis, which may have yielded a different result. It would be worth testing the same hypothesis and comparing reaction times between regular recreational cannabis users and non-users with a larger sample. In real-life situations such as driving, milliseconds can matter and make the difference between an accident occurring or not. Any reduction in reaction time related to substance use is worth consideration.

The combined pattern of slightly slower reaction times on the Stroop task and slightly better performance efficacy in cannabis users compared to non-users may possibly even be reflective of a slight speed/accuracy trade off. Perhaps as a group the cannabis users took slightly longer to process the information presented in the Stroop trials, which may have resulted in slightly elevated efficacy. Further research examining a potential speed/accuracy trade-off might be worthy of exploring.

There was a slight positive correlation between total impulsivity scores and the number of errors made on the Stroop task, however, the result was statistically insignificant. It would make sense that that with higher impulsivity scores might result in a greater likelihood of impulsively blurting out an erroneous response, failing to inhibit this rash response before taking time to process incongruent trials. When doing correlative analyses, having an abundance of observations provides greater statistical power. Ideally, we would have liked to have had a much larger pool of participants in our study.

Related to our exploration of time perception (estimate of time duration on the vigilance task), we were curious whether there might be a difference in the estimated number of trials on the Stroop task would differ between the regular recreational cannabis users and non-users. Extending from other time perception research, if cannabis users phenomenologically experience the passing of time in a more elongated fashion, perhaps over an equivalent duration (12 minute) Stroop task, the cannabis users would estimate a higher number of trials occurred within that time window. Once again we failed to find a statistically significant result, however, the cannabis users did as a group have a higher mean Stroop estimate (97.00) than non-users (93.71). We would expect there to be a greater gap between means in a study design that involved the cannabis users being acutely intoxicated by THC.

For the IGT, we hypothesised that the regular recreational cannabis users would select from the more risky but overall disadvantageous decks than the less risky decks, which again we failed to confirm. Contrary to our hypothesis, while a statistically insignificant result, the cannabis users actually made more frequent selections from the two advantageous decks than the non-users. While other research has indicated association between substance use and risky behaviours, the cannabis users in our sample were apparently not enticed by the risky decks offering some high rewards (but more probable high penalty) cards, in fact, they selected from the risky decks just slightly less frequently than the non-users. This was admittedly a very narrow measure of risk-taking behaviour and does not come close to reflecting the scope of real-world risky behaviours. It is possible that given the historical change of cannabis legalisation, perhaps this result is indicative of a weakening relationship between cannabis use and risk-taking behaviour that prior researchers found previously when cannabis was an illegal substance.

Our hypothesis that there would be a negative relationship between impulsivity scores and the frequency of card selections from the advantageous decks on the IGT was aligned with the general pattern/direction of the results, however, the confirmed negative association that we found was slight and not statistically significant. Higher impulsivity scores were somewhat though statistically insignificantly associated with more frequent selections from the risky, overall disadvantageous decks that on rare occasions would result in a high value reward card. There was a bit of a trend in the more impulsive participants being willing to take risks and take a chance on earning a high reward from the more disadvantageous decks. Note that there is a degree of implicit learning to occur for participants to recognize win/loss results as they engage in the IGT. Some people would naturally be faster learners than others and more consistently select from the advantageous decks than others. Also, it is highly probable that some participants just complacently clicked cards at random to get through the study as fast as possible in exchange for their research credit.

A notable consideration is that, given our sample was comprised of young university students, cannabis use, elevated impulsivity scores, and risk-taking behaviours may all just be a normalised part of being a young person making the life stage transition between adolescence and adulthood. Experimenting with new experiences and rebelling against norms can be considered normal parts of growing up, so we must be careful to stereotype cannabis users as an impulsive, risk-taking bunch.

The regular cannabis users in our sample were far more inclined to report “it depends” (20.12%) in regards to potential impairment than the non-users (1.60%). It would have been worthwhile to collect follow-up responses from participants that selected “it depends” to further explore the variety of factors that participants believe influence potential impairment associated with cannabis use. More research is needed to explore cannabis-related impairment and its longevity.

Our findings in response to our survey question “Is cryptocurrency a real currency?” were intriguing, with 20.53% participants stating “No” it was not a real currency and 55.13% stating “I’m not sure”. Subsequently, when asked “Do you think cryptocurrency has any practical value?”, only 23.23% responded “Yes”, while the overwhelming majority responded either “No” or “I’m not sure” (cumulatively 75.66%).

Throughout history, many emerging technologies that subsequently gained traction initially struck some as ludicrous and lacking in credibility. Marco Polo in the 13th century, for example, was dumbfounded by the observation of Chinese people using paper money as an exchange of value (Surowiecki, 2012). The material money is manufactured of itself lacks inherent value, however, money is deemed as valuable for its potential trading merit by social consensus. When a commodity is identified as having value by a group and is by consensus deemed to have utility, therein lies its value. For this reason, the attitudes that individuals harbour towards cryptocurrency matter, for a critical mass of people believing in the value of cryptocurrency can secure its credence, legitimacy, and role in society as a new medium of commerce. On May 22 2010 (now known as 'Bitcoin Pizza Day' in the cryptosphere), long before many members of society thought Bitcoin held value, it was used as a medium of exchange for the first time in history when Laszlo infamously traded 10 000 of his Bitcoins in exchange for two pizzas (Sparks, 2021). How the times have changed – at this time of writing (July 23 2024), one Bitcoin is worth $91 704 (Canadian dollars), indicating a change in peoples' attitudes towards and endorsement of cryptocurrency, as indicated by the massive increase in the amount of fiat currency being exchanged for Bitcoin.

Limitations and Future Directions

A major limitation was having such a small sample of recreational cannabis users and non-users within our in-lab component of the study. We ran t-tests on an extremely small sample of 13 regular recreational cannabis users and 31 non-users. Not only was there massive inequality between the two group sizes, but both groups were too small to be able to make generalizable statements about recreational cannabis users or non-users beyond our sample. We would expect results to at least somewhat vary with a larger sample pool, having more variance with a larger sample from which to draw conclusions. As is, our statistical power was too low, however, with a time limit imposed on completing program completion deadlines, we did not have the option to continue collecting more data. Given our limited sample, a replication of the study is strongly recommended to examine the reliability and generalizability of the negative and positive findings discovered in our research.

A notable limitation in our study was the choice to use the Reduced Dickman Scale. As the literature review for this paper progressed, it was realised that there are much more comprehensive measures of impulsivity. For example, the SUPPS-P taps five factors of impulsivity: negative urgency, lack of perseverance, lack of premeditation, sensation seeking, and positive urgency (Cyders, Littlefield, Coffey, Karyadi, 2014). Upon examining the items on the SUPPS-P, it was realised that the items on the reduced Dickman scale used in our survey were all very similar to those tapping the lack of premeditation factor, however, there were a lack of items in our survey related to the other impulsivity factors. This was a rash oversight, and in retrospect, ironically, a different impulsivity scale should have been utilised.

Our sample comprised of young university students. With current economic conditions (expensive housing, decent paying job scarcity) and many of these students being so young and probably financially strapped (and possibly lacking the resources for cryptocurrency investment at this stage in life), it would be worth exploring whether there are connections between substance use and engagement in the cryptocurrency market in an older, employed adult sample. Cryptocurrency trading platforms have age restrictions (18+) and it is reasonable to assume that between our sample pool age and the surrounding economy that it is too soon to rule out a connection between cannabis use and openness to engage in cryptocurrency markets based on this sample. This potential connection would be worth exploring in an older sample in future research.

Further explorations of other forms of risk-taking behaviour, such as engagement in unprotected sex, might be worth including in future research of cannabis use and risk-taking behaviour in young adult participant samples. Given that much psychological research involves undergraduate psychology students as the primary cohort of participants, inclusion of risky sexual practices as a variable would be a more applicable measure of risk-taking behaviour than engagement in cryptocurrency behaviour, given the limitations of that previously discussed.

The lack of self-awareness about cannabis strain and strength dosage amongst our cannabis user group highlights a particularly difficult problem in retrospective and self report cannabis studies. Cannabis strains and dosages are extremely variable and important factors to consider as the psychoactive impacts of cannabis use will vary immensely depending on the concentrations of endocannabinoids (including but not limited to the CBD:THC ratio) within the strain used.

Conclusion

In conclusion, the regular recreational cannabis users scored significantly higher in impulsivity and they were more inclined to use other substances (alcohol and tobacco) than non-users. Even in the contemporary context of cannabis legalisation, cannabis use was associated with higher impulsivity scores. The regular recreational cannabis users in our sample rated both occasional and regular cannabis use as less harmful than non-users.

The regular recreational cannabis users were not proportionally more inclined than the non-users to have either purchased cryptocurrency in the past or to express willingness to purchase some in the future.

The regular recreational cannabis users performed significantly better than the non-users for “hit” targets on the vigilance task, however no significant differences were found between the substance use groups on “false alarm” nor “miss” target trials. While there was a slight negative relationship between impulsivity scores and performance efficiency on the vigilance task, the result was not significant.

In regards to our time perception-related explorations, our results were not statistically significant, though there were slight trends in the direction that we expected. Cannabis users did have a slightly higher mean estimated number of trials on the Stroop task than the non-users and they did have slightly higher duration estimates of the vigilance task than non-users.

While statistically insignificant, the regular recreational cannabis users both made less errors on the Stroop task and had longer reaction times than the non-users. These results indicate there are not lingering detrimental impacts on attention or reaction time from regular cannabis use.

It was statistically insignificant, but there was a small positive correlation between impulsivity scores and the number of errors participants made on the Stroop task. The slight positive correlation makes sense, as more impulsive individuals may be more prone to erroneously blurt out an incorrect answer without taking more time to process the information provided on the screen.

On the IGT, while also insignificant statistically, the regular recreational users selected from the advantageous decks more frequently than the non-users. This is in the opposite direction of what we hypothesised, however, given our very small sample and unbalanced group sizes, it would be highly speculative to make any claims based on this finding. There was a slight negative correlation between impulsivity scores and the frequency of selecting cards from the advantageous IGT decks, but this too lacked statistical significance.

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Appendix A

In-Lab Task Instructions

Vigilance Task Instructions

“This is a visual target detection experiment. You can think of it as a SONAR or RADAR watchkeeping task where the display contains a bunch of small moving dots that are no threat. The important targets are larger dots. If the autodetection software recognizes the large dot, it will circle it with green. When this happens the software has made a good decision and you should press 'x'. If a large dot appears without a green circle, the detector missed it and you should press 'v'. If any shape other than a big dot gets green circled, this is a software error (a false alarm) and you should press 'n'. The large dots and other large shapes appear at random intervals, sometimes a few seconds apart, and other times there may be long periods of time between signals. Just keep with it. Remember good detections = 'x' (large dot with green circle)\n , misses = 'v' (large dot not circled) false alarms= 'n' any other shape is circled green. Press [spacebar] to start."”

Stroop Task Instructions

"Each trial starts with a white fixation dot to draw your attention to the center of the screen. After this, you will see one of the following words: RED or GREEN or BLUE . These words will be shown in one of the following colours: [participants were shown three circles demonstrating each of the colours] On each trial, speak the name of the colour you see and ignore the words. You have 2 seconds to report the colour which should be more than enough. Press [spacebar] to start."

Iowa Gambling Task Instructions

"This is a casino-type card game. There are 4 decks of cards and each card has a win or lose dollar value. You start with a borrowed cash account of $2000 and the dollar value on each card increases or decreases the money in your account. The decks each have different mixes of values for wins and losses. Some decks are consistently more profitable than others. Your job is to pick from the best deck(s) to earn enough money to pay off the debt and take home the winnings. You get 101 card draws total across the 4 decks. To pull a card, clicking on the deck of your choice. Your account balance is shown at the top and updates for each card. Press [spacebar] to start"

Appendix B

Table 1
Descriptive Statistics of Sample Demographics

Variable	Total *n*	%	Missing
Sex			3
Female	698	85.54	
Male	118	14.46	
Physical Health			2
Excellent	124	15.18	
Very Good	320	41.62	
Good	272	33.29	
Fair	89	10.89	
Poor	12	0.15	
Mental Health			6
Excellent	32	3.93	
Very Good	140	17.22	
Good	284	34.69	
Fair	258	31.73	
Poor	99	12.18	
Social Life			1
Excellent	52	6.36	
Very Good	308	37.65	
Good	310	37.90	
Fair	120	14.67	
Poor	28	3.42	
	Total (n)	%	Missing

English as Primary Language			
Yes	739	90.23	
No	80	9.76	
Presence of Acute Health Condition			1
Yes	25	3.06	
No	793	96.94	

Note. N=819.

Table 2
Self-Reported Social Acceptability Beliefs of Substance Use, Comparing Frequency of Use and Method of Intake

Substance & Intake Method	Occasional Use				Regular Use			
	n	*%*	*SD*	*N*	*n*	*%*	*SD*	*N*
Drinking Alcohol	544	**66.91**		815	89	**10.94**		813
Use Tobacco	219	**27.07**		814	80	**9.89**		809
Vaping Tobacco	243	**29.93**		814	229	**28.20**		812
Smoking Cannabis	328	**40.34**		815	38	**4.67**		813
Vaping Cannabis	243	**29.93**		814	222	**27.34**		812
Consuming Cannabis Edibles	336	**41.38**		818	206	**25.74**		812

Note. Table indicates the number of participants that rated each form of substance use, used either occasionally or regularly, as being “completely acceptable” socially.

Table 3

Self-Reported Perceptions of the Degree of Risk of Harm from Various Substance Use

Substance & Intake Method	Great Risk		Moderate Risk		Don't Know		Slight Risk		No Risk		*N*
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Once in a While											
Drinking Alcohol	4	**0.05**	210	**25.67**	160	**19.60**	76	**9.29**	368	**44.99**	818
Smoking Tobacco	222	**27.17**	265	**32.40**	7	**0.90**	260	**31.82**	63	**7.71**	817
Vaping ECigarettes	210	**25.70**	284	**34.76**	10	**1.22**	249	**39.48**	64	**7.83**	817
Smoking Cannabis	126	**15.44**	282	**34.56**	9	**1.10**	313	**38.36**	86	**10.54**	816
Vaping Cannabis	153	**18.70**	284	**34.72**	17	**2.08**	291	**35.57**	73	**8.92**	818
Cannabis Edibles	102	**12.47**	230	**28.12**	22	**2.69**	331	**40.46**	133	**12.26**	818
On a Regular Basis											
Drinking Alcohol	485	**60.25**	68	**8.44**	2	**0.25**	2	**0.25**	248	**30.81**	805
Smoking Tobacco	593	**74.13**	158	**19.75**	6	**0.75**	30	**3.75**	13	**1.63**	800
Vaping ECigarettes	544	**68.00**	194	**24.25**	6	**0.75**	45	**5.63**	11	**1.38**	800
Smoking Cannabis	415	**51.94**	283	**35.42**	8	**1.00**	76	**9.51**	17	**2.13**	799
Vaping Cannabis	421	**52.76**	264	**33.08**	20	**2.51**	79	**9.90**	14	**1.75**	798
Cannabis Edibles	332	**41.55**	263	**32.92**	22	**2.75**	151	**18.90**	31	**3.88**	799

Note. This table indicates the degree of risk of harm from the occasional and regular use of various substances.

Table 4

Self-Reported Perceptions of the Impacts of Cannabis Use, Comparing Responses of Cannabis Users and Non-Users

Variable	Full Sample		Missing	Cannabis Users		Non-Users	
	n	%	*n*	*n*	%	*n*	%
Occasional Use is Non-Harmful			2				
Strongly Agree	220	26.93		100	**58.82**	19	**7.60**
Somewhat Agee	328	40.15		58	**34.12**	80	**32.00**
Neither Agree/Disagree	88	10.77		9	**5.29**	37	**14.80**
Somewhat Disagree	120	14.69		2	**1.18**	70	**28.00**
Strongly Disagree	61	7.47		1	**0.59**	44	**17.60**
Daily Use is Non-Harmful			1				
Strongly Agree	15	1.83		9	**5.45**	1	**0.40**
Somewhat Agree	89	10.88		58	**35.15**	6	**2.40**
Neither Agree/Disagree	82	10.02		9	**5.45**	19	**7.60**
Somewhat Disagree	278	33.99		66	**40.00**	65	**26.00**
Strongly Disagree	354	43.28		23	**13.94**	159	**63.60**
Short -Term Cognitive Effects							
Strongly Agree	318	38.83		69	**40.59**	82	**32.80**
Somewhat Agee	300	36.63		70	**41.18**	87	**34.80**
Neither Agree/Disagree	77	9.40		15	**8.82**	27	**10.80**
Somewhat Disagree	79	9.65		14	**8.24**	28	**11.20**
Strongly Disagree	45	5.49		2	**1.18**	26	**10.40**
Long-Term Cognitive Effects							
Strongly Agree	330	40.29		37	**21.76**	132	**52.80**
Somewhat Agree	340	41.51		88	**51.76**	80	**32.00**
Neither Agree/Disagree	103	12.58		28	**16.47**	29	**11.60**
Somewhat Disagree	33	4.02		15	**8.82**	4	**1.60**
Strongly Disagree	13	1.59		2	**1.18**	5	**2.00**

Note. Full sample *N* = 819. Cannabis Users *n* = 170; Non-Users *n* = 250.

Table 5

Belief Statements About Cannabis Use

Variable	Full Sample *n*	Full Sample %	Missing *n*	Cannabis Users *n*	Cannabis Users %	Non-Users *n*	Non-Users %
Does Cannabis Impair Driving Ability			2				
Yes	709	86.79		129	**76.33**	220	**88.00**
It Depends	59	7.22		34	**20.12**	4	**1.60**
Don't Know/Not Sure	34	4.16		2	**1.18**	24	**9.60**
No	15	1.84		4	**2.37**	2	**0.80**
How Long Until It Is Safe to Operate a Motorized Vehicle Post-Cannabis Use			1				
Immediately	8	0.98		3	**1.78**	1	**0.40**
30 to 60 Minutes	20	2.44		11	**6.50**	2	**0.80**
1 to 3 Hours	71	8.68		26	**15.38**	19	**7.60**
3 to 5 Hours	167	20.42		42	**24.85**	44	**17.60**
5 to 7 Hours	175	21.39		32	**18.83**	50	**20.00**
7 to 8 Hours	84	10.27		14	**8.28**	26	**10.40**
8 or More Hours	292	35.70		41	**24.26**	108	**43.20**
Can Cannabis Be Habit Forming			8				
Yes	790	97.41		166	**98.80**	237	**95.95**
Don't Know/Not Sure	13	1.60		1	**0.59**	7	**2.83**
No	8	0.98		1	**0.59**	3	**1.21**
Is Occasional Use Safer than Chronic Use			11				
Yes	724	89.60		160	**95.24**	204	**82.59**
No	84	10.39		8	**4.76**	43	**17.41**

Note. Full sample N = 819. Cannabis Users n = 170; Non-Users n = 250.

Table 6

Cannabis Use Patterns in Our Whole Sample

Variable	Total *n*	%	Missing
Ever Used Cannabis			2
Yes, More than Once	485	59.36	
Yes, Just Once	77	9.42	
No	255	31.21	
Medical Purpose Cannabis Use in 12mths			3
Yes, With a Prescription	7	0.86	
Yes, Without a Prescription	118	14.46	
No	691	84.68	

Note. N=819.

Table 7

Comparing Rates of Other Substance Use in Cannabis Users and Non-Users

Variable	Full Sample		Missing	Cannabis Users		Non-Users	
	n	%	*n*	*n*	%	*n*	%
Do You Smoke Tobacco			3				
Yes	748	91.67		34	**20.24**	2	**0.8**
No	68	8.33		134	**79.76**	248	**99.2**
Do You Vape Tobacco			1				
Yes	84	10.26		45	**26.47**	0	**0.00**
No	735	89.74		125	**75.53**	250	**100.00**
Do You Drink Alcohol							
Yes	612	38.83		157	**92.35**	123	**49.20**
No	206	36.63		13	**7.65**	127	**50.80**

Note. N = 819. Cannabis Users = 170; Non-Users N = 250.

Table 8. Part 1 of 3

Self-Reported Cannabis Use Patterns and Preferences Over the Past 12 Months

Variable	Total *n*	%	*N*
Non-Medical Cannabis Use in 12 Months			562
Yes	448	79.72	
No	114	20.28	
Frequency of Cannabis Use Per Month			453
< Once/Month	167	36.87	
Once/Month	45	9.93	
2-3/Month	70	15.45	
1-2/Week	49	10.82	
3-4/Week	43	9.49	
5-6/Week	23	5.08	
Daily	56	12.46	
Cannabis Type Preference			449
Indica Dominant	68	15.14	
Indica/Sativa Blends	105	23.39	
Sativa Dominant	93	20.71	
No Preference	183	40.76	
Preferred Non-Medical THC Level			438
High (20%+ THC)	97	22.15	
Moderate (10-20% THC)	107	24.42	
Low (<10% THC)	72	16.44	
None (0% THC)	11	2.51	
Don’t Know/Not Sure	151	34.47	

Table 8. Part 2 of 3.

	Total (n)	%	*N*
Preferred Non-Medical CBD Level			435
High (20%+CBD)	28	6.44	
Moderate (10-20% CBD)	71	16.32	
Low (<10% CBD)	128	29.43	
None (0% CBD)	23	5.29	
Don't Know/Not Sure	185	42.53	
Non-Medical Cannabis Use in 30 Days			562
Yes	309	54.98	
No	253	45.01	
Cannabis Use Setting in Prior 30 Days			308
House/Private Dwelling	275	89.29	
Concert, Sports Event, Festival	44	14.29	
Restaurant/Cafe/Night Club/Bar	58	18.83	
Indoor Public Building (Mall, Hotel, Office)	16	5.19	
At school/college/university	75	24.35	
At Work	11	3.57	
Inside a Car	39	12.66	
Outdoor Public Place (Street, Park, Mall)	126	40.91	
Non-Medical Cannabis Use at Work or Within 2 Hours of Going to Work in Prior 12 Months			446
I haven't Done This	313	70.18	
Rarely	61	13.68	
Sometimes	23	5.16	
Often	9	2.02	
Always or Almost Always	11	2.47	
I'm Unemployed	29	6.50	

Table 8. Part 3 of 3.

	Total (n)	%	N
I Use Cannabis			446
Socially	197	44.17	
On My Own	29	6.50	
Both Socially and on My Own	220	49.33	
Cannabis Consumption Method Used in the Past 12 Months			445
Smoked	343	77.08	
Ate It (edible)	249	55.96	
Drank It (liquid edible)	59	13.26	
Vaped in Non-Portable Vaporizer	32	7.19	
Vaped in Pen/E-Cigarette	286	64.27	
Dabbing (hot knife/nail)	15	3.37	
Applied to Skin (topical)	23	5.17	
Non-Medical Cannabis Use Prior 3 Months			447
Never	57	12.75	
Once or Twice	150	33.56	
Monthly	74	16.55	
Weekly	76	17.00	
Daily or Almost Daily	90	20.13	
Strong Desire/Urge to Use Cannabis in Prior 3 Months			447
Never	166	37.14	
Once or Twice	130	29.08	
Monthly	22	4.92	
Weekly	51	11.41	
Daily or Almost Daily	78	17.45	

Note. These questions had embedded logic to them, and only appeared to participants that reported prior cannabis use.

Table 9

Self-Reported Frequencies of Mixing Cannabis with Other Substances

Substance	Always		Often		Sometimes		Rarely		Never		*N*
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Alcohol	20	**4.44**	81	**18.00**	141	**31.33**	100	**22.22**	108	**24.00**	450
Tobacco or ECig with Nicotine	53	**11.94**	61	**13.74**	45	**10.14**	40	**9.00**	245	**55.18**	444
Prescription Opioids	0	**0.00**	1	**0.10**	5	**1.12**	26	**5.83**	414	**92.83**	446
Prescription Sedatives/ Tranqs	2	**0.45**	2	**0.45**	9	**2.01**	5	**1.19**	429	**95.97**	447
Illegal Opioids	0	**0.00**	0	**0.00**	0	**0.00**	2	**0.45**	443	**99.55**	445
Hallucinogens/ Dissociatives	1	**0.22**	1	**0.22**	3	**0.67**	10	**2.24**	431	**96.64**	446

Note. Prescription Opioid examples included: oxy, Dilaudid, Morphine, Demerol, and Tylenol). Prescription Sedatives/Tranquilizer examples included Diazepam, Lorazepam, Valium, Ativan, Alprazolam, Xanax, Clonazepam, and Rivotril. Illegal opioid examples included heroin and non-pharmaceutical Fentanyl. Illegal stimulant examples included: cocaine, crack, methamphetamine, ecstasy/MDMA. Hallucinogens/dissociative examples included LSD, magic mushrooms, Ketamine, and PCP.

Table 10. Part 1 of 2.
Self-Reported Driving-Related Behaviours

Variable	Total(n)	%	Missing
Do You Drive a Vehicle			
Yes	576	70.33	
No	243	29.67	
Since Covid has your Tendency to Break Speed Limits Changed??			258
Increased	78	13.90	
Remained the Same	462	82.35	
Decreased	21	4.74	
Since Covid has your Tendency to do Rolling Stops Changes?			246
Increased	48	8.38	
Remained the Same	502	87.61	
Decreased	23	4.01	
Have You Been a Passenger Within 2 Hours of the Driver Having Used Cannabis?			1
Yes	130	15.89	
Don’t Know/not sure	286	34.96	
No	402	49.14	
Have you Driven Within 2 Hours of Using Cannabis in the Past 12 Months?			1
Yes	62	7.58	
Prefer not to Disclose	16	1.95	
No	740	90.46	

Table 10. Part 2 of 2.

	Total (n)	%	Missing
Have you Driven Within 4 Hours of Using Cannabis in the Past 12 Months?			2
Yes	74	9.06	
Prefer not to Disclose	10	1.22	
No	733	89.72	
Have you Driven Within 2 Hours of Having 2+ Alcoholic Beverages in the Past 12 Months?			1
Yes	44	5.38	
Prefer not to Disclose	7	0.86	
No	767	93.75	

Note. *N* = 819.

Table 11
Comparing Drinking and Driving Behaviour in Cannabis Users and Non-Users

Variable	Full Sample		Missing	Cannabis Users		Non-Users	
	n	%	*n*	*n*	%	*n*	%
Have You Driven Within 2 Hours of Having 2+ Alcoholic Beverages in the Past 12 Months?			1				
Yes	44	5.08		11	**6.47**	4	**1.60**
Prefer not to Disclose	7	0.86		3	**1.76**	1	**0.40**
No	767	93.75		156	**91.76**	244	**97.99**

Note. Full sample N = 819. Cannabis Users n = 170; Non-Users n = 249.

Table 12
Comparing Risky Driving Behaviours in Cannabis Users and Non-Users

Variable	Full Sample		Missing	Cannabis Users		Non-Users	
	M	*SD*	*n*	*M*	*SD*	*M*	*SD*
How Often Do You Break 50kph Speed Limits by MOre than 10kph?	2.83	1.29	248	2.69	1.25	3.12	1.27
How Often Do You Break 90-100kph Speed Limits by More than 10kph?	2.51	1.38	247	2.24	1.28	3.08	1.44
How Often Do You Roll Stop Signs?	3.60	1.28	248	3.39	1.26	3.78	1.22
How Often Do You Change Lanes Across White Solid Lines?	1.41	0.69	247	1.37	0.58	1.38	0.71

Note. All items above were rated between a scale of 1(*never*) and 5(*very often*). N = 819. Cannabis Users n = 170; Non-Users n = 250.

Table 13
Cryptocurrency Beliefs & Engagement Scale

Survey Item	Yes *n*	Yes %	No *n*	No %	Not Sure *n*	Not Sure %	*N*
Blockchain Awareness	88	**10.74**	731	**89.26**			819
Cryptocurrency Awareness	711	**87.99**	97	**12.00**			808
Know Anyone Involved with Crypto?	293	**41.21**	418	**58.79**			711
Know Anyone that Mines Crypto?	95	**13.40**	614	**86.60**			709
Has Anyone Encouraged You to Purchase Crypto?	219	**30.85**	491	**69.15**			710
Is Crypto Real Currency?*	173	**24.33**	146	**20.53**	392	**55.13**	711
Does Crypto Have Practical Value?*	167	**23.23**	222	**31.22**	321	**44.65**	719

	Very Risky *n*	Very Risky %	Considerably Risky *n*	Considerably Risky %	A Little Risky *n*	A Little Risky %	Not Risky *n*	Not Risky %	*N*
How Risky is the Crypto Market?	180	**25.46**	350	**49.50**	171	**24.19**	6	**0.08**	707
How Risky is it to Send Crypto?	171	**24.15**	297	**41.94**	80	**11.30**	66	**9.32**	708

Note. N=819. "*Not Sure*" was provided as a response option for this survey item.

Table 14

Cryptocurrency Engagement Willingness, Comparing Cannabis Users and Non-Users

Variable	Full Sample		N	Cannabis Users		Non-Users	
	n	*%*		*n*	*%*	*n*	*%*
Have You Purchased Crypto?*			711				
Yes	42	5.91		5	**3.40**	15	**6.91**
No	669	94.09		142	**96.60**	202	**93.09**
Would You Purchase Crypto In the Future?*			711				
Yes	49	6.89		11	**7.48**	17	**7.83**
Maybe	246	34.60		48	**32.65**	72	**32.58**
No	416	58.51		88	**59.86**	128	**57.92**

Note. *Due to embedded survey logic, only participants that previously stated they had heard of cryptocurrency before were asked this question.

Table 15

Participant Estimates About What Percentage of the Canadian Population Owns Cryptocurrency

Percentage of the Population	< 1%		< 5%		5-9%		10-19%		20-39%		*40-49%*		50%+	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
	23	**3.25**	116	**16.41**	164	**23.20**	192	**27.16**	156	**22.07**	41	**5.80**	14	**1.98**

Note. N=707. Due to embedded survey logic, only participants that previously stated they had heard of cryptocurrency before were asked this question.

Table 16
Self-Reported Gambling Behaviour

Variable	Full Sample *n*	Full Sample %	N	Cannabis Users *n*	Cannabis Users %	Non-Users *n*	Non-Users %
Do You Purchase Lottery Tickets			818				
Yes	232	28.36		47	**27.64**	62	**24.90**
No	586	71.64		123	**72.36**	187	**75.10**
How Frequently Do You Purchase Lottery Tickets?			819				
Never	529	64.59		115	**67.64**	183	**73.20**
<1/Month	245	29.91		47	**27.65**	56	**22.40**
Once/Month	17	2.08		2	**1.18**	5	**2.00**
2-3/Month	16	1.95		6	**3.53**	4	**1.60**
Weekly	12	1.47		0	**0.00**	2	**0.80**
Do You Ever Go to the Casino?			819				
Yes	121	14.77		20	**11.76**	18	**7.20**
No	698	85.23		150	**88.23**	232	**92.80**

Note. Cannabis Users *n* = 170; Non-Users *n* = 250.

Table 17

Gambling Behaviour Changes Since Covid

Variable	Total *n*	%	Missing
Has Your Lotto Ticket Spending Changed Since Covid?			8
More Spending	37	4.56	
No Change	761	93.83	
Less Spending	13	1.60	
Has the Frequency of your visits to the Casino Changed since Covid?			698
Increased	35	28.93	
Remained the Same	81	66.94	
Decreased	5	4.13	

Note. N=819.

Table 18

Comparison of Reaction Time Between Congruent and Incongruent Stroop Trials

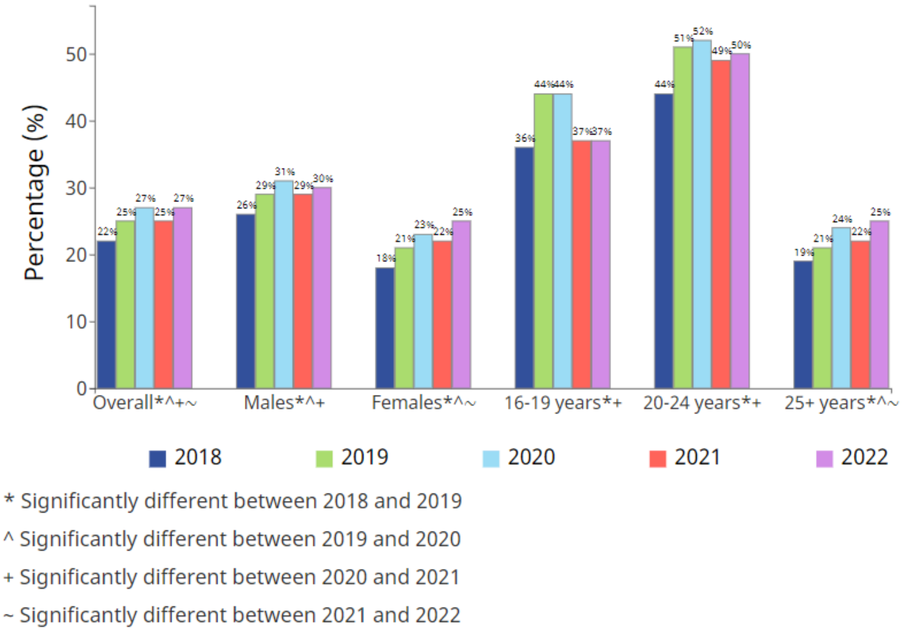
Measure	Congruent		Incongruent		$F(1, 67)$	ηp2
	M	*SD*	*M*	*SD*		
Error Proportions	0.0159	0.0269	0.0383	0.0428	32.485***	.3265

Note: ***$p < .001$. $N = 68$. Participants made roughly double the frequency of errors on the incongruent trials compared to the congruent trials.

Appendix C

Figure 4

Canadian Cannabis Use in the Past 12 Months, by Sex and Age Group, 2018 to 2022



Source: **https://health-infobase.canada.ca/cannabis/index.html**

Appendix D

A Brief History of Cryptocurrency

Long before the advent of cryptocurrency humans developed other encrypted technologies to facilitate a protected method of exchange that obscures communications to unintended onlookers. A couple of early cryptographic technologies known for their capabilities of encryption includes the ancient Scytale Cipher and the Enigma machine (Gensler, 2018). To decrypt communications with a Scytale Cipher, users must wrap a parchment that has a series of letters written on it around a precisely sized cylinder to reveal the words – the letters become meaningful word chunks as they are aligned in congruence. The Enigma machine was invented during the 1920s and was famously used during WWII by Nazis to relay critical military information. Both the Scytale Cipher and the Enigma Machine were effective cryptographic inventions for encrypting information to protect sensitive information from adversaries.

The cryptographic invention of asymmetric cryptography in 1976 was a pivotal development that would later be implemented with the creation of cryptocurrency (Gensler, 2018). Asymmetric cryptography was pioneered by Diffie and Hellman and is a system that involves both public and private keys to securely transmit information between parties without revealing sensitive identifying information. In relation to cryptocurrency, every holder has both a public key, which serves as a public address for others to wire cryptocurrency to or from, as well as a private key which should be kept secret as it serves as one's password to access one's cryptocurrency wallet.

The first cryptocurrency created was Bitcoin, conceptualised by a programmer under the pseudonym Satoshi Nakamoto, and was developed as a peer-to-peer method of anonymously exchanging digital currency without the involvement of an intermediary financial institution (Nakamoto, 2008). With a direct method for transactions between parties, there is an elimination of the costs associated with financial banking institutions. Prior digital currency startups had a problem with double-spending, wherein a sender could send the same token twice (Gensler, 2018), a problem solved by Nakamoto. With Bitcoin, every single transaction is time-stamped and irreversibly stored in a validated chain of occurrence (Nakamoto, 2008).

The technology underlying Bitcoin's physiology is blockchain, and while blockchain was invented in the early 1990s by Haber, in 2008 Nakamoto was the first person to apply blockchain technology to the creation of a digital currency (Gensler, 2018). Blockchain technology is a cryptographic digital ledger system composed of data blocks that are impervious to doctoring – transactions are published in a distributed public ledger database that cannot be subsequently altered unflagged (Yaga, Mell, Roby & Scarfone, 2018). All blocks are serially linked cryptographically and any attempt to alter data in a prior block would immediately be evidenced as invalid, for the coding would not align with the successive blocks. By having a distributed ledger, there are parallel copies of the blockchain accessible to multiple parties/nodes in the network, so changes within one of them will not only corrupt the subsequent chain of blocks in that user's ledger, that doctoree's altered blockchain would be flagged as invalid due to its lack of consensus in the blockchain coding compared against the mutually congruent copies of the blockchain held by others in the network (Yaga et al., 2018). Blocks are linked together with a sophisticated system of hashing – and it is the congruence of these hashes that affirms the validity of the blocks. Hashing is a means of compressing and encrypting any amount of data into a condensed code that can later be used to retrieve information stored within the hash, similar to the way a DOI may be used by researchers to access the entirety of information represented by that DOI.

The adoption of cryptocurrency has been growing exponentially – in 2008 there was only Bitcoin, whereas at this time of publication there are over 10 000 different cryptocurrencies. There has been increasing adoption of cryptocurrency from individuals and corporations alike, explaining the increase in the global market cap to 3.34 trillion Canadian dollars as listed on CoinMarketCap at this time of writing (July 23 2024). Expedia, Shopify, Microsoft, Visa, Mastercard, Paypal, and KFC are a shortlist of a small fraction of some corporations that have taken cryptocurrency on board in offering it as a method of payment, endorsement that lends a backbone of credibility to the market. Prolific throughout the media are messages about the volatility of cryptocurrency. This volatility is what makes engagement with cryptocurrency potentially very risky, for it is very possible someone could purchase a cryptocurrency which could rapidly plummet in market value.

Appendix E

Part One Survey Participant Screening Process

Prior to any deletions our online survey collected 1068 responses.

1. First I deleted ineligible Ps on account of incomplete participation. I wanted to ensure data from the in-lab Ps was preserved so first their cells were highlighted with yellow filler to ensure their data was preserved. Under the "Progress" column, any participants that did not have "100" (which means they didn't see the entirety of the survey due to closing the browser) were deleted. (55, 22, 2, 42, 32, 2, 35, etc). In total, 40 were deleted. New *N*= 1028

2. Next I deleted all Ps that admitted in question Lie7 that they did not answer the survey questions carefully – that was an instant disqualifier. In total 7 were deleted, new *N* = 1021

3. There was a glitch in the SONA research survey link portal. Participants should not have been able to access the survey for subsequent attempts. Only the first attempt data was kept and subsequent entries were deleted – this was tracked via duplicate SONA id #s. In R I ran the "lapply" command (output depicted below) to see which participants had more than one entry. I then tracked each SONA id that had a number greater than "1" in the R output and deleted subsequent survey attempts. In total 86 were deleted, new *N* = 935.

```
$id

71713 74734 76585 77164 78706 78793 80017 81964 82555 84337 84346 84721 85147 85576 85585
    1     1     1     1     1     1     1     1     1     1     1     1     1     1     1
86464 86500 86650 86674 87082 87226 87235 87337 87577 87799 88039 88183 88210 88549 88663
    1     1     1     1     1     1     1     1     1     1     1     1     1     1     1
88693 88774 88810 88867 88906 88969 89182 89419 89527 89614 89698 89809 89815 89836 89938
    2     2     2     1     1     1     2     1     1     1     1     1     2     1     1
```

4. Next I looked at the "Totallie" scores (sum of survey lie questions 1-6). Anyone with a score of 2 or higher was excluded from analyses, as they indicated in their self-reported lie question answers that they were not taking the survey seriously. ***Exception: two of our in-lab participants had lie scores of "2", but I decided to include them as they were part of our very small sample of in-lab Ps. In total, 116 were deleted, final sample *N* = 819.

Appendix F

Part One Qualtrics Survey Items

Note: Indicated beside the response options are numbers indicating how that response was coded, along with recording (where applicable). These values were not visible to participants.

Demographics

D1. Age: ______ (enter a number using digits, eg: "20")

D2. What was your biological sex at birth? [recode: find 3, replace with 0]

- Male = 1
- Female = 2
- Prefer not to say = 0

D3. In general, how is your physical health? (eg. no recent change, acute or chronic condition of medical concern)

- Excellent = 1
- Very good = 2
- Good = 3
- Fair = 4
- Poor = 5
- Prefer not to say = 0 [recode: find 6, replace with 0]

D4. Do you have a chronic or acute condition that could limit your participation in research?

- Yes = 1
- No = 2

D5. In general, how is your mental health? (Source: NCS 2020)

- Excellent = 1
- Very good = 2
- Good = 3
- Fair = 4
- Poor = 5
- Prefer not to say = 0 [recode: find 6, replace with 0]

D6. In general, how would you rate your satisfaction with your social activities and relationships? (Bastyr)

- Excellent = 1
- Very good = 2
- Good = 3
- Fair = 4
- Poor = 5

D7. Is English your primary language?

- Yes = 1
- No = 2

Lie1. Are you reading these questions and answering them honestly?
- Yes = 0 [recode: find 1, replace with 0]
- No = 1 [recode: find 2, replace with 1]

Substance Beliefs
The following section will provide a series of beliefs statements about substances. For the following belief statements, indicate which statement represents your view.

B1.1. How socially acceptable do you think it is for a person to use the following substances occasionally? Alcohol
- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B1.2. How socially acceptable to others do you think it is for a person to use the following substances occasionally? Tobacco (cigarette/cigar/smokeless tobacco)
- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B1.3. How socially acceptable do you think it is for a person to use the following substances occasionally? E-cigarettes (vaping a liquid with nicotine)
- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B1.4. How socially acceptable do you think it is for a person to use the following substances occasionally? Smoking cannabis for non-medical purposes
- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B1.5. How socially acceptable do you think it is for a person to use the following substances occasionally? Vaporizing cannabis for non-medical purposes

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable =4
- No opinion = 0 [recode: find 5, replace with 0]

B1.6. How socially acceptable do you think it is for a person to use the following substances occasionally? Eating cannabis for non-medical purposes

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B2.1. How socially acceptable do you think it is for a person to use the following substances regularly? Alcohol

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion= 0 [recode: find 5, replace with 0]

B2.2. How socially acceptable do you think it is for a person to use the following substances regularly? Tobacco (cigarette/cigar/smokeless tobacco)

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion= 0 [recode: find 5, replace with 0]

B2.3. How socially acceptable do you think it is for a person to use the following substances regularly? E-cigarettes (vaping a liquid with nicotine)

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B2.4. How socially acceptable do you think it is for a person to use the following substances regularly? Smoking cannabis for non-medical purposes

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B2.5. How socially acceptable do you think it is for a person to use the following substances regularly? Vaporizing cannabis for non-medical purposes

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

B2.6. How socially acceptable do you think it is for a person to use the following substances regularly? Eating cannabis for non-medical purposes

- Completely acceptable = 1
- Somewhat acceptable = 2
- Somewhat unacceptable = 3
- Completely unacceptable = 4
- No opinion = 0 [recode: find 5, replace with 0]

Lie2. This question is meant to find out if you are thoroughly reading each item. Respond "Mars" if you are.

- Aero = 1
- Mars = 0 [recode: find 2, replace with 0]
- Kitkat = 1 [recode: find 3, replace with 1]
- Eat-More = 1 [recode: find 4, replace with 1]

B3.1. How much do you think people risk harming themselves when they do each of the following activities? Drink alcohol once in a while. (Source: NCS 2020)

- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don't know. = 0 [recode: find 5, replace with 0]

B3.2. How much do you think people risk harming themselves when they do each of the following activities? Smoke tobacco once in a while. (Source: NCS 2020)

- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don't know = 0 [recode: find 5, replace with 0]

B3.3. How much do you think people risk harming themselves when they do each of the following activities? Use an e-cigarette with nicotine once in a while.

- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don't know. = 0 [recode: find 5, replace with 0]

B3.4. How much do you think people risk harming themselves when they do each of the following activities? Smoke cannabis once in a while.
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don’t know. = 0 [recode: find 5, replace with 0]

B3.5. How much do you think people risk harming themselves when they do each of the following activities? Vaporizing cannabis once in a while. (NCS)
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don’t know. = 0 [recode: find 5, replace with 0]

B3.6. How much do you think people risk harming themselves when they do each of the following activities? Consuming cannabis edibles once in a while. (NCS)
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don’t know = 0 [recode: find 5, replace with 0]

B4.1. How much do you think people risk harming themselves when they do each of the following activities? Drink alcohol on a regular basis. (Source: NCS 2020)
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don’t know. = 0 [recode: find 5, replace with 0]

B4.2. How much do you think people risk harming themselves when they do each of the following activities? Smoke tobacco on a regular basis.
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don’t know. = 0 [recode: find 5, replace with 0]

B4.3. How much do you think people risk harming themselves when they do each of the following activities? Use an e-cigarette with nicotine on a regular basis.
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don’t know. = 0 [recode: find 5, replace with 0]

B4.4. How much do you think people risk harming themselves when they do each of the following activities? Smoke cannabis on a regular basis. (NCS)
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don't know. = 0 [recode: find 5, replace with 0]

B4.5. How much do you think people risk harming themselves when they do each of the following activities? Vaporizing cannabis on a regular basis. (Source: NCS 2020)
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don't know = 0 [recode: find 5, replace with 0]

B4.6. How much do you think people risk harming themselves when they do each of the following activities? Consuming cannabis edibles on a regular basis. (NCS)
- No risk = 1
- Slight risk = 2
- Moderate risk = 3
- Great risk = 4
- I don't know = 0 [recode: find 5, replace with 0]

B5. I believe occasional cannabis is non-harmful (neither physically not mentally):
- Strongly agree = 1
- Somewhat agree = 2
- Neither agree nor disagree = 3
- Somewhat disagree = 4
- Strongly disagree = 5

Lie3. Have you ever smoked a blunt while filling a car with gasoline?
- No = 1 [recode: find 1, replace with 0]
- Yes = 0 [recode: find 2, replace with 1]

B6. I believe daily cannabis use is non-harmful (neither physically not mentally):
- Strongly agree = 1
- Somewhat agree = 2
- Neither agree nor disagree = 3
- Somewhat disagree = 4
- Strongly disagree = 5

B7. Cannabis has short-term effects on cognitive abilities:
- Strongly agree = 1
- Somewhat agree = 2
- Neither agree nor disagree = 3
- Somewhat disagree = 4
- Strongly disagree = 5

B8. Cannabis has long-term effect on cognitive abilities:
- Strongly agree = 1
- Somewhat agree = 2
- Neither agree nor disagree = 3
- Somewhat disagree = 4
- Strongly disagree = 5

B9. I believe that long-term cannabis use affects (select all that apply):
- Memory = 1
- Vision = 2
- Motor skills = 3
- Impulsivity = 4
- Attention = 5
- Hearing = 6
- Executive function (planning) = 7

B10. In your opinion, does using cannabis for non-medical purposes impair one's ability to drive or operate a motor vehicle? (eg: smoking a joint and then driving immediately afterwards)
- Yes = 1
- No = 2
- It depends (please specify) __________ = 3
- Don't know/Not sure = 4

B11. In your opinion, when is it safe to operate a vehicle after using cannabis? (NCS 2018)
- Immediately = 1
- 30 to under 60 minutes = 2
- 1 to under 3 hours = 3
- 3 to under 5 hours = 4
- 5 to under 7 hours = 5
- 7 to under 8 hours = 6
- 8 or more hours = 7

B12 . Based on what you know or believe, can using cannabis become habit forming for some people? NCS 2020
- Yes = 1
- No =2
- Don't know/not sure = 0 [recode: find 3, replace with 0]

B13 Which of the following means of ingesting cannabis are risky? Select all that apply.
- Smoking = 1
- Vaping = 2
- Edibles = 3

B14 . Occasional use of cannabis is safer than chronic use.
- Yes = 1
- No = 2

Substance Use

S1 During your lifetime have you ever used cannabis for non-medical purposes? *?* By non-medical purposes we mean recreational (e.g., for enjoyment, pleasure, amusement), socially, for spiritual, lifestyle and other similar non-medical uses.
- Yes, just once = 1
- Yes, more than once = 2
- No = 0 [recode: find 3, replace with 0]

S2. What age were you the first time you used cannabis? ___________

S3. In the past 12 months, have you used cannabis for medical purposes (used to treat disease/disorder or improve symptoms)?
- Yes, with a medical document from a healthcare professional = 1
- Yes, without a medical document from a healthcare professional = 2
- No = 3 [recode: find 3, replace with 0]

S4. In the past 12 months, have you used cannabis for non-medical purposes?
- Yes = 1
- No = 2

S5. In the past 12 months, how often did you typically use cannabis for non-medical purposes?
- 1 Less than 1 day per month = 1
- 1 day per month = 2
- 2 or 3 days per month = 3
- 1 or 2 day(s) per week = 4
- 3 or 4 days per week = 5
- 5 or 6 days per week = 6
- Daily = 7

S6. In the past 12 months, did you use the following method to consume cannabis for non-medical purposes? Select all that apply
- Smoked (e.g., a joint, bong, pipe or blunt) = 1
- Eaten it in food (e.g., brownies, cakes, cookies or candy) = 2
- Drank it (e.g., tea, cola, alcohol, other drinks) = 3
- Vaporised it with a vaporizer (non-portable) = 4
- Vaporised it with a vape pen or e-cigarette (portable) = 5
- Dabbing (e.g., including hot knife/nail) = 6
- Applied to skin (e.g., topicals) = 7
- Used it some other way (please specify): = 8

S7. In the past 12 months, have you used the following cannabis products for non-medical purposes? Select all that apply

- Dried flower/leaf = 1
- Hashish/kief = 2
- Cannabis oil for oral use – e.g., in dropper/syringe, capsules, spray bottle =3
- Cannabis vape pens/cartridges = 4
- Cannabis concentrate/extracts – e.g., shatter/wax/budder/butane honey oil = 5
- Cannabis edible food products – e.g., cookies, candy = 6
- Cannabis beverages – e.g., cola, tea, coffee = 7
- Topicals – e.g., lotion, ointment, creams applied to skin = 8
- Other (please specify): ______________________________________ = 9

S8. When selecting cannabis, I prefer...

- Indica dominant strains = 1
- Sativa dominant strains = 2
- Indica/sativa blends = 3
- I do not have a preference =0 [recode: find 4, replace with 0]

S9.1. When choosing cannabis products for non-medical purposes, what levels of THC and CBD do you typically use for: Dried flower/leaf? Please make a selection in each of the CBD and THC sections.

THC Levels

- High (greater than 20% THC or greater than 200mg/g THC) = 1
- Moderate (between 10% and 20% THC or 100mg/g to 200mg/g THC) = 2
- Low (less than 10% THC or less than 100mg/g THC) = 3
- None (0% THC or 0mg/g THC) = 4
- Don't know/Not sure = 0 [recode: find 5, replace with 0]

S9.2: CBD Levels

- High (greater than 20% CBD or greater than 200mg/g CBD) = 1
- Moderate (between 10% and 20% CBD or 100mg/g to 200mg/g CBD) = 2
- Low (less than 10% CBD or less than 100mg/g CBD) = 3
- None (0% CBD or 0mg/g CBD) = 4
- Don't know/Not sure = 0 [recode: find 5, replace with 0]

S10. How frequently do you use cannabis on average in a month?

- Less than once/month = 1
- Once/ month = 2
- 2-3 days/month = 3
- 1-2 days/week = 4
- 3-4 days/week = 5
- 5-6 days/week = 6
- Daily = 7

Lie4. How frequently do you travel to the South Pole to speak with penguins?
- Never = 0 [recode: find 1, replace with 0]
- Less than once/month = 1 [recode: find 2-8, replace with 0]
- Once/ month = 1
- 2-3 days/month = 1
- 1-2 days/week = 1
- 3-4 days/week = 1
- 5-6 days/week = 1
- Daily = 1

S11. In the past 30 days, have you used cannabis for non-medical purposes?
- Yes = 1
- No = 2

S12. In the past 30 days, on approximately how many days did you use cannabis for non-medical purposes? Minimum: 1.0, Maximum: 30.0. Please enter the number of days

S13. In the past 30 days, on the days that you used cannabis for non-medical purposes, how many times (a time includes a period of continuous use) per day did you use on average?
- 1 time = 1
- 2 times = 2
- 3 times = 3
- 4 times = 4
- 5 times = 5
- 6 times = 6
- 7 times = 7
- 8 times = 8
- 9 times = 9
- 10 times = 10
- More than 10 times = 11

S14. In the past 30 days, where have you used cannabis for non-medical purposes? Select all that apply NCS 2020
- House/private dwelling = 1
- At a concert, sports event, festival, etc. = 2
- At a restaurant/café/coffee shop/night club/bar/pub = 3
- Indoor publicly accessible building (e.g., office, hotel, mall) = 4
- At school/college/university = 5
- At your workplace = 6
- Inside a car = 7
- At an outdoor public place (e.g., street, park, alley, mall, etc.) = 8
- Other (please specify without providing any identifiable information): = 9

S15. In the past 12 months, how often did you use cannabis for non-medical purposes at work (including breaks) or within 2 hours before going to work?

- Rarely (less than one day per month) = 1
- Sometimes (1 to 3 days per month) = 2
- Often (weekly) = 3
- Always or almost always (most days you work) = 4
- Have not done this in the past 12 months = 5
- I have not been employed = 0 [recode: find 6, replace with 0]

S16.1. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Alcohol

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S16.2. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Tobacco or e-cigarette with nicotine

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S16.3. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Prescription opioids (e.g., oxy, Dilaudid®, morphine, Demerol®, Tylenol #3®)

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S16.4. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Prescription sedatives/tranquilizers (e.g., diazepam, lorazepam, Valium®, Ativan®, Alprazolam, Xanax®, clonazepam, Rivotril®)

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S16.5. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Illegal opioids (e.g., heroin, non-pharmaceutical fentanyl)

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S16.6. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Illegal stimulants (e.g., cocaine, crack, methamphetamine, ecstasy/MDMA)

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S16.7. During the past 12 months, when you used cannabis, how often did you combine it with any of the following substances? "Combine" means mixed or consumed at the same time. Hallucinogens/dissociatives (e.g., LSD, magic mushrooms, ketamine, PCP)

- Never = 1
- Rarely = 2
- Sometimes = 3
- Often = 4
- Always = 5

S17. I use cannabis...

- Socially = 1
- On my own = 2
- Both socially and on my own = 3

S18. When choosing cannabis products for non-medical purposes, what levels of THC and CBD do you typically use?

- Higher THC, Lower CBD = 1
- Higher CBD, Lower THC = 2
- Equal levels of THC and CBD = 3
- THC only = 4
- CBD only = 5
- I typically use a mix of the products above = 6
- Don't know/Not sure = 0 [recode: find 7, replace with 0]

S19. During the past 3 months, how often did you use cannabis for non-medical purposes

- Never = 1
- Once or twice = 2
- Monthly = 3
- Weekly = 4
- Daily or almost daily = 5

S20. During the past 3 months, how often have you had a strong desire or urge to use cannabis for non-medical purposes? NCS2020

- Never = 1
- Once or twice = 2
- Monthly = 3
- Weekly = 4
- Daily or almost daily = 5

S21. Do you smoke tobacco (cigarettes, cigars, cigarellos, etc)?

- Yes = 1
- No = 2

S22. On average how many cigarettes do you smoke per day?

- <1 per day = 1
- 1-2 = 2
- 3-5 = 3
- 6-10 = 4
- 11+ = 5

S23. Do you vape tobacco?

- Yes = 1
- No = 2

S24. Do you drink alcohol?

- Yes = 1
- No = 2

S25. How frequently do you drink alcohol on average in a month?

(1 drink= 1 pint of beer = 1glass wine = 1 oz liquor)

- I don't drink alcohol = 1
- Monthly or less = 2
- 2-4 days/month = 3
- 1-2 days/week = 4
- 3-4 days/week = 5
- 5-6 days/week = 6
- Daily = 7

S26. How many alcoholic drinks do you consume per week?

(1 drink= 1 pint of beer = 1 glass wine = 1 oz liquor) (Bastyr)

- I don't drink alcohol = 1
- Less than 1 per week = 2
- 1 - 3 drinks per week = 3
- 4-6 drinks per week = 4
- 1 drink per day = 5
- 2 drinks per day = 6
- 3 drinks per day

- 5 drinks per day
- More than 5 drinks per day

S27. When I drink alcohol, I typically have (1 drink= 1 pint of beer = 1 glass wine = 1 oz liquor):

- 1 drink = 1
- 2 drinks = 2
- 3 drinks = 3
- 4 drinks = 4
- 5+ drinks = 5

Risky Driving

RD1. Do you drive a vehicle?

- Yes = 1
- No = 2

RD2. On a scale from 1 (very often) to 5 (never), how often do you break 50 kph speed limits by more than 10 kph? (Source: adapted from Iversen, 2004)

1 2 3 4 5

RD3. On a scale from 1 (very often) to 5 (never), how often do you break 90–100 kph speed limits by more than 10 kph? (Source: adapted from Iversen, 2004)

1 2 3 4 5

RD4. Since the Covid-19 Pandemic has your tendency to break speed limits increased, decreased, or remained the same?

- Increased = 1
- Decreased = 2
- Remained the same = 3

RD5. On a scale from 1 (very often) to 5 (never), how often do you roll stop signs [not come to a full stop before proceeding]?

1 2 3 4 5

RD6. Since the Covid-19 Pandemic has your tendency to roll stop signs increased, decreased, or remained the same?

- Increased = 1
- Decreased = 2
- Remained the same = 3

RD7. Have you ever been a passenger in a motor vehicle (e.g., car, snowmobile, motor boat or all-terrain vehicle (ATV) driven by someone who had used cannabis for non-medical purposes within 2 hours before driving? (NCS 2020)

- Yes = 1
- No = 2
- Don't know/Not sure = 0

Lie5. Have you continued to read each question and answer honestly?
- Yes = 0 [recode: find 2, replace with 0]
- No = 1

RD8. In the past 12 months have you driven a motor vehicle (e.g., car, snowmobile, motor boat or all-terrain vehicle (ATV)) within 2 hours of using cannabis ?
- Yes = 1
- No = 2
- I prefer not to disclose = 3

RD9. Have you driven a motor vehicle (e.g., car, snowmobile, motor boat or all-terrain vehicle(ATV)) within 4 hours of ingesting cannabis (e.g., cannabis food/beverages, capsules)?
- Yes = 1
- No = 2
- I prefer not to disclose = 3

RD10. In the past 12 months have you driven a vehicle within 2 hours after drinking at least 2 alcoholic beverages?
- Yes = 1
- No = 2
- I prefer not to disclose = 3

RD11. On a scale from 1 (very often) to 5 (never), how often do you change lanes across white solid lines?

1 2 3 4 5

Cryptocurrency Beliefs

C1. Have you ever heard of blockchain?
- Yes = 1
- No = 2

C2. Have you ever heard of cryptocurrency?
- Yes = 1
- No = 2

C3. Is cryptocurrency a real currency?
- Yes = 1
- No = 2
- I'm not sure = 3

C4. Do you think cryptocurrency has practical value?
- Yes = 1
- No = 2
- I'm not sure = 3

C5. How many types of cryptocurrencies do you think exist?
- 1 = 1
- 2 - 10 = 2
- 11-99 = 3
- 100 - 1000 = 4
- 1001 - 10 000 = 5
- 10 000+ = 6

C6. Do you know anyone involved with cryptocurrency?
- Yes = 1
- No = 2

C7. Has anyone you know encouraged you to purchase cryptocurrency?
- Yes = 1
- No = 2

C8. What percentage of the Canadian population do you estimate owns cryptocurrency?
- Less than 1% = 1
- Less than 5% = 2
- 5 - 9 % = 3
- 10 - 19% = 4
- 20 - 39% = 5
- 40 - 49% = 6
- More than 50% = 7

C9. Have you ever purchased cryptocurrency?
- Yes = 1
- No = 2

C10. Would you purchase cryptocurrency in the future?
- Yes = 1
- No = 2
- Maybe = 3

C11. Why would you purchase cryptocurrency?
(open ended, qualitative response)

C12. Do you think cryptocurrency has a place in the future of commerce (eg. stores accepting cryptocurrency as payment)?
- Definitely yes = 1
- Probably yes = 2
- I'm not sure = 3
- Probably not = 4
- Definitely not = 5

C13. In general, how risky do you think the cryptocurrency market is?
- Not at all risky = 1
- A little bit risky = 2
- Considerable risky = 3
- Very risky = 4

C14. How risky do you think the cryptocurrency market is compared with the stock market?
- Cryptocurrency is less risky than the stock market = 1
- Cryptocurrency is equally risky as the stock market = 2
- Cryptocurrency is more risky than the stock market = 3

C15. How risky do you think it is to send cryptocurrency?
- Very risky = 1
- A little bit risky = 2
- Not risky = 3
- I don't know = 4

C16. Do you personally know of anyone involved in "mining" cryptocurrency?
- Yes = 2
- No = 1

C17. Do you trust banking institutions?
- Yes = 2
- No = 1

Gambling

G1. Do you purchase lottery tickets?
- Yes = 1
- No = 2

G2. How frequently do you purchase lottery tickets?
- More than once per week = 1
- About once per week = 2
- About 2-3 times per month = 3
- Monthly = 4
- Less than monthly = 5
- Never = 6

G3. Since the Covid pandemic, has your spending on lottery tickets changed?
- Yes, I spend more on lottery tickets than pre-Covid. = 1
- Yes, I spend less on lottery tickets than pre-Covid. = 2
- No, my spending on lottery tickets has not changed. = 3

G4. Do you ever go to the Casino?
- Yes = 1
- No = 2

G5. Since the Covid pandemic, has the frequency of your visits to the Casino increased, decreased or remained the same?
- Increased = 1
- Decreased = 2
- Remained the same = 3

Reduced Dickman Impulsivity Scale

IMP1. I frequently make appointments without thinking about whether I am able to keep them.
- False = 0 [recode: find 1, replace with 0]
- True = 1 [recode: find 2, replace with 1]

IMP2. I often make up my mind without taking the time to consider the situation from all angles.
- False = 0 [recode: find 1, replace with 0]
- True = 1 [recode: find 2, replace with 1]

IMP3. Often, I do not spend enough time thinking over the situation before I act.
- False = 0 [recode: find 1, replace with 0]
- True = 1 [recode: find 2, replace with 1]

IMP4. I often get into trouble because I do not think before I act.
- False = 0 [recode: find 1, replace with 0]
- True = 1 [recode: find 2, replace with 1]

IMP5. Many times the plans I make don't work out because I haven't gone over them carefully enough in advance.
- False = 0 [recode: find 1, replace with 0]
- True = 1 [recode: find 2, replace with 1]

Lie6. I often make up my mind to do things, please answer true for this question.
- False = 1
- True = 0 [recode: find 2, replace with 0]

IMP6. I rarely get involved in projects without first considering the potential problems.
- False = 1
- True = 0 [recode: find 2, replace with 0]

IMP7. Before making any important decisions, I carefully weigh the pros and cons.
- False = 1
- True = 0 [recode: find 2, replace with 0]

IMP8. I am good at careful reasoning.
- False = 1
- True = 0 [recode: find 2, replace with 0]

IMP9. I often say and do things without considering the consequences.
- False = 0 [recode: find 1, replace with 0]
- True = 1 [recode: find 2, replace with 1]

IMP10. I frequently buy things without thinking about whether I can actually afford them.
- False [recode: find 1, replace with 0]
- True [recode: find 2, replace with 1]

Lie 7. You will be awarded research credit for your participation in this survey regardless of effort/consideration. Did you honestly answer the questions carefully?
- Yes, I answered considerately. = 0 [recode: find 1, replace with 0]
- No, I answered quickly or without careful consideration. = 1 [recode: find 2, replace with 1]