Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates

Jessica Paglaro

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Supervisor: Dr. Christopher Mushquash

Second Reader: Dr. Dwight Mazmanian

External Examiner: Dr. Fred Schmidt

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Abstract

University students in Canada endorse higher levels of alcohol consumption than their non-college peers. This heavy drinking carries with it the risk of adverse consequences, including physical injuries, academic struggles, and legal problems. University students also report positive consequences associated with their alcohol consumption, which may function to reinforce heavy drinking patterns. Impairments in executive functions (EFs) may be a potential cognitive factor that increases student vulnerability to alcohol-related consequences. EFs have been found to continue developing into emerging adulthood and are associated with an earlier age of onset for alcohol use and heavier alcohol use patterns. With this in mind, the goal of this study was to examine the relationships between EFs and alcohol-related consequences among undergraduate students. To do this, undergraduate students from Lakehead University ($N = 211$; 82.5% female; 82.5% Caucasian) completed an online self-report questionnaire. Emotion Regulation and Working Memory were significant predictors of both positive and negative consequences, while Inhibitory Control was a significant predictor of negative consequences only. This study serves as a preliminary step toward better understanding the link between EFs and alcohol-related consequences among university students, providing a knowledge base for future prevention and intervention strategies.

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Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates

Executive function is an umbrella term referring to a collection of cognitive processes directly related to our ability to monitor and control behavior (Bull & Lee, 2014; Day et al., 2015; Friedman & Miyake, 2017; Gross & Hayne, 2011). It is clear from previous research that executive functions are essential for self-regulation and goal-directed behavior (Bull & Lee, 2014; Day et al., 2015; Friedman & Miyake, 2017; Gross & Hayne, 2011). However, it is less clear which cognitive processes should be classified as executive functions (Day et al., 2015). The literature lacks a unified operational definition for executive function (Day et al., 2015), with some researchers proposing that executive function encompasses distinct executive abilities as well as an umbrella construct (Day et al., 2015; Gustavson et al., 2017). For example, Gustavson et al. (2017) argue that executive function involves specific executive abilities including response inhibition, working memory, and set shifting, as well as a common factor that represents overall executive functioning. Other researchers posit that executive function should describe additional cognitive abilities, including sustained and selective attention, planning, emotion regulation, self-initiating behavior, and organization (Day et al., 2015; Naglieri & Goldstein, 2014). Despite this lack of consensus, it appears that executive function is most conceptualized as a multidimensional construct incorporating three distinct facets including inhibitory control, cognitive flexibility, and working memory (Bø et al., 2017; Diamond, 2013; Martins et al., 2018; O'Rourke et al., 2020). Diamond (2013) posits that these three cognitive processes are the core components of executive function and underlie other higher-order cognitive abilities such as planning and emotion regulation.

Impairments in executive functions can occur due to a range of factors, including high levels of stress, depression, loneliness, sleep-deprivation, substance use, and impairments in the prefrontal cortex (Diamond, 2013; Friedman & Miyake, 2017; Gross & Hayne, 2011). Many of these risk factors are present during the transition from high school to university. For example, this transitional period is characterized by increased levels of stress, substance use, and lack of sleep (Bland et al., 2012; Goodman et al., 2016; O'Rourke et al., 2020). Additionally, the prefrontal cortex continues to develop into emerging adulthood, which is the area of the brain responsible for executive functioning (Bø et al., 2017; Friedman et al., 2016; Gustavson et al., 2017; López-Caneda et al., 2014). The formation of executive functions in emerging adulthood is also influenced by the continuation of synaptic pruning and myelination processes that began in adolescence (McGrath et al., 2021). These biological changes occur within the context of several new experiences characteristic of emerging adulthood, including experimentation with substances, changes in residence, and increased education and work responsibilities (Friedman et al., 2016). Preliminary evidence for the influence of these environmental factors on changes in executive functions arises from a twin study conducted by Friedman and colleagues (2016). In this study, executive functioning was found to be quite stable across the emerging adulthood period (i.e., six years), however, environmental factors accounted for a small (15%) but significant amount of variance in executive functions (Friedman et al., 2016). Overall, these findings indicate that the combination of these biological and environmental changes in emerging adulthood may make this developmental period particularly conducive to changes in executive functions.

Lower levels of executive functions are implicated in several types of psychopathology, including but not limited to depression, chronic anxiety, attention-deficit/hyperactivity disorder,

and substance use (Bull & Lee, 2014; Diamond, 2013; Friedman & Miyake, 2017; Gross & Haynes, 2011; Hilt et al., 2011; Lees et al., 2020; Looby et al., 2018; López-Caneda et al., 2014; Martinez et al., 2014; Martins et al., 2018; O'Rourke et al., 2020). This may be particularly relevant for emerging adults as the first onset of most mental health disorders occurs before or during this developmental period (Hunt et al., 2010). Additionally, these mental health problems may be triggered or further exacerbated by the many pressures faced by emerging adults enrolled in post-secondary education (Goodman et al., 2016; Newcomb-Anjo, 2017; Pedrelli et al., 2015). Common university-related stressors include pressure to perform well academically, changing living conditions or moving, decreased parental supervision and support, increased academic demands, financial strain, and interpersonal stressors (Bland et al., 2012; Goodman et al., 2016; O'Rourke et al., 2020). Students must learn to cope with these novel experiences, challenges, and stressors while simultaneously experiencing an increase in autonomy and a decrease in social support (Bland et al., 2012; Borsari et al., 2007; Goodman et al., 2016; Martinez et al., 2014; O'Rourke et al., 2020). The relatively high number of changes and stressors characteristic of this period when compared to other developmental stages can make university the most stressful time in people's lives (Bland et al., 2012). Difficulties coping adaptively during this period is associated with an increased risk of experiencing a range of negative mental health outcomes, including alcohol abuse, smoking, eating disorders, and depression (Bland et al., 2012; O'Rourke et al., 2020).

Prevalence rates for substance use and co-occurring mental health disorders are higher among emerging adults than other adult age groups (Goodman et al., 2016; Newcomb-Anjo et al., 2017; O'Rourke et al., 2020; Palmer et al., 2009). For example, according to the Substance Abuse and Mental Health Services Administration (SAMHSA; 2019) survey, 13.8% of

American individuals aged 18 to 25 had a past year episode of major depression compared to only 8% of adults aged 26 to 49 and 4.5% of those aged 50 and older. The SAMHSA (2019) survey also found that 15.3% of those aged 18 to 25 required treatments for their substance use in 2018 compared to only 3.8% of adolescents and 7.0% of older adults. Additional research indicates that heavy drinking[1] increases and peaks during late adolescence and early adulthood, especially among those aged 18-24 who attend post-secondary institutions (Borsari et al., 2007; Goldstein et al., 2018; Kwan et al., 2013; Palmer et al., 2009). For example, emerging adults enrolled in post-secondary education report consuming higher amounts of alcohol more frequently than their non-college peers and are at an increased risk for heavy episodic drinking[2] (*AOR* = 1.56; Reckdenwald et al., 2016).

In addition to engaging in the highest rates of alcohol use, university students experience the most alcohol-related problems (Canadian Centre on Substance Use and Addiction (CCSA), 2018; Goldstein et al., 2018; Martinez et al., 2014; Molnar et al., 2009; Piazza-Gardner et al., 2016) including difficulties in interpersonal relationships, conflict with the law, personal injury, hangovers, and physical illness (Mallett et al., 2011; Martinez et al., 2014; Molnar et al., 2009; Park, 2004). Previous studies have primarily focused on the negative consequences of alcohol use; however, more recent research suggests that many of the alcohol-related consequences deemed as "negative" by researchers (e.g., vomiting or hangovers) may not be perceived as negative by university students who frequently engage in heavy alcohol use (Rinker et al., 2017). Instead, these consequences are often viewed as an expected and small "price to pay" for a positive and enjoyable experience (Martinez et al., 2014; Rinker et al., 2017). Additionally,

[1] Heavy drinking is defined as engaging in heavy episodic drinking at least once every month in the past year (Statistics Canada, 2019a; Statistics Canada, 2019b).

[2] Heavy episodic drinking for men involves consuming 5 or more drinks on one occasion and for women is defined as having 4 or more drinks (Looby et al., 2018).

many students report experiencing more positive than negative consequences of alcohol use including tension reduction, performance or activity enhancement, social stimulation, and increased confidence (Logan et al., 2012). For example, in a study conducted by Patrick and Maggs (2008) four out of five students (80.1%) reported negative consequences at least once, whereas 91.5% of students reported positive consequences. These findings highlight the importance of examining both the positive and negative outcomes of alcohol use among university students.

One mechanism believed to relate to problematic substance use and substance related problems is impairments in executive functions (Gustavson et al., 2017). There is evidence suggesting a bidirectional relationship between executive function deficits and heavy alcohol use. For example, Nixon (2013) shows that heavy episodic drinking can alter specific executive functions including attention and working memory capacity, while other research suggests that low levels of executive functioning is a risk factor for substance use and dependence (Gustavson et al., 2017). In particular, executive function deficits are a risk factor for the onset and maintenance of heavy drinking among individuals aged 18-25 (Bø et al., 2017; Day et al., 2015; Lees et al., 2020; Peeters et al., 2015). Persistent and heavy alcohol consumption during this neurodevelopmental stage can have serious implications for neurocognitive functioning in adulthood (Mota et al., 2013) and could lead to several long-term adverse effects including chronic illness, mental health disorders, substance dependence into adulthood, and impairment in educational attainment, employment, and social relationships (Goodman et al., 2014; Zhu et al., 2019). These findings suggest that executive function deficits are implicated in the experience of heavy episodic drinking and negative outcomes of alcohol use during emerging adulthood,

making university undergraduates an important group to study these associations with the potential to develop improvements in supportive resources.

Literature Review

Executive Functions

Executive functions are a group of higher-order cognitive processes that underlie the ability to regulate our thoughts, actions, and emotions (Friedman et al., 2016). High levels of executive function is associated with higher academic performance, greater productivity within vocational settings, healthier interpersonal relationships, and better quality of life (Diamond, 2013), while low levels of executive function is associated with poorer adaptive functioning and negative mental health outcomes (Friedman & Miyake, 2017; O'Rourke et al., 2020). As shown in Table 1, the literature suggests that there are nine distinct cognitive abilities commonly classified as executive functions (Friedman & Miyake, 2017; Looby et al., 2018; Naglieri & Goldstein, 2014).

Table 1.

Executive Functions

Executive Function	Definition
Organization	How well one manages time, thoughts, work, and personal effects appropriately and effectively (Naglieri & Goldstein, 2014).
Initiation	The motivation and ability to approach or start tasks independently (Naglieri & Goldstein, 2014).
Planning	The ability to develop and implement strategies to accomplish tasks or goals (Naglieri & Goldstein, 2014).
Attention	The ability to select which stimuli to attend to in order to remain focused on a task or goal while avoiding distractions (Diamond, 2013; Naglieri & Goldstein, 2014).
Cognitive Flexibility	The ability to shift attention, thinking, and behavior from one task or strategy to another as required by a situation (Diamond, 2013; Martins et al., 2018; Naglieri & Goldstein, 2014).
Self-monitoring	Involves evaluating one's own behavior or performance by assessing progress towards a desired goal and identifying necessary changes or improvements (Hustad et al., 2009; Naglieri & Goldstein, 2014).

Inhibitory Control	The ability to suppress impulsive behaviors or cognitions for more goal-directed behaviors or outcomes (Bull & Lee, 2014; Diamond, 2013; López-Caneda et al., 2014; Martins et al., 2018; Naglieri & Goldstein, 2014).
Working Memory	Allows us to hold, process, store, and manipulate relevant information in the mind while simultaneously filtering new information (Diamond, 2013; Looby et al., 2018; Martins et al., 2018; Naglieri & Goldstein, 2014).
Emotion Regulation	A multidimensional process involving the ability to identify, generate, and effectively manage emotions (Naglieri & Goldstein, 2014; Weinberg & Klonsky, 2009) that helps individuals engage in healthy and adaptive emotional expression and experience (Hilt et al., 211; Weinberg & Klonsky, 2009)

These nine executive functions are primarily housed in the prefrontal cortex, which is heavily involved in decision-making ability (Friedman & Miyake, 2017; Gross & Hayne, 2011). Impairments in the prefrontal cortex subsequently impair executive functioning, which reduces the ability to assess the risks and rewards of behaviors (Gross & Hayne, 2011) and increases the likelihood of developing a mental health disorder (Diamond, 2013; Friedman & Miyake, 2017; López-Caneda et al., 2014; O'Rourke et al., 2020). Deficits in executive functions are associated with several mental health disorders including substance use disorders, conduct disorder, attention-deficit/hyperactivity disorder, depression, obsessive compulsive disorder, and schizophrenia (Diamond, 2013; Friedman & Miyake, 2017; O'Rourke et al., 2020). In particular, deficits in working memory, attention, and inhibitory control are significantly associated with anxiety and depression (O'Rourke et al., 2020). Additionally, impairments in working memory and/or inhibition increases impulsivity and reduces the ability to modulate behavior, which can lead to risky behaviors such as heavy drinking (Looby et al., 2018; Squeglia et al., 2014). Low levels of emotion regulation can reduce one's ability to apply appropriate and effective coping strategies to stressful or emotional situations, which may lead to more intense or prolonged negative emotional responses (Hilt et al., 2011). As a result, impaired emotion regulation is

linked with depression, chronic anxiety, poor interpersonal relationships, and risky behaviors (Hilt et al., 2011). Deficits in self-monitoring can impair an individual's ability to develop adaptive goals and monitor behavior, which increases the likelihood of engaging in behaviors directed towards immediate gratification rather than long-term goals (Hustad et al., 2009). Collectively, these findings indicate that several executive functions have the potential to lead to risky and impulsive behaviors when impaired, including heavy episodic drinking.

There is an ongoing debate within the literature regarding whether these negative outcomes are the result of impairments in overall executive functioning or deficits in specific abilities (Day et al., 2015; Gustavson et al., 2017). For example, Day et al. (2015) argued that impairments in distinct aspects of executive function are more indicative of specific behaviors (e.g., alcohol use) than overall executive functioning, while Gustavson and colleagues (2017) argue that overall executive functioning is more relevant. This debate is further complicated by the fact that executive functions are closely related to each other, in that impairments in one may lead to impairments in another, making it difficult to disentangle one cognitive function from another (Bull & Lee, 2014; Diamond, 2013; Miyake & Friedman, 2012; O'Rourke et al., 2020). Some researchers suggest that these distinct functions are correlated with one another because they tap into a common underlying ability (Diamond, 2013; Miyake & Friedman, 2012; O'Rourke et al., 2020). Miyake and Friedman (2012) found that the three core executive functions (inhibition, shifting, and working memory) involve actively maintaining focus on task goals and goal-related information and propose that this is the common underlying ability.

Emerging Adulthood

Emerging adulthood is a distinct developmental period between the ages of 18 and 25 that lengthens the transition from adolescence to adulthood (Reckdenwald et al., 2016). This

developmental period emerged due to the growing emphasis on post-secondary education, which delayed the onset of several major life events traditionally signifying adulthood (e.g., marriage or starting a career; Reckdenwald et al., 2016). By not meeting these adulthood milestones, emerging adults cannot be classified as adults or adolescents and instead represent a distinct developmental status involving unique stressors, events, and experiences (Reckdenwald et al., 2016). These stressors can be educational, vocational, environmental, interpersonal, or financial in nature (Goodman et al., 2016; O'Rourke et al., 2020) and commonly include identifying a major or career choice, decreased parental control and support, increased peer pressure, and an increased exposure to risk-taking behaviors (Bland et al., 2012; Nixon, 2013). Undergraduate students are a subgroup of emerging adults who must learn to navigate and cope with these major life changes while simultaneously experiencing a number of daily stressors revolving around a busy academic schedule. Daily stressors frequently reported by university students include tests, assignments, procrastination, lack of sleep, time-management, increased workloads and deadlines, and changes in social habits (Bland et al., 2012). In addition to experiencing stress related to academic demands, undergraduate students may experience an increase in their adult-like responsibilities without having the necessary skills or cognitive maturity, which can potentially lead to several mental health concerns (Pedrelli et al., 2015).

The prevalence rates for mental health disorders peak during emerging adulthood (Goodman et al., 2016; O'Rourke et al., 2020; Pedrelli et al., 2015). For example, the 12-month prevalence rates for anxiety disorders (including specific phobias) among individuals aged 18 to 33 years is between 19.4% –22.3% (Gustavson et al., 2018), compared to 7%-9% in the general population Diagnostic and Statistical Manual of Mental Disorders (5th ed).; DSM-5). Similarly, prevalence rates for Major Depressive Disorder (MDD) among emerging adults is between

8.3%-12.4% (Gustavson et al., 2018), which is slightly higher than the prevalence rates for adults in the general population (7%; DSM-5). Individuals transitioning from high school to university may be at an increased risk of experiencing mental health difficulties as the stressors characteristic of this period may exacerbate pre-existing problems or trigger their onset (Goodman et al., 2016; Newcomb-Anjo, 2017; Pedrelli et al., 2015). Mental health difficulties and increased levels of stress among university students can have both short and long-term consequences (Saleem et al., 2013). For example, feeling more stressed by and/or less engaged with academic work and feeling lonely within the university context is associated with greater symptoms of depression and poorer academic performance (Newcomb-Anjo et al., 2017). The American College Health Association (ACHA; 2019) found that over half (59.5%) of Canadian university students rate academics as very difficult to handle, and just less than half (41.9%) report that stress negatively impacts their ability to meet these academic demands. ACHA (2019) also found that a quarter (24.2%) of students reported experiencing impaired academic performance as a result of depressive symptoms and a third (34.6%) reported that anxiety symptoms negatively affected their academic performance.

Additionally, the demands and stress of emerging adulthood is associated with an elevated risk for problematic substance use, substance use disorders, and other comorbid disorders (Goodman et al., 2016; Palmer et al., 2009). Alcohol use rapidly increases during emerging adulthood (Borsari et al., 2007; Kwan et al., 2013), with emerging adults exhibiting the highest prevalence rates of alcohol use and heavy episodic drinking (Borsari et al., 2007). For example, in 2018, more than a third of American adults aged 18 to 25 engaged in heavy episodic drinking in the past month compared to a quarter of adults aged 26 or older (SAMHSA, 2019). Additionally, 9% of adults aged 18 to 24 were currently heavy drinkers compared to only 0.5%

of those aged 12 to 17 and 6.2% of those aged 26 and older (SAMHSA, 2019). Emerging adults also demonstrate higher rates of substance use disorders than the general population with approximately 10.1% (3.4 million) of young American adults having had an alcohol use disorder in 2018 compared to 5.1% of those aged 26 or older (SAMHSA, 2019). Many individuals classified as heavy drinkers in emerging adulthood show a pattern of continued or escalating use into adulthood (Borsari et al., 2007; Lee et al., 2013). For example, Lee and colleagues (2013) found that approximately 43% of young adults who reported high-risk drinking[3] continued heavy alcohol use into adulthood. Furthermore, Moure-Rodriguez and colleagues (2018) found that the risk of continuing with problematic alcohol use into adulthood is greater for university students who report risky alcohol consumption and heavy episodic drinking earlier in emerging adulthood than those who experience an onset of these drinking behaviors at the ages of 24 and 25. This risk was significantly higher for female students, who demonstrated higher odds ratios for risky consumption and heavy episodic drinking (*OR* = 8.14 and *OR* = 5.53) compared to their male counterparts (*OR* = 2.91 and *OR* = 2.80; Moure-Rodriguez et al., 2018). These findings indicate that emerging adulthood may be a critical period for the development of alcohol use patterns that persist into adulthood (Borsari et al., 2007; Lee et al., 2013; Molnar et al., 2009) and that heavy alcohol use during this time increases the risk of experiencing a number of short- and long-term alcohol-related consequences (CCSA, 2018; Martinez et al., 2014; Molnar et al., 2009; Piazza-Gardner et al., 2016).

Alcohol Use

Alcohol use increases in frequency and amount during the transition from high school to university (Borsari et al., 2007; Logan et al., 2012), with 60% of Canadian university students (*N*

[3] High-risk drinking: weekly heavy-episodic drinking combined with high risk for alcohol-related problems (Lee et al., 2013).

= 8,182) endorsing heavy episodic drinking behaviors (Kwan et al., 2013). When assessing alcohol use in the previous 30 days, Edkins and colleagues (2017) found that most students (69.7%) reported heavy episodic drinking at least once, with 42.8% engaging in heavy episodic drinking 2-3 times (Edkins et al., 2017). Emerging adults enrolled in post-secondary education are more likely to engage in these risky alcohol use patterns than others in their same age group not attending university (Borsari et al., 2007; Molnar et al., 2009; Reckdenwald et al., 2016). For example, according to Statistics Canada (2019b) approximately 33.5% of Canadian males and 23.8% of females aged 18 to 24 were identified as heavy drinkers, while 38.9% of Canadian male university students and 33.5% of female students engage in heavy drinking (CCSA, 2019). These findings suggest that the unique conditions present during the transition from high school to university may increase student vulnerability to problematic alcohol use (Pedrelli et al., 2015).

Alcohol-Related Consequences

Undergraduate drinking patterns appear to remain relatively stable, with many students continuing to drink heavily and frequently from first year to fourth year despite experiencing several negative consequences (Martinez et al., 2014). Negative consequences associated with alcohol consumption can range from social and academic consequences to those characteristic of an alcohol use disorder (e.g., increased tolerance; Martinez et al., 2014). Academic consequences of consuming alcohol include falling behind in coursework, receiving a lower grade, arriving late to school, and missing class (Mallett, Marzell et al., 2011; Martinez et al., 2014; Park & Grant, 2005; Piazza-Gardner et al., 2016). In a survey of undergraduate students at 58 Canadian university campuses, it was found that 3.6% of students reported that alcohol use interfered with their academic performance, which was defined as: (1) receiving a lower grade on an assignment, exam, or in a course, (2) receiving an incomplete or dropped course, or (3)

experiencing a significant disruption to thesis, research, or practicum work as a result of alcohol consumption (ACHA, 2019). Piazza-Gardner and colleagues (2018) found that the number of drinks consumed by students was significantly associated with their overall GPA. In particular, the likelihood of being an "A" student decreased with each additional drink consumed at the most recent social event attended by the student (Piazza-Gardner et al., 2018). Additionally, the likelihood of achieving an "A" grade decreased as the frequency of heavy episodic drinking over the last 2 weeks increased (Piazza-Gardner et al., 2018). These findings indicate that undergraduate students who report consuming a greater number of alcoholic beverages and engage in heavy drinking more regularly have lower GPAs than those who consume less alcohol (Piazza-Gardner et al., 2018).

The most commonly reported consequences among university students are generally evaluated as the least negative (Rinker et al., 2017) and include having a bad hangover, poor memory of the night before, trouble thinking clearly, not enjoying the experience (Molnar et al., 2009), vomiting, blacking out (Mallett et al., 2011), binge-eating late at night, and waking up in someone else's bed (Mallet et al., 2018). Severe alcohol-related consequences are less frequent (White & Ray, 2014) and are more likely to be rated as negative by students (Mallett et al., 2008). These consequences include having belongings stolen, regretting sexual situations, losing belongings, becoming obnoxious while drinking, being embarrassed (Mallett et al., 2008), experiencing unintentional death or injury, and engaging in behaviors that place students in conflict with the legal system (Mallett et al., 2011; Martinez et al., 2014; Molnar et al., 2009), such as physical or sexual assault (Logan et al., 2012), impaired driving, and property damage or vandalism (Molnar et al., 2009).

Negative alcohol-related consequences are commonly experienced by undergraduate students (ACHA, 2019; Patrick & Maggs, 2008; Mallett, Marzell et al., 2011; White & Ray, 2014). For example, Mallett, Marzell, and colleagues (2011) found that over 80% of their undergraduate sample (N = 169) experienced multiple consequences in the past year, with 34% reporting six or more consequences and nearly 50% endorsing three or more consequences repeatedly. According to the ACHA (2019), 53.2% of Canadian undergraduate students experience at least one or more of the following alcohol-related consequences: did something that was later regretted (35%), forgot details of the night before (27%), experienced conflict with the police (0.4%), someone had sex with you without your consent (2.3%), you had sex with someone else without their consent (0.3%), had unprotected sex (25.3%), physically injured yourself (16.6%), physically injured another person (1.8%), and seriously considered suicide (6.5%). Prevalence rates for consequences characteristic of an alcohol use disorder among students are as follows: tried to control drinking (13.4%), was avoided by relatives (1.0%), had withdrawal symptoms (2.2%), felt dependent on alcohol (2.9%), experienced an increase in tolerance (18.3%), perceived their alcohol use to be a problem (7.2%), neglected responsibilities (26.5%), and missed a day (or part of a day) of school or work (21.8%; White & Ray, 2014).

Despite frequently experiencing negative short- and long-term drinking-related consequences, many post-secondary students do not perceive heavy episodic drinking as a serious issue and instead view alcohol consumption as an expected and positive aspect of the university experience (CCSA, 2018). This may be due to the recent finding that many of the consequences deemed as negative by researchers (e.g., hangovers, blackouts) are perceived as neutral or even positive by students themselves (Mallett et al., 2013; Martinez et al., 2014; Rinker et al., 2013; White & Ray, 2014). This is particularly relevant for heavier drinkers who

tend to rate alcohol-related consequences as neutral or positive more frequently than light drinkers (Mallett et al., 2008; Rinker et al., 2017). Positive alcohol-related consequences appear to reinforce positive expectancies regarding alcohol consumption among university students (Logan et al., 2012; Park, 2004; Park & Grant, 2005) and are a stronger predictor of future heavy drinking than negative consequences (Logan et al., 2012; Park, 2004; Patrick & Maggs, 2008). Many post-secondary students report that alcohol consumption can help them to have fun, socialize, meet new people, bond with friends, increase confidence, reduce peer pressure or anxiety, and overcome boredom (CCSA, 2018). Additional positive consequences endorsed by undergraduate students include forgetting about school-related problems (Park & Grant, 2005), tension reduction, performance or activity enhancement, social stimulation, and expressing oneself (Park, 2004).

The literature suggests that males and females may experience alcohol-related consequences differently. For example, female students endorse a greater number of positive consequences compared to males, who tend to report negative consequences more frequently (Park & Grant, 2005). Additionally, males are more likely than females to report specific negative consequences including aggression, property destruction, arrests (Borsari et al., 2007), behaving obnoxiously when intoxicated (Martinez et al., 2014), missing class, and overdosing (Park & Grant, 2005). However, when females do experience negative consequences, they often rate them as more distressing compared to their male counterparts (White & Ray, 2014) and show a greater vulnerability to the effects of these consequences (Squeglia et al., 2014).

EF and Alcohol Use

Emerging adulthood is a period of significant psychological and cognitive development (Goldstein et al., 2018) and is a critical period for the development of executive functioning and

substance use patterns (Bø et al., 2017; Friedman et al., 2016; Gustavson et al., 2012; Peeters et al., 2015). The prefrontal cortex continues to develop from late adolescence into early adulthood (Bø et al., 2017; Friedman et al., 2016; Gustavson et al., 2012; Peeters et al., 2015) and is particularly vulnerable to the effects of alcohol during this time (Bø et al., 2017; Mota et al., 2013). Consuming large amounts of alcohol in emerging adulthood could lead to disruptions in the functioning of the prefrontal cortex and subsequent impairments in executive functioning (Bø et al., 2017; Looby et al., 2018). Additionally, executive function deficits have been found to precede the initiation of alcohol consumption among adolescents (Peeters et al., 2015) and are linked with the onset and maintenance of problematic alcohol use patterns, such as heavy episodic drinking, among individuals aged 18 to 24 (Bø et al., 2017; Day et al., 2015; Gustavson et al., 2017). Low levels of executive functioning in late adolescence have been identified as a risk factor for frequent polysubstance use (Gustavson et al., 2017), high levels of alcohol consumption, and the onset of alcohol use disorder symptoms (Lees et al., 2020). These findings suggest that executive function deficits are both a risk factor for and negative consequence of problematic alcohol use among emerging adults (Day et al., 2015; Gustavson et al., 2017).

Pregaming is a common alcohol use behavior within university populations that involves the consumption of large amounts of alcohol in a short period of time prior to attending a social event (CCSA, 2018; Borsari et al., 2007; Mallett et al., 2013). Pregaming typically involves drinking games that are highly cognitively demanding (Looby et al., 2018) and have the potential to negatively influence executive functions (Lees et al., 2020). For example, working memory is a limited cognitive resource that can become quickly depleted through alcohol consumption and heavy cognitive loads, making it particularly susceptible to the adverse effects of pregaming (Looby et et al., 2018). Individuals with working memory impairments or other pre-existing

executive function deficits may experience a greater loss of behavioral control when engaging in drinking games, which places them at an elevated risk for alcohol-related consequences (Looby et al., 2018), such as excessive drinking, blacking out, vomiting, and being involved in conflicts or physical fights (CCSA, 2018).

Individuals with executive function deficits in emerging adulthood are more likely to engage in heavy and frequent alcohol use compared to those without executive function deficits (Gustavson et al., 2016), including impairments in working memory, inhibitory control (Bø et al., 2017; Martins et al., 2018; Peeters et al., 2015), self-monitoring (Bø et al., 2017; Hustad et al., 2009), planning (Day et al., 2015), and emotion regulation (Lees et al., 2020). Additionally, individuals with executive function deficits engage in polysubstance use more frequently than those with high levels of executive functioning (Gustavson et al., 2017), which may lead to a greater number of alcohol related consequences. For example, Keith and colleagues (2015) found that using marijuana and alcohol together is associated with increased negative consequences (e.g., regretting an event while intoxicated, forgetting events, engaging in risky sexual behaviors, and getting into trouble with police) when compared to consuming only alcohol. These findings demonstrate that polysubstance use and heavy episodic drinking is more common among undergraduate students with executive function deficits, which may place these individuals at an elevated risk of experiencing both positive and negative alcohol-related consequences (Molnar et al., 2009; Park, 2004; Park & Grant, 2005).

There is a gap in the literature regarding the role of all nine executive functions in university students' experiences and perceptions of alcohol-related consequences as most research to date has focused on three executive functions, including working memory, shifting, and inhibition (Diamond, 2013; Friedman & Miyake, 2017; Gustavson et al., 2017; Looby et al.,

2018; Martins et al., 2018; Miyake & Friedman, 2012; Peeters et al., 2015). Additionally, these executive functions have primarily been examined in relation to alcohol use patterns rather than alcohol-related consequences. In the literature, executive function deficits have consistently been found to have small but significant associations with problematic substance use and substance use disorders (Bø et al., 2017; Day et al., 2015; Diamond, 2013; Gross & Haynes, 2011; Gustavson et al., 2017; Lees et al., 2020; Looby et al., 2018; López-Caneda et al., 2014; Martins et al., 2018; O'Rourke et al., 2020; Peeters et al., 2015; Squeglia et al., 2014). Additionally, recent research suggests that executive functions may increase the risk of experiencing alcohol-related consequences (Day et al., 2015; Looby et al., 2018). Despite these recent findings, little is known regarding which executive functions are significantly related to the experience of negative and positive alcohol-related consequences among university students. Understanding the relationships between executive functions and alcohol-related consequences may help to identify those who are at risk of experiencing adverse consequences as well as those who are at risk of continuing with problematic alcohol consumption post-graduation (Dvorak et al., 2014). Additionally, identifying the executive function deficits that interfere with students' ability to prevent, manage, or reduce their heavy drinking can inform alcohol-use interventions targeting university students. For example, several strategies recommended to protect students from alcohol-related consequences require the use of executive functions (e.g., consuming non-alcoholic beverages between drinking games; CCSA, 2018), despite the finding that individuals with executive function deficits are at a greater risk for problematic alcohol use and related consequences (Lees et al., 2020). Investigating the relationships between executive functions and alcohol-related consequences among university students can provide valuable information for improving these interventions.

Previous research examining alcohol-related consequences among university students has primarily focused on the negative consequences of drinking despite the finding that many students report positive alcohol-related consequences more frequently (Mallett et al., 2013; Park & Grant, 2005) and rate them as more important than negative consequences (Park, 2004; Patrick & Maggs, 2008). For example, Patrick and Maggs (2008) found that students who report experiencing more positive consequences plan on consuming more alcohol in the future than students who report fewer positive consequences, whereas negative consequences had little influence on students' future drinking plans. Additionally, recent research has discovered that the evaluations applied to alcohol-related consequences by researchers is often not congruent with student perceptions (Mallett et al., 2013; Martinez et al., 2014; Rinker et al., 2013; White & Ray, 2014). Positive alcohol-related consequences are important to examine as they are strong predictors of continued and future heavy drinking (Patrick & Maggs, 2008) and often occur earlier after consuming lower amounts of alcohol (Logan et al., 2012). In other words, the reinforcing effects of positive consequences may have implications for light drinkers, in addition to heavy drinkers, by increasing the likelihood that they will continue to drink and possibly progress to more problematic patterns of alcohol use. These findings highlight the importance of investigating the relationships between executive functions and positive and negative consequences of drinking among undergraduate students. Understanding these relationships can aid in identifying which specific factors are associated with the most problematic alcohol-related consequences and may assist in guiding prevention and treatment measures as a function of identified deficits (Dvorak et al., 2014).

These relationships are especially critical to examine within a Canadian university student population as research indicates that alcohol consumption in Canada is higher than the

global average (CCSA, 2019). For example, alcohol consumption per capita in Canada in 2016 was higher than the United States, Sweden, and Australia (CCSA, 2019). Additionally, in 2017, 84.2% of individuals in Ontario reported alcohol use, with prevalence of risky consumption being highest among individuals aged 18 to 24 (CCSA, 2019).

COVID-19 Considerations

The COVID-19 pandemic may have implications for the present study through its influence on the alcohol use patterns of university students. Research conducted early in the pandemic suggested that COVID-19 may be a high-risk event for alcohol use among post-secondary students as alcohol sales and consumption appeared to be increasing (Jaffe et al., 2021). However, this early increase in alcohol use may be explained by typical changes in alcohol use trends among university students (Jaffe et al., 2021). The data for these early studies were primarily collected during the months of March, April, and May, which are times of the year where alcohol consumption among university students is typically higher, most likely due to spring break and the end of the academic year (Jaffe et al., 2021). This theory is supported by a growing body of research indicating that alcohol use among university students has either remained the same or decreased since the start of the pandemic (Graupensperger et al., 2021; Jackson et al., 2021; Jaffe et al., 2021; Minhas et al., 2021). Graupensperger and colleagues (2021) found that most students ($N = 507$) reported consuming "a lot less" alcohol during the COVID-19 pandemic, with only a small proportion of male (10.38%) and female (16.72%) students drinking more than the recommended amount per week (i.e., 14 or more drinks for males and 7 or more drinks for females; Graupensperger et al., 2021). Similarly, Jaffe et al. (2021) found that 83.5% of college student drinkers self-reported that their drinking stayed the same or decreased during the pandemic. This decrease in alcohol use may be partially explained

by the closures of university campuses, bars, and nightclubs, where the risk for heavy episodic drinking is greatest (Graupensperger et al., 2021; Jackson et al., 2021; Jaffe et al., 2021; Minhas et al., 2021).

The restrictions put in place during the COVID-19 pandemic has forced university students to alter their drinking contexts, with many students drinking alone or with family rather than in social settings (Jackson et al., 2021). This shift in drinking context has resulted in a change in the quantity, frequency, and type of alcohol consumed by university students (Jackson et al., 2021; Jaffe et al., 2021; Minhas et al., 2021). During the pandemic, many students have been consuming smaller quantities of alcohol more frequently and have transitioned from hard liquor to wine and/or beer (Jackson et al., 2021). Jaffe and colleagues (2021) found a 28% reduction in the quantity of alcohol consumed by university students and Jackson et al. (2021) found a 29% reduction in liquor consumption since the beginning of the pandemic. These findings suggest that although the pandemic has had significant influences on the alcohol use patterns of university students, it is unlikely to be a particularly high-risk time for student alcohol use in general. It may, however, be a particularly risky time for individuals with pre-existing executive function deficits due to the high levels of stress and cognitive demands placed on individuals during the pandemic (Applehans et al., 2021). Applehans and colleagues (2021) found that approximately 25% of young adults with pre-existing executive function deficits (N = 1364) reported significant increases in alcohol and substance use during the COVID-19 pandemic. These findings indicate that the pandemic has placed students with executive function deficits at a higher risk for increased alcohol consumption and associated consequences.

Current Study

The current study aimed to shed light on the relationships between executive functions and alcohol-related consequences among university students. Due to the exploratory nature of this study, hypotheses regarding concrete outcomes of the study results were not feasible to construct, however, there were some general expectations of this study's results.

- Firstly, individuals who demonstrated lower scores on measures of executive function would show higher scores on measures of positive alcohol-related consequences,
- Secondly, individuals who demonstrated lower scores on measures of executive function would show higher scores on measures of negative alcohol-related consequences.

Method

Participants:

Participants in the study included 211 Lakehead University undergraduate students. The mean age of the sample was 22 years (*SD* = 5.1, age range = 18 to 42 years). Relevant participant demographic information can be found in Table 2. Participants were recruited through the Department of Psychology Research Sign-Up Portal (SONA; see Appendix A) and data collection occurred over one month beginning in March of 2022 via SurveyMonkey. Students were eligible for this study if they could read, speak, and understand English, had consistent access to the internet, and consumed at least one alcoholic beverage in the past three months (see Appendix B). Participants who did not meet the eligibility criteria were redirected to a disqualification page (see Appendix C).

Table 2.

Participant Demographics

Variable		Total (*N* = 211; %)
Sex	Male	37 (17.5)

	Female	174 (82.5)
Age	18-24 years	171 (83.3)
	25-32 years	20 (9.4)
	33-42 years	17 (7.3)
Year of Study	First	81 (38.4)
	Second	44 (20.9)
	Third	55 (26.1)
	Fourth	25 (11.8)
	Greater than four	4 (1.9)
Ethnicity	Asian	18 (8.5)
	Caucasian	173 (82.5)
	Indigenous	9 (4.3)
	Black	11 (5.2)
Marital Status	Single	88 (41.7)
	Dating	95 (45.0)
	Separated	1 (0.5)
	Married	23 (10.9)
	Divorced	1 (0.5)
	Other	3 (1.4)
Annual Income	<$20 000	4 (1.9)
	$20 000 to $39 999	24 (11.4)
	$40 000 to $59 999	20 (9.5)
	$60 000 to $79 999	24 (11.4)
	$80 000 to $99 999	27 (12.8)
	≥$100 000	110 (52.1)
Employment Status	Full-time	17 (8.1)
	Part-time	131 (62.1)
	Unemployed	47 (22.3)
	Other	16 (7.6)
Frequency of HED*	Once	109 (51.7)
	Twice	63 (29.9)
	Three	27 (12.8)
	≥ Four	12 (5.6)
Alcohol Quantity	0	47 (22.3)
	1-3	78 (37)
	4-6	59 (28)
	7-9	19 (8.9)
	≥ 10	5 (2.3)

*HED = Heavy Episodic Drinking. *Note.* Alcohol Quantity and Frequency of HED refer to past week alcohol use.

Procedure:

Participants were provided with a Letter of Information (see Appendix D) that explained the purpose of the study as well as the potential risks and benefits of participation. Participants

were informed that their decision to take part or not take part in the study was completely voluntary and that they could drop out of the study at any time without consequence. Participants were informed that their data would be confidential and anonymous. If they were interested in participating, they were given a consent form (see Appendix E) to complete. Upon providing informed consent, participants were asked to complete a set of questionnaires through SurveyMonkey (see Appendices F-J). After completing the study, participants were provided with an End of Study Letter (see Appendix K) and were compensated for their time with one bonus point towards an eligible psychology course.

Measures:

The Comprehensive Executive Function Inventory - Adult (CEFI Adult; Naglieri & Goldstein, 2017). The CEFI Adult is an 80-item self-report measure designed to assess the strengths and weaknesses of executive functioning in adults aged 18 and older. The CEFI Adult assesses the following nine domains of executive functioning: attention, inhibitory control, planning, emotion regulation, initiation, self-monitoring, flexibility, organization, and working memory. Respondents rate the frequency of each item in the past four weeks on a 5-point Likert-type scale (0 = "Never" to 5 = "Always"). An example item from the inhibitory subscale is *"show self control?*". An example item from the emotion regulation subscale is "stay calm when handling small problems?". An example item from the working memory subscale is "*remember many things at one time?*". The CEFI Adult produces a total of 12 scores including a Full-Scale score, a Consistency Index score, a Negative Impression score, and a score for each of the nine domains of executive functioning. Lower scores on the nine domain scales indicate greater impairments in those specific executive functions, while a lower total score suggests poorer overall executive functioning. The CEFI Adult has good overall psychometric properties

(Brinkman & Lautzenheiser, 2021; Multi Health Systems [MHS], 2020). The Full Scale has high internal consistency (α = .97) and the scales showed good internal consistency (scales median α = .83; MHS, 2020). Lower reliability was demonstrated for specific scales including Attention, Emotion Regulation, Planning, Self-monitoring, and Working Memory, with Chronbach's alpha ranging from .73-.77 for these scales (Brinkman & Lautzenheiser, 2021). The Full Scale shows good test-retest reliability over a period ranging from 2-4 weeks and 2-3 months (*r* = .93; Brinkman & Lautzenheiser, 2021; MHS, 2020). The CEFI Adult scales showed similar degrees of test-retest reliability (scales median *r* = .91; MHS, 2020). Additionally, the CEFI Adult has good construct and criterion-related validity (Brinkman & Lautzenheiser, 2021).

The Heavy Episodic Drinking - Frequency (HED-F; National Institute on Alcohol Abuse and Alcoholism, 2003). Participants will be asked to report frequency of heavy episodic drinking as well as the greatest number of drinks consumed in a 2-hour period over the past seven days (where one alcohol drink = one 12-ounce bottle or can of beer, a 5-ounce glass of regular (12%) wine, or a drink containing 1.5-ounces of hard liquor). Frequency of heavy episodic drinking will be measured with two sex-specific items. If the participant is female, they will respond to the question "During the past 7 days, how often did you have 4 or more drinks containing any kind of alcohol within a 2-hour period?". If the participant is male, the question changes to five or more drinks. The participants will have the option to respond anywhere from "0 times" to "11 times". Self-report measures of alcohol use behaviors that are brief or contain a single-item have demonstrated excellent test-retest reliability and good validity (Dollinger & Malmquist, 2009).

The Consequences of Alcohol Measure (CAM; Sinclair, 2016). The consequences of alcohol use will be measured using the CAM, which is a 33 item self-report measure. The CAM

yields a total score for consequences of alcohol use, a total score for valence ratings, and eight subscales: “positive consequence subscale”, “negative behavioral consequences subscale”, “negative emotional consequences subscale”, “positive consequences valence”, “negative behavioral consequences valence”, “negative emotional consequences valence”, “suicide/self-harm consequences”, and “suicide/self-harm consequences valence”. All items are assessed on a Likert-type scale ranging from 1 (never) to 5 (daily or almost daily) for alcohol consequences and from 0 (does not apply) to 5 (very bad) for valence ratings. A higher total CAM score indicates a greater number of alcohol-related experiences. A higher total valence rating score indicates the endorsement of a greater number of negative consequences. Sinclair (2016) found that the CAM has sufficient evidence of construct, concurrent, and convergent validity. The three consequence subscales (i.e., positive, negative emotional, negative behavioral) were moderately interrelated and loaded on the same overarching factor (e.g., alcohol use consequences). However, the intercorrelations did not exceed .85 (i.e., the cutoff for redundancy), which provides discriminant validity for the consequences subscales (Sinclair, 2016). Sinclair (2016) found that the CAM total score has high internal consistency ($\alpha = .95$), and good test-retest reliability over a period ranging from 6-11 days. All eight CAM subscales had high internal consistency and demonstrated moderate to high test-retest reliability ($r = .70$-$.90$; Sinclair, 2016).

Software Used for Statistical Analyses:

The computer software program Statistical Package for the Social Sciences – Version 27 (SPSS-27) was used for all analyses.

Pre-Analysis Issues:

Missing Values: There were two forms of missing values within this study. First, there were full sections of measures not completed. Second, there were missing values at random

throughout completed questionnaires. Participants who did not complete full measures required for analyses were excluded from the relevant analyses (this included the removal of 10 cases). Meanwhile, missing values at random were dealt with using complete cases analysis. Graham (2009) notes that if only a few data points (e.g., 5% or fewer) are missing in a random pattern in a large data set, the bias and loss of power with listwise deletion is likely to be inconsequential, especially for multiple regression models. Within this study, missing values largely involved errors in completing the Likert-type scale questionnaires, where a single item contributing to an overall subscale score was skipped. To assess the randomness of the missing values, the missing data analysis function of SPSS was used. In an examination of the potential patterns among the missing values of data, they were found to be non-significant, and the missing data were deemed to be random.

Outliers: To address the potential influence of univariate outliers, Cook's distances were calculated, which is a measure of overall influence of a datapoint on the model. Cook's D systematically removes datapoints from the regression model to identify significant changes when the *n*th observation is removed. Cook's D values greater than 1.00 indicate datapoints that might be influencing the model (Field, 2009). Outliers with a Cook's D less than 1.00 do not have a large effect on the regression analysis and do not need to be removed (Field, 2009). A conservative cut-off of greater than 0.05 was used to determine influential data points. None of the data points had a Cook's D greater than 0.05, which indicates that no cases have undue influence on the model. To assess for multivariate outliers, Mahalanobis distances were calculated, which takes the covariances of each variable's distributions into consideration in a multivariate analysis using linear regression. From there, the Mahalanobis distances were compared to a chi-square distribution with the same degrees of freedom. This presents

multivariate outliers as any new probability cases that are less than 0.01, this being a very conservative probability estimate for outliers (Tabachnick & Fidell, 2014). No multivariate outliers were found.

Normality: To assess for normality, skewness and kurtosis were analyzed. Skewness involves the symmetry of the distribution and may distort the mean and standard deviation, leading to skewed bivariate statistics. Kurtosis represents the peakedness of the distribution, which may create an underestimate of the variance in a given variable when non-normal. For skewness, each variable was assessed to determine skewness as greater than .8. Meanwhile, for Kurtosis, output was examined to see if it is clustering close to zero. Additionally, scatterplots were created for each variable and examined for skewness and kurtosis. The CAM negative consequences subscale variable demonstrated slight skewness (2.304) and kurtosis (6.358). However, no other variables were determined to have significant skewness or kurtosis. The degree of skewness and kurtosis of the distribution for the CAM negative consequences subscale variable was slight-moderate. However, Kline (2011) states that skewness values less than $\pm$ 3 and kurtosis values less than $\pm$ 10 are unlikely to influence the model. Additionally, a deviation from skewness and kurtosis likely does not have a significant effect on the model when the sample size is greater than 200 (Tabachnick & Fidell, 2014). As such, the degree of skewness and kurtosis detected was deemed to be within an acceptable range.

Multicollinearity: To assess multicollinearity of the predictor variables, a variance inflation factor (VIF) was calculated for each variable. The variance inflation factor is the ratio of variance in a model with multiple predictors, divided by the variance of a model with one predictor alone. A calculation of the VIF provides a number for the severity of multicollinearity associated with each predictor by quantifying how much the variance of each predictor in the

regression is inflated. A VIF between 5 and 10 indicates high collinearity. All VIFs examined were between 1.009 and 1.907, suggesting no significant multicollinearity among multivariate predictors.

Results

Descriptives

The means and standard deviations for the frequency and quantity of alcohol use by sex are shown in Table 3. Overall, students in the current study endorsed heavy episodic drinking about 1.79 times (*SD* = 1.18) in the past seven days and reported consuming an average of 3.04 drinks (*SD* = 2.75) in a 2-hour period. Additionally, over three quarters (78.6%) of students endorsed negative alcohol-related consequences in the past 12 months and 98.6% reported positive consequences. Table 4 presents the frequencies for positive and negative consequences by sex.

Among participants, the total mean CEFI Full-Scale score was 220.49 (*SD* = 39.24). Table 5 includes a summary of the different domains of the CEFI and overall executive functioning compared to American population norms.

Table 3.

Descriptive Statistics for Quantity of Alcohol Use and Frequency of HED by Sex

Variable	Male			Female		
	M	*SD*	*N*	*M*	*SD*	*N*
Frequency	1.92	1.21	37	1.75	1.17	175
Quantity	3.61	.51	37	2.91	.20	171

Table 4.

Frequency of Alcohol-Related Consequences within the Sample by Sex

Variable	Frequency	
	Male	Female

Positive Consequences	35 (97.2%)	170 (98.8%)
Negative Behavioral Consequences	28 (77.8%)	110 (64.7%)
Negative Emotional Consequences	27 (73.0%)	109 (63.0%)
Total Consequences	35 (97.2%)	170 (98.8%)

Table 5.

Mean Raw Scores of Each EF Domain Compared to Average Population Norms

EF Domain	Study sample mean (*SD*)	Average population norm range
Overall EF		
18-22 years	219.35 (3.52)	185-248
23-29 years	221.74 (6.33)	196-287
30-44 years	228.22 (8.96)	209-266
Working Memory		
18-22 years	23.89 (.52)	21-27
23-29 years	24.04 (.92)	21-28
30-44 years	24.33 (1.20)	22-29
Inhibitory Control		
18-22 years	26.80 (.44)	22-29
23-29 years	26.52 (.98)	22-30
30-44 years	27.83 (1.07)	23-30
Emotion Regulation		
18-22 years	22.78 (.51)	20-27
23-29 years	25.07 (1.07)	21-28
30-44 years	25.06 (1.22)	22-29

Note. Number of participants in each age group as follows: 18-22 years, $N = 135$; 23-29 years, $N = 27$; 30-44 years, $N = 18$

Bivariate Correlations

To understand the relationships between predictor and outcome variables, bivariate correlations were computed between alcohol use, executive functions, and alcohol-related consequences (see Table 12). Positive associations were found between the alcohol use predictors and both outcome variables, suggesting that increases in the frequency and quantity of past week alcohol use was associated with a greater number of positive and negative consequences. Additionally, negative associations were found between the executive function

domains of Emotion Regulation, Inhibitory Control, and Working Memory and both outcome variables, indicating that lower scores on measures of executive function are associated with higher scores on measures of alcohol-related consequences.

Table 6.

Bivariate Correlations of the Study Variables

Variable	1	2	3	4	5	6	7
1. Positive Consequences	---	.55**	.47**	.44**	-.24**	-.21**	-.30**
2. Negative Consequences	---	---	.38**	.44**	-.30**	-.33**	-.32**
3. Alcohol Quantity	---	---	---	.60**	-.13	-.18**	-.25**
4. Frequency of HED	---	---	---	---	-.20**	-.27**	-.36**
5. Emotion Regulation	---	---	---	---	---	.61**	.50**
6. Inhibitory Control	---	---	---	---	---	---	.56**
7. Working Memory	---	---	---	---	---	---	---

Note. * p<.05, *p<.01

EFs and Positive Consequences

Three hierarchical linear regression analyses were conducted to assess whether participants CEFI subscale scores predicted positive alcohol-related consequences (Tables 6-8). In each model, the same order was used to input variables. Demographic variables (age and sex) were entered into block one, followed by alcohol use variables (quantity and frequency) in the second block. One of the three CEFI subscales of interest (emotion regulation, inhibitory control, and working memory) were added in the final block.

The results from the hierarchical linear regression analysis with emotion regulation as the predictor and positive consequences as the outcome are presented in Table 6. Age and sex were not significant predictors of positive consequences in any step of the model. The introduction of alcohol use variables (quantity and frequency) significantly improved the amount of variance

accounted for (R^2 = .26, F(4, 195) = 17.10, p < .001). At this step, both the frequency of HED (β = .27, t = 3.49, p < .01) and quantity of alcohol consumption (β = .30, t = 3.87, p < .01) individually contributed to the model. The addition of the CEFI Emotion Regulation subscale in the final step significantly improved the model (R^2 = .29, F(5, 194) = 15.84, p < .001). The Emotion Regulation subscale score (β = -.18, t = -2.87, p < .01), frequency of HED (β = .23, t = 3.05, p < .01), and alcohol quantity (β = .30, t = 3.92, p < .01) individually contributed to the model at this step.

Table 7.

Hierarchical Regression with Sex, Age, Alcohol Use, and Emotion Regulation as Predictors and Positive Consequences as Outcome

		Model 1				Model 2				Model 3			
		B	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
	Age	-.04	.11	-.03	-.34	.05	.09	.04	-.56	.08	.09	.05	.88
	Sex	-1.47	1.42	-.07	-1.04	-.63	1.23	-.03	-.51	-1.37	1.24	-.07	-1.12
Alcohol Use	Frequency					1.7	.49	.27	3.49**	1.48	.49	.23	3.05**
	Quantity					.82	.21	.30	3.87**	.82	.21	.30	3.92**
CEFI Sub-scales	Emotion Regulation									-.23	.09	-.18	-2.87**
R^2	R^2		.006				.260				.290		
	R^2 change		.006				.254				.030		
	F change		.570				33.435**				8.247**		

Note. *p < .05, **p < .01

The results from the hierarchical linear regression analysis with inhibitory control as the predictor and positive consequences as the outcome are presented in Table 7. Age and sex were not significant predictors of positive consequences in any step of the model. The introduction of alcohol use variables (quantity and frequency) significantly improved the amount of variance accounted for (R^2 = .27, F(4, 193) = 18.25, p < .001). At this step, both the frequency of HED (β

= .29, t = 3.79, p < .01) and quantity of alcohol consumption (β = .30, t = 3.87, p < .01) individually contributed to the model. The addition of the CEFI Inhibitory Control subscale in the final step did significantly improve the model (R^2 = .28, F(5, 192) = 15.01, p < .001), although the Inhibitory Control subscale score did not individually contribute to the model (β = -.08, t = -1.33, p > .05). However, frequency of HED (β = .27, t = 3.45, p < .01) and quantity of use (β = .30, t = 3.90, p < .01) were significant predictors of positive consequences at this step.

Table 8.

Hierarchical Regression with Sex, Age, Alcohol Use, and Inhibitory Control as Predictors and Positive Consequences as Outcome

		Model 1				Model 2				Model 3			
		B	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
	Age	-.03	.11	-.02	-.31	.05	.09	.04	-.58	.06	.09	.04	.66
	Sex	-1.47	1.45	-.07	-1.01	-.90	1.25	-.05	-.72	-.96	1.25	-.05	-.77
Alcohol Use	Frequency					1.9	.50	.29	3.79**	1.76	.51	.27	3.45**
	Quantity					.82	.21	.30	3.87**	.82	.21	.30	3.90**
CEFI Sub-scales	Inhibitory Control									-.13	.09	-.08	-1.33
R^2	R^2		.005				.274				.281		
	R^2 change		.005				.269				.007		
	F change		.535				35.770**				1.758		

Note. *p <.05, **p < .01

The results from the hierarchical linear regression analysis with Working Memory as the predictor and positive consequences as the outcome are presented in Table 8. Age and sex were not significant predictors of positive consequences in any step of the model. The introduction of alcohol use variables (quantity and frequency) significantly improved the amount of variance accounted for (R^2 = .26, F(4, 193) = 17.23, p < .001). At this step, both the frequency of HED (β = .27, t = 3.50, p < .01) and quantity of alcohol consumption (β = .30, t = 3.89, p < .01)

individually contributed to the model. The addition of the CEFI Working Memory subscale in the final step did significantly improve the model (R^2 = .28, F(5, 192) = 14.82, p < .001). The Working Memory subscale score (β = -.13, t = -2.02, p < .01) and both alcohol use variables (frequency: (β = .22, t = 2.81, p < .01) and quantity: (β = .30, t = 3.85, p < .01)) individually contributed to the model at this step.

Table 9.

Hierarchical Regression with Sex, Age, Alcohol Use, and Working Memory as Predictors and Positive Consequences as Outcome

		Model 1				Model 2				Model 3			
		B	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
	Age	-.03	.11	-.02	-.30	.05	.09	.04	-.58	.05	.09	.03	.51
	Sex	-1.47	1.45	-.07	-1.02	-.72	1.26	-.04	-.57	-.84	1.25	-.04	-.67
Alcohol Use	Frequency					1.72	.50	.27	3.50**	1.43	.51	.22	2.81**
	Quantity					.84	.21	.30	3.89**	.82	.21	.30	3.85**
CEFI Sub-scales	Working Memory									-.18	.09	-.13	-2.02*
R^2	R^2		.006				.263				.278		
	R^2 change		.006				.258				.015		
	F change		.540				33.734**				4.091*		

Note. *p < .05, **p < .01

EFs and Negative Consequences

Three hierarchical linear regression analyses were conducted to assess whether participants CEFI subscale scores predicted negative alcohol-related consequences (Tables 9-11). In each model, the same order was used to input variables. Demographic variables (age and sex) were entered into block one, followed by alcohol use variables (quantity and frequency) in the second block. One of the three CEFI subscales of interest (emotion regulation, inhibitory control, and working memory) were added in the final block.

The results from the hierarchical linear regression analysis with Emotion Regulation as the predictor and negative consequences as the outcome are presented in Table 9. Age and sex were not significant predictors of negative consequences in any step of the model. The introduction of alcohol use variables (quantity and frequency) significantly improved the amount of variance accounted for (R^2 = .22, F(4, 193) = 13.22, p < .001). At this step, the frequency of HED (β = .35, t = 3.10, p < .01) individually contributed to the model, however, quantity of alcohol consumption did not (β = .15, t = 1.66, p > .05). The addition of the CEFI Emotion Regulation subscale in the final step significantly improved the model (R^2 = .28, F(5, 192) = 14.93, p < .001). The Emotion Regulation subscale score (β = -.26, t = -4.16, p < .01) and frequency of HED (β = .33, t = 3.85, p < .01) individually contributed to the model at this step. However, alcohol quantity was not a significant predictor of negative consequences at this step (β = .13, t = 1.56, p > .05).

Table 10.

Hierarchical Regression with Sex, Age, Alcohol Use, and Emotion Regulation as Predictors and Negative Consequences as Outcome

		Model 1				Model 2				Model 3			
		B	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
	Age	-.06	.11	-.04	-.60	.15	.10	.10	1.61	.19	.09	.13	2.07*
	Sex	-.06	1.41	-.00	-.04	.96	1.27	.05	.75	-.10	1.24	-.01	-.08
Alcohol Use	Frequency					2.74	.69	.35	3.10**	2.55	.66	.33	3.85**
	Quantity					.40	.24	.15	1.66	.36	.23	.13	1.56
CEFI Sub-scales	Emotion Regulation									-.34	.08	-.26	-4.16**
R^2	R^2		.002				.215				.280		
	R^2 change		.002				.213				.065		
	F change		.183				26.207**				17.297**		

Note. *p < .05, **p < .01

The results from the hierarchical linear regression analysis with Inhibitory Control as the predictor and negative consequences as the outcome are presented in Table 10. Age and sex were not significant predictors of negative consequences in any step of the model. The introduction of alcohol use variables (quantity and frequency) significantly improved the amount of variance accounted for (R^2 = .22, F(4, 191) = 13.47, p < .001). At this step, frequency of HED (β = .37, t = 4.18, p < .01) individually contributed to the model, however, quantity of alcohol consumption did not (β = .13, t = 1.46, p > .05). The addition of the CEFI Inhibitory Control subscale in the final step did significantly improve the model (R^2 = .27, F(5, 190) = 14.27, p < .001). The Inhibitory Control subscale score (β = -.24, t = -3.72, p < .01) and frequency of HED (β = .31, t = 3.59, p < .01) individually contributed to the model at this step. Alcohol quantity was not a significant predictor of negative consequences at this step (β = .13, t = 1.53, p > .05).

Table 11.

Hierarchical Regression with Sex, Age, Alcohol Use, and Inhibitory Control as Predictors and Negative Consequences as Outcome

		Model 1				Model 2				Model 3			
		B	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
	Age	-.06	.11	-.04	.60	.15	.10	.10	1.57	.16	.09	.11	1.78
	Sex	.18	1.43	.01	.12	.85	1.28	.04	.66	.69	1.24	.04	.56
Alcohol Use	Frequency					3.02	.72	.37	4.18**	2.55	.71	.31	3.59**
	Quantity					.35	.24	.13	1.46	.36	.23	.13	1.53
CEFI Sub-scales	Inhibitory Control									-.35	.09	-.24	-3.72**
R^2	R^2		.002				.215				.280		
	R^2 change		.002				.213				.065		
	F change		.183				26.207**				17.297**		

Note. *p < .05, **p < .01

The results from the hierarchical linear regression analysis with Working Memory as the predictor and negative consequences as the outcome are presented in Table 11. Age and sex were not significant predictors of positive consequences in any step of the model. The introduction of alcohol use variables (quantity and frequency) significantly improved the amount of variance accounted for (R^2 = .22, F(4, 191) = 13.47, p < .001). At this step, the frequency of HED (β = .37, t = 4.11, p < .01) individually contributed to the model, however, quantity of alcohol consumption did not (β = .14, t = 1.58, p > .05). The addition of the CEFI Working Memory subscale in the final step did significantly improve the model (R^2 = .25, F(5, 190) = 12.84, p < .001). The Working Memory subscale score (β = -.19, t = -2.88, p < .01) and frequency of HED (β = .32, t = 3.60, p < .01) individually contributed to the model at this step. However, alcohol quantity was not a significant predictor of negative consequences at this step (β = .13, t = 1.46, p > .05).

Table 12.

Hierarchical Regression with Sex, Age, Alcohol Use, and Working Memory as Predictors and Negative Consequences as Outcome

		Model 1				Model 2				Model 3			
		B	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*	*B*	*SE B*	*β*	*t*
	Age	.06	.11	.04	.60	.15	.10	.10	1.58	.14	.09	.09	1.46
	Sex	-.18	1.44	-.01	-.12	.76	1.28	.04	.59	.58	1.26	.03	.46
Alcohol Use	Frequency					2.83	.69	.37	4.11**	2.50	.69	.32	3.60**
	Quantity					.38	.24	.14	1.58	.35	.24	.13	1.46
CEFI Sub-scales	Working Memory									-.26	.09	-.19	-2.88**
R^2	R^2		.002				.220				.253		
	R^2 change		.002				.218				.033		
	F change		.199				26.696**				8.263**		

Note. *p < .05, **p < .01

Discussion

The objective of this study was to examine the relationships between executive functions and alcohol-related consequences within an undergraduate population to better understand the factors that increase the likelihood of alcohol-related consequences. Consistent with the expectations of the current study, lower scores on all three executive function domains examined (Emotion Regulation, Inhibitory Control, and Working Memory) were associated with higher scores on measures of positive and negative alcohol-related consequences. Additionally, hierarchical regression revealed that these executive functions account for a statistically significant amount of variance in alcohol-related consequences after accounting for patterns of alcohol use. However, the specific variables that were independently predictive in the models differed between positive and negative consequences. Overall, these findings suggest that executive functions may be relevant to consider when examining the experience of both positive and negative alcohol-related consequences among undergraduate students.

Age and sex did not independently predict alcohol-related consequences in any of the models. Previous research indicates that male university students consume alcohol at greater frequencies and quantities than their female counterparts (Borsari et al., 2007; Edkins et al., 2017) and are at an increased risk of experiencing both positive and negative alcohol-related consequences (Park, 2004; Patrick & Maggs, 2008). The lack of significant prediction from the sex variable may be due to the limited diversity of the sample in the current study, where males comprised only 17.4% of the sample ($N = 211$). The ability to detect significant predictions from age may have also been limited by the lack of diversity in the sample. Past research has demonstrated that students experience an increase in their alcohol use and alcohol-related consequences from high school to university (Borsari et al., 2007; Kwan et al., 2013). However,

alcohol use remains relatively stable during emerging adulthood (ages 18-24), after which it begins to decrease (Borsari et al., 2007; Logan et al., 2012; Martinez et al., 2014). It should be noted that the average age of participants in this sample is 22 years (*SD* = 5.1), with 83.3% of the sample being 18-24 years old. Considering the fact that changes in alcohol use patterns tend to occur outside the age range in this sample, it is not unexpected that age was not a significant predictor of alcohol-related consequences in this study.

The addition of the alcohol use variables (frequency and quantity) displayed a small but statistically significant increase in the amount of variance accounted for in the models. Frequency of heavy episodic drinking was a significant predictor across models and independently predicted both negative and positive consequences. Similarly, the quantity of alcohol use variable independently predicted positive consequences, however, it was not a significant predictor in models with negative consequences as the outcome. Limitations of the study design and sample may explain the lack of statistical significance between quantity of alcohol use and negative alcohol-related consequences in the current study. Past research indicates that alcohol quantity is positively associated with both positive and negative alcohol-related consequences (Molnar et al., 2009; Park, 2004; Park & Grant, 2005), however, positive consequences tend to occur after consuming lower quantities of alcohol than negative consequences (Logan et al., 2012). It should be noted that the average number of drinks consumed by participants in this sample was 3.04 drinks (*SD* = 2.75), with approximately 60% of the sample consuming only 0-3 drinks in the past week. The number of drinks consumed by students in the current study is lower than that found in previous studies, where students consumed an average of 4.5 drinks (Arria et al., 2015). The lower quantities of alcohol consumption found in the current study may be due the fact that data collection occurred amidst

the Covid-19 pandemic, where students have reported consuming lower quantities of alcohol than normal (Jackson et al., 2021; Minhas et al., 2021). Additionally, the lower number of drinks reported by students may be due to the high frequency of females in the sample. Female students have been consistently found to consume lower amounts of alcohol than male students (Borsari et al., 2007; Edkins et al., 2017). Additionally, females are more likely to report positive consequences than their male counterparts, who are more at risk of experiencing negative consequences (Park, 2004; Park & Grant, 2005). These two limitations of the current study may explain why statistical significance was found in models predicting positive consequences and not in models predicting negative consequences.

The Emotion Regulation and Working Memory domains of executive function were significant predictors across models. The addition of these two domains in their respective models displayed a statistically significant increase in the amount of variance accounted for. Additionally, Emotion Regulation and Working Memory both independently predicted positive and negative consequences. Similarly, the Inhibitory Control domain of executive function significantly increased the amount of variance accounted for in both negative and positive consequences. Inhibitory Control independently contributed to models with negative consequences as the outcome variable, however, it was not a significant predictor of positive consequences. Inhibitory Control refers to the ability to inhibit impulsive behavior for more adaptive and goal-directed behaviors (Bull & Lee, 2014; Diamond, 2013; Naglieri & Goldstein, 2014). Low levels of inhibitory control are associated with increases in risky and impulsive behaviors that are commonly classified as negative alcohol-related consequences (e.g., binge drinking, poly-substance use, and aggressive behavior; López-Caneda, et al., 2017; Pawliczek et al., 2013). Additionally, alcohol consumption has acute effects on inhibition that can impair

control over drinking and decision-making ability while intoxicated, including decisions to drive, engage in risky sexual behaviors, and get into physical conflicts (Weafer & Fillmore, 2016). Alcohol consumption can lead to these impairments at low doses (e.g., 2-3 drinks; Weafer & Fillmore, 2016), especially for individuals with pre-existing inhibitory control deficits. These findings provide evidence for a strong relationship between inhibitory control and negative alcohol-related consequences. However, less is known about the link between inhibitory control and positive consequences of alcohol use (e.g., tension reduction, decreases in worrying, enjoying the taste and experience of drinking), which makes it difficult to ascertain potential explanations for this lack of prediction. Further research is needed in this area to better understand the potential association between inhibitory control and positive consequences.

Overall, the results of this study indicate that executive functions demonstrate small to moderate negative associations with positive and negative alcohol-related consequences. Additionally, executive functions were found to explain a statistically significant amount of variance in alcohol consequences after accounting for the frequency of heavy episodic drinking and quantity of alcohol consumption. Together these findings suggest that executive functions should be considered in future research examining the experience of positive and negative alcohol-related consequences within an undergraduate population.

Limitations

There are important limitations to consider within the current study. Firstly, the current findings may not be generalizable to other undergraduate student populations as the sample was drawn from a single university campus in Ontario and may not be representative of students from other campuses and provinces. Additionally, generalizability across programs is cautioned as the sample was drawn from undergraduate psychology courses consisting largely of female

psychology students. However, the findings are representative of undergraduate psychology students and provide novel insight into the relationships between executive functions and alcohol-related consequences that can be replicated with more representative samples.

Secondly, the study was conducted amidst the Covid-19 pandemic and changes in the perceived levels of stress, social behaviors, drinking patterns, and mental health of students during this time may have had unknown implications for the results of the proposed study. Emerging evidence suggests that most university students are engaging in less alcohol use during the Covid-19 pandemic (Graupensperger et al., 2021; Jaffe et al., 2021), which may have attenuated the degree of association between executive functions and alcohol-related consequences in the current study.

Lastly, the current study utilized retrospective and self-report measures, which should always be interpreted with caution due to potential bias in responding. While the CEFI-Adult has a scale to capture negative impressions (i.e., the likelihood an individual underestimated their abilities), this scale was not calculated in the current study given the average scores seen across the CEFI. Additionally, the patterns of alcohol consumption and alcohol-related consequences reported by participants in the current study were consistent with previous research. As such, the results of the current study are likely an accurate reflection of the cognitive abilities and alcohol use patterns of participants. Despite these limitations, the results of this study identified executive functions as important factors to consider in the examination and prevention of alcohol-related consequences among undergraduate students.

Implications and Future Directions

In this study, a link between executive functions and alcohol-related consequences was identified within an undergraduate population. To our knowledge, this is the first study to

examine executive functions as a potential contributing factor to the experience of both positive and negative alcohol-related consequences among university students. The current study identifies the need for interventions aimed at addressing executive function difficulties among university students to reduce the risk of experiencing alcohol-related consequences. The results of the current study can be used to inform future research pursuits and clinical intervention efforts targeting alcohol use and its associated consequences among university populations.

Future research pursuits may expand on the current study by exploring the link between alcohol-related consequences and all nine executive function domains. Little is known about the role that all nine executive functions may play in the experience of heavy drinking and alcohol-related consequences as past research has focused heavily on overall executive functioning, working memory, set shifting, and inhibitory control (Diamond, 2013; Friedman & Miyake, 2017; Gustavson et al., 2017; Looby et al., 2018; Martins et al., 2018; Miyake & Friedman, 2012; Peeters et al., 2015). Understanding the relationships between all executive function domains and alcohol-related consequences may help to inform prevention and intervention strategies. Future research should also explore these relationships using performance-based measures of executive function in addition to self-report measures as each assesses unique aspects of cognitive and behavioral functioning (Toplak et al., 2013). Performance-based measures provide information regarding the underlying processing efficiency of executive functions, while self-report ratings inform us of the behavioral output of executive functions (i.e., relative degree of success in pursuit of a goal; Toplak et al., 2013). Both performance-based and self-report measures should be utilized in future research to provide a comprehensive understanding of the link between executive functions and alcohol-related consequences. Finally,

results should be replicated with samples that are more representative of the general undergraduate student population.

Conclusion

The overall objective of this study was to better understand the relationships between executive functions and alcohol-related consequences within an undergraduate population. The results demonstrate that executive functions are associated with an increase in the number of alcohol-related consequences experienced by undergraduate university students. Emotion regulation and working memory are significant predictors of both positive and negative alcohol-related consequences, while inhibitory control is a significant predictor of negative consequences only. It is the hope that the findings of this study can be used to inform future prevention, intervention, and research pursuits aimed at reducing alcohol-related problems among university students.

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Appendix A: Recruitment Ad

The following is the advertisement that appeared on the online Participant Pool website.

Study Information

Study Name	The Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates
Study Type	Online Study This study is an online study on another website. To participate, sign up, and then you will be given access to the website to participate in the study.
Credits	1 Credits
Duration	60 minutes
Abstract	The main purpose of this study is to develop a better understanding of the alcohol-related consequences experienced by post-secondary students and to explore the role of executive functions in these experiences.
Description	We are seeking undergraduate students (of any age and gender) at Lakehead University to participate in a 60-minute online study. Participants will be directed to SurveyMonkey where they will be asked a series of questions pertaining to alcohol use, alcohol-related consequences (e.g., feeling relaxed, missing school) and skills necessary for learning, working, and managing daily life (e.g., planning, paying attention). Participants will receive 1 bonus credit for an eligible psychology course.
Eligibility Requirements	Must have consumed at least one alcoholic drink in the last 3 months, be able to read fluently in English, and have consistent access to the internet.
Website	View Study Website
Researcher	Jessica A Paglaro
Principal Investigator	Chris Mushquash

Appendix B: Eligibility Criteria Question

Have you consumed at least one drink of alcohol in the past 3 months? (Note: one standard drink is defined as one bottle/can of beer, one glass of wine, or one shot of hard liquor either straight or with a mixer)

- Yes
- No

Appendix C: Disqualification Page

Appendix D: Disqualification Page

Based on your response, it appears you are not eligible to participate in our study. As outlined in the Letter of Information participants must have consumed alcohol at least once in the past 12 months. Thank you for your interest!

Appendix D: Letter of Information

Lakehead UNIVERSITY

Letter of Information

Dear Potential Participant,

We invite you to take part in a research study titled "The Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates." The study will be conducted by Jessica Paglaro, a Lakehead University Master's student in Clinical Psychology under the supervision of Dr. Christopher Mushquash, Associate Professor in the Department of Psychology. You have been invited to participate because you are an undergraduate student enrolled in a psychology course and speak English fluently.

PURPOSE OF THE STUDY
The main purpose of this study is to better understand the experience of alcohol use consequences among post-secondary students. In particular, the role of executive functions in the experience of both positive and negative consequences will be explored as these relationships have been overlooked in previous research.

WHO CAN PARTICIPATE IN THIS STUDY?
You must speak and read fluently in English. You must be a university student and have access to the internet. You must have consumed at least one alcoholic drink in the last 3 months to be able to participate. 1 alcoholic drink is defined as either: 1 bottle/can of beer, 1 glass of wine, or 1 shot of hard liquor (either straight or with a mixer).

WHAT WILL YOU BE ASKED TO DO?
First, you will be asked to provide some demographic information including your age, gender, ethnicity, and income. Second, you will be asked to complete a series of questionnaires pertaining to your alcohol use patterns and things that may have happened to you because of drinking (e.g., feeling relaxed, missing school, etc.). These questionnaires will also ask about skills you may have that are necessary for learning, working, and managing daily life (e.g., planning, paying attention, and following instructions). The survey will take approximately 45 minutes to complete, and it is expected that the total time involved in the study will take no longer than 60 minutes (e.g., sign consent form, complete and submit survey).

POTENTIAL HARMS OF INVOLVEMENT
There will be no direct, physical harm to any participant completing this study. However, this study may elicit some feelings of discomfort or distress due to partaking in survey questions that ask participants to reflect on their alcohol use behaviors and outcomes. It

is important that you know that you do not have to answer any question you are not comfortable with, and you are free to withdraw from the study at any time prior to the submission of the survey without penalty. Once the survey is submitted, your responses cannot be removed because they are anonymous and there is no way to link your name to your responses. We ask that as a participant, you be as honest as you can with your responses and share only what you feel comfortable with. If you are distressed during or after your participation in this study, you may access Lakehead Universities Student Health and Wellness Centre, by calling (807) 343-8361 to book an appointment with a counsellor. You may also call Thunder Bay Crisis Response Services at (807) 346-8282, or the "Good2Talk" post-secondary student helpline at 1-866-925-5454.

POTENTIAL BENEFITS OF INVOLVEMENT

There are no direct benefits to you as a result of participating in this study. However, you will have the opportunity to learn about the findings of the study upon request, which could provide you with useful information that may enhance your personal and professional knowledge. Additionally, by participating in this study, you will receive 1 bonus mark towards an eligible psychology course.

ANONYMITY AND CONFIDENTIALITY

Strong efforts will be made to ensure full confidentiality for all study results. Personal information regarding your participation will remain anonymous and identifiable information (e.g., contact email) will not be linked to your survey responses in any way. Your individual data will not be identified in any reports or publications as data will only be presented in grouped format. Several precautions will also be taken to protect the confidentiality of data collected via the Internet. First, all data collected through the Internet will be encrypted when it is sent electronically. Secondly, any identifiable information collected will not be connected to your responses. Third, we will be utilizing a survey company that uses the highest levels of security regarding the collection, transmission, and storage of data collected through the Internet. This includes sending data in an encrypted format when data are transmitted electronically, a secure database, and password protection to access the data. Only the Principal Investigator and Student Investigator will have access to this password. The survey company will not have access to any identifying information about you. Please note that the online survey tool used in the study, Survey Monkey, is hosted by a server located in the USA. The US Patriot Act permits U.S. law enforcement officials, for the purpose of anti-terrorism investigation, to seek a court order that allows access to the personal records of any person without the person's knowledge. In view of this we cannot absolutely guarantee the full confidentiality and anonymity of your data. With your consent to participate in this study, you acknowledge this.

STORAGE OF DATA

Consistent with the Lakehead University's policy on research integrity data, electronic versions of the data will be retained for a minimum of 5 years, up to an indefinite period of time, and will be kept in a password-protected computer in the locked laboratory of the Principal Investigator. Data from Survey Monkey will be kept electronically until the Principal Investigator has deleted the survey account. Deleted data may remain for a

maximum of 12 months in accordance with Survey Monkey's policy. Electronic versions of the data will not include your name or contact information but will contain the following information about you: age, sex, weight, height, ethnicity (i.e., self-reported ethnicity and country of birth), length of time lived in Canada, occupation, nature of employment (e.g., full-time, part-time, etc.), years of formal education, year of study if you are a university student, total annual family income, and the number of individuals supported by this family income.

PARTICIPANT RIGHTS

As a participant, you must understand that your study involvement is completely voluntary. You may refuse to answer any questions during the survey or interview without judgement. You may also withdraw from this study at any time without penalty. Each participant also has the right to remain anonymous.

PROBLEMS OR CONCERNS

This study has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team please contact Sue Wright at the Research Ethics Board at 807-343-8283 or research@lakeheadu.ca.

RESEARCHER CONTACT INFORMATION

If you have questions or concerns about the research, please feel free to contact us via the contact information below.

Thank you for your interest in our study.

With warm regards,

Jessica

Student Investigator:
Jessica Paglaro, HBA Specialized Psychology
MA Candidate and Student Researcher
Clinical Psychology, Lakehead University
Email: japaglar@lakeheadu.ca

Principal Investigator:
Christopher Mushquash, Ph.D., C.Psych.
Associate Professor
Department of Psychology, Lakehead University
Email: cjmushqu@lakeheadu.ca

Appendix E: Consent Form

Lakehead UNIVERSITY

Consent Form

I agree to the following:

- ✓ I have read and understood the information contained in the Information Letter
- ✓ I agree to participate
- ✓ I understand the potential risks and/or benefits of the study
- ✓ I understand that I am a volunteer and can withdraw from the study at any time prior to submission and may choose not to answer any question
- ✓ I understand that the data will be securely stored on a password-protected computer in the locked laboratory of the Principal Investigator for at least 5 years following the completion of the research
- ✓ I understand that a summary of the research findings will be made available to me upon request via email
- ✓ I understand that all data collected from me will remain anonymous

- o I consent to take part in this study.
- o I do not consent to take part in this study.

Please indicate if you would like a summarized copy of the results from the study:

- o Yes, I would like a copy. Email: _____
- o No, I would not like a copy.

Appendix F: Demographic Questions

Demographics	
1. Your age: _____ years 2. Your biological sex: o Male o Female o Intersex o Prefer not to disclose 3. Your gender: o Man o Woman o Transgender o Non-binary o Other (please specify) _____ 4. Your ethnicity: o Asian o Caucasian o First Nations o Other (please specify) _____ 5. Your country of birth: _____ 6. How long have you lived in Canada? ____ years 7. Your relationship status: o Single o Dating o Married or cohabitating o Widowed o Divorced o Separated o Other (please specify) _____ 8. Your number of years of formal education (i.e., from kindergarten to the present): _____ 9. Your year of study in university (e.g., 1st): _____ 10. Your major in university (e.g., Economics): _____	11. Your occupation (e.g., teacher): _____ *Note:* "student" may be listed as an occupation 12. Check the option that best describes your employment situation: o I work full-time o I work part-time o I am unemployed o Other (please specify) _____ 13. Check the option that best describes your education situation: o I am a part-time student o I am a full-time student o Other (please specify) _____ 14. This question does ***not*** ask about your annual personal income. Instead, it asks about your annual family income. In other words, indicate how much money was earned last year in the household where you were raised. Check the option that best describes your annual family income in Canadian Dollars (before taxes, deductions, etc.): o $0.00-$19 999 o $20 000 - $39 999 o $40 000 - $59 999 o $60 000 - $79 999 o $80 000 - $99 999 o $100 000 - $119 999 o $120 000 - $139 999 o $140 000 - $159 999 o $160 000 - $179 999 o $180 000 - $199 999 o Greater than $200 000 15. How many people are supported by your total family income (listed in question 14)? _____ 16. What is your current weight? Report either in pounds _____ or in kilograms _____

Note: "undecided" or "undeclared may be listed as a major	17. What is your current height? Report in feet/inches _____ or in meters/centimeters _____

Appendix G: Comprehensive Executive Function Inventory (CEFI) – Adult Self Report

Please read each statement that follows the phrase, ***"During the past four weeks, how often did you…,"*** and select how often it happened in the ***past four weeks***.

During the past four weeks, how often did you…	Never	Rarely	Some-times	Often	Very Often	Always
1. show self-control?	1	2	3	4	5	6
2. have trouble finding things?	1	2	3	4	5	6
3. maintain self-control?	1	2	3	4	5	6
4. plan ahead?	1	2	3	4	5	6
5. remember many things at one time?	1	2	3	4	5	6
6. know when a task was completed?	1	2	3	4	5	6
7. come up with different ways to solve problems?	1	2	3	4	5	6
8. pay attention for a long time?	1	2	3	4	5	6
9. have trouble solving problems?	1	2	3	4	5	6
10. start tasks easily?	1	2	3	4	5	6
11. get upset?	1	2	3	4	5	6
12. get things done efficiently?	1	2	3	4	5	6
13. think of the consequences before acting?	1	2	3	4	5	6
14. pay attention during a boring task?	1	2	3	4	5	6
15. forget to do things?	1	2	3	4	5	6
16. know what to do first?	1	2	3	4	5	6
17. stay calm when handling small problems?	1	2	3	4	5	6
18. like everyone you met?	1	2	3	4	5	6
19. accept a different way of doing things?	1	2	3	4	5	6
20. need others to tell you to get started on things?	1	2	3	4	5	6
21. work neatly?	1	2	3	4	5	6
22. have trouble listening to instructions?	1	2	3	4	5	6
23. keep all your commitments?	1	2	3	4	5	6
24. remember instructions with many steps?	1	2	3	4	5	6
25. keep track of time?	1	2	3	4	5	6
26. prepare for upcoming events?	1	2	3	4	5	6
27. find it hard to control your emotions?	1	2	3	4	5	6
28. get things done on time?	1	2	3	4	5	6
29. respond thoughtfully?	1	2	3	4	5	6
30. fail to put plans into action?	1	2	3	4	5	6
31. work well in a noisy environment?	1	2	3	4	5	6
32. hold several ideas in memory?	1	2	3	4	5	6
33. have trouble judging how long it takes to do something?	1	2	3	4	5	6
34. react with the right level of emotion?	1	2	3	4	5	6
35. start something without being asked?	1	2	3	4	5	6
36. pay attention to details?	1	2	3	4	5	6
37. have good thoughts about everyone?	1	2	3	4	5	6

38. notice your mistake?	1	2	3	4	5	6
39. think through your decisions?	1	2	3	4	5	6
40. manage frustrations?	1	2	3	4	5	6
41. change your behavior as needed?	1	2	3	4	5	6
42. need others to tell you to do things?	1	2	3	4	5	6
43. manage time effectively?	1	2	3	4	5	6
44. have trouble waiting your turn?	1	2	3	4	5	6
45. concentrate while reading?	1	2	3	4	5	6
46. get bothered by something?	1	2	3	4	5	6
47. follow instructions well?	1	2	3	4	5	6
48. learn from past mistakes?	1	2	3	4	5	6
49. solve problems creatively?	1	2	3	4	5	6
50. become upset in new situations?	1	2	3	4	5	6
51. compromise when needed?	1	2	3	4	5	6
52. appear motivated?	1	2	3	4	5	6
53. organize your thoughts well?	1	2	3	4	5	6
54. have trouble waiting to get what you wanted?	1	2	3	4	5	6
55. notice how your actions affected others?	1	2	3	4	5	6
56. make a mistake?	1	2	3	4	5	6
57. remember important things?	1	2	3	4	5	6
58. respond calmly to delays?	1	2	3	4	5	6
59. consider other points of view?	1	2	3	4	5	6
60. get distracted?	1	2	3	4	5	6
61. organize tasks well?	1	2	3	4	5	6
62. have a bad day?	1	2	3	4	5	6
63. ask for help when needed?	1	2	3	4	5	6
64. resist change?	1	2	3	4	5	6
65. think before acting?	1	2	3	4	5	6
66. stay on topic when talking?	1	2	3	4	5	6
67. keep goals in mind when making decisions?	1	2	3	4	5	6
68. make careless errors?	1	2	3	4	5	6
69. come up with a new way to reach a goal?	1	2	3	4	5	6
70. get upset when plans were changed?	1	2	3	4	5	6
71. start a task without help?	1	2	3	4	5	6
72. appear disorganized?	1	2	3	4	5	6
73. think before speaking?	1	2	3	4	5	6
74. tell a fib?	1	2	3	4	5	6
75. fix your mistake?	1	2	3	4	5	6
76. forget where you put things?	1	2	3	4	5	6
77. make good decisions?	1	2	3	4	5	6
78. control emotions when under stress?	1	2	3	4	5	6
79. react well to new demands?	1	2	3	4	5	6
80. take initiative?	1	2	3	4	5	6

Appendix H: Heavy-Episodic Drinking Questions

One standard drink is defined as: one bottle/can of beer, one glass of wine, or one shot of hard liquor (either straight or with a mixer)

2.1 **ONLY ANSWER THIS QUESTION IF YOU ARE FEMALE:** During the past 7 days, how often did you have 4 or more drinks containing any kind of alcohol, within a 2-hour time period?

- 0 times
- 1 time
- 2 times
- 3 times
- 4 times
- 5 times
- 6 times
- 7 times
- 8 times
- 9 times
- 10 or more times

2.2 **ONLY ANSWER THIS QUESTION IF YOU ARE MALE:** during the past 7 days, how often did you have 5 or more drinks containing any kind of alcohol, within a 2-hour time period?

- 0 times
- 1 time
- 2 times
- 3 times
- 4 times
- 5 times
- 6 times
- 7 times
- 8 times
- 9 times
- 10 or more times

3. What is the greatest number of drinks you consumed in a 2-hour period in the last 7 days?
_____ drinks

Appendix I: Consequences of Alcohol Measure (CAM)

People experience different things while they are drinking alcohol or because of alcohol. Please indicate how often in the last 12 months these things have happened to you. Please indicate how it made you feel.

In the last 12 months, **while drinking** alcohol, or **because of drinking** alcohol…

1. I have failed to do things I was responsible for — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

2. I stopped worrying about things I had been thinking about all day — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

3. While drinking, I have said harsh or cruel things to someone — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

4. I often have thought about needing to cut down or stop drinking — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

5. I approached a person that I probably wouldn't have spoken to otherwise — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

6. told a funny story or joke and made others laugh — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

7. I have had a blackout while drinking heavily (i.e., could not remember hours at a time) — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

8. I have felt guilty about my drinking — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

9. Missed a day (or part of a day) of school or work — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

10. Something that would have ordinarily made me upset or emotional didn't really get me down — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

11. Got into physical fights with other people (i.e., friends, relatives, strangers) — *If this has happened to you, how did it make you feel?*

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

12. I have felt bad about myself because of my drinking

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

13. I have enjoyed the taste of beer, wine, or liquor

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

14. I have been unhappy because of my drinking

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

15. Drinking has helped me to relax

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

16. I have gotten into trouble because of drinking

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

17. I felt sad, blue, or depressed

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

18. I drank alcohol normally, without any problems

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

19. When drinking, my social life has been more enjoyable

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

20. My drinking has gotten in the way of my growth as a person

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

21. I noticed a release of tension on a stressful day

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

22. I have taken foolish risks when I have been drinking

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

23. Things that I had been worrying about all day no longer seemed relevant

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

24. I have missed days of work or school because of my drinking

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

25. I found it easy to make conversation in a situation where I would usually have stayed quiet

If this has happened to you, how did it make you feel?

Never	Less than Monthly	Monthly	Weekly	Daily/ Almost Daily	Does Not Apply	Very Good	Good	Neutral	Bad	Very Bad
1	2	3	4	5	0	1	2	3	4	5

Appendix J: Bonus Point Information

Lakehead UNIVERSITY

Bonus Point Information

The Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates – Contact Information

Contact Information

Please note that your contact information will not be linked to your answers on The Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates study on SurveyMonkey. This information is used to provide bonus points towards an eligible psychology course.

1. First and Last Name: _____

2. Date: _____

3. Student Number: _____

4. Email Address: _____

5. Please indicate the professor of the course you would like the credit to apply to.
_____

6. Please indicate the name of the course that you would like the credit to apply to.
_____

Thank you for completing the contact information page. Please allow up to 48 hours for your bonus point to be allotted through Sona Systems.

Appendix K: End of Study Letter

End of Study Letter

You have completed the online survey for our study "The Relationships Between Executive Functions and Alcohol-Related Consequences Among Undergraduates."

By participating in this study, you were exposed to the Tri-Council Policy Statement 2 (TCPS-2) informed consent process (e.g., overview of risks and benefits of a study, explanation of privacy). More information about the TCPS-2 can be found through the link below. Throughout this study, you completed online surveys providing you with exposure to different types and formats of questions used in psychological research. In our research, we were interested in exploring the relationships between executive functions (independent variables) and alcohol-related consequences (dependent variables) among undergraduate students. You can access the references below for additional information on executive functions, alcohol consumption, and alcohol-related consequences.

Thank you for your participation in this study, it is greatly appreciated. Please allow up to 48 hours for your bonus point (towards an eligible psychology course) to be allotted through Sona Systems.

References:

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Lees, B., Stapinski, L. A., Prior, K., Sunderland, M., Newton, N., Baillie, A., Teesson, M., &
Mewton, L. (2020). Exploring the complex interrelations between internalising symptoms, executive functioning, and alcohol use in young adults. *Addictive Behaviors, 106,* 106351. doi:https://doi.org/10.1016/j.addbeh.2020.106351

Patrick, M. E., & Maggs, J. L. (2008). Short-term changes in plans to drink and importance of positive and negative consequences. *Journal of Adolescence, 31*(3), 307-321. doi:10.1016/j.adolescence.2007.06.002

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Counselling Services

As a student at Lakehead University, you can access counselling services through the Student Health and Wellness Centre. To make an appointment with a counsellor you can call 807-343-8361 or email health@lakeheadu.ca and leave your full name, student number and phone number.

If you require immediate support for feelings of distress, please call the 24/7 Crisis Response Services line at 807-346-8282 or the Good2Talk post-secondary student helpline at 1-866-925-5454.

Researcher Contact Information

If you have questions or concerns about the research, please feel free to contact us via the contact information below.

Student Investigator:
Jessica Paglaro, HBA Specialized Psychology
MA Candidate and Student Researcher
Clinical Psychology, Lakehead University
Email: japaglar@lakeheadu.ca

Principal Investigator:
Christopher Mushquash, Ph.D., C.Psych.
Associate Professor
Department of Psychology, Lakehead University
Email: cjmushqu@lakeheadu.ca