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April 19, 2022

APPROVAL SHEET

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Date 04/22/2022

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Impulsivity and Impaired Control in Relation to Alcohol Consumption in Alcohol Use Disorder

by

Courtney L. Vaughan

Thesis submitted to the Faculty of the
Clinical Psychology Graduate Program
Uniformed Services University of the Health Sciences
In partial fulfillment of the requirements for the degree of
Doctor of Philosophy 2024

ACKNOWLEDGMENTS

I want to acknowledge and thank my research advisor Dr. Andrew Waters and my committee members for their help and guidance preparing this thesis.

DEDICATION

To my inspiration, mentors, friends, and family. Without their love, guidance, and support, this thesis would not be possible.

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ABSTRACT

Impulsivity and Impaired Control in Relation to Alcohol Consumption in Alcohol Use Disorder

Courtney L. Vaughan, B.S., B.A., 2022

Alcohol Use Disorder (AUD) is a significant health problem characterized by excessive consumption, impaired control, and chronic relapse. Impaired control represents an important marker of problematic drinking. Previous studies have reported that impaired control is a mediator of the relationship between impulsivity and alcohol consumption, especially in heavier drinkers. This study examined impulsivity, impaired control, and alcohol consumption in individuals with AUD (Current-AUD) as well as participants who never experienced an AUD (Never-AUD). Participants (N = 307) completed assessments of impulsivity (negative/positive urgency from the UPPS-P Scale), impaired control (attempted/failed control from the Impaired Control Scale), and alcohol consumption (90-day timeline followback, TLFB) at the National Institute on Alcohol Abuse and Alcoholism Intramural Research Program. As hypothesized, Current-AUDs reported higher scores on the Impaired Control Scale (ICS) than Never-AUDs. Also as hypothesized, in Current-AUDs there was a significant indirect effect from negative urgency to alcohol consumption via failed control, when controlling for sex. The direct effect from negative urgency to alcohol consumption, independent of failed control, was not significant. Contrary to hypothesis, in Never-AUDs, attempted control did not mediate the relationship between positive urgency and alcohol consumption. In sum, in AUDs the influence of impulsive response to negative affect is mediated by failed control, and these findings add to the growing literature on impulsivity and impaired control in alcohol dependence.

Thesis directed by: Dr. Andrew J. Waters, Professor, Department of Medical and Clinical Psychology

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CHAPTER 1: INTRODUCTION

Alcohol and Society

In 2016, harmful alcohol use contributed to more than 3 million deaths worldwide, overall causing over 5% of the world's disease burden (World Health Organization, 2018). Alcohol addiction has been described as a "chronic relapsing brain disorder characterized by neurobiological changes that lead to a compulsion to take a drug with loss of control over drug intake" (Koob, 2000). Alcohol use has been directly linked to changes in neurotransmitter activity and changes in behavior. Of these behavior changes, a loss of control over consumption will be explored in this study. Some health-related conditions associated with alcohol use are liver cirrhosis, cancer, pancreatitis, and heart disease. Overall, Alcohol Use Disorder (AUD) can cause disability, decrease quality of life, and shorten the lifespan.

Alcohol Use Disorder (AUD)

The DSM-5 (Diagnostic and Statistical Manual 5th edition) defines AUD as a problematic pattern of alcohol use leading to significant impairment or distress in at least two of the following symptoms in a 12-month period: consuming alcohol in larger quantities over a longer period of time, persistent yet unsuccessful reduction attempts, time spent in activities related to alcohol, craving, failure to fulfill major role obligations because of alcohol use, recurrent use in hazardous situations, continuing use with mental or physical health consequences, tolerance, and withdrawal (American Psychiatric Association, 2013). Alcohol withdrawal can include headaches, nausea, shaking, irritability, insomnia, restlessness, delirium tremens, or even death. The DSM-5 also describes AUD as a highly prevalent, often comorbid, disabling disorder that often goes without treatment in the United States. In 2018, the United States prevalence of AUD was 5.9% for the past 12-months (SAMHSA, 2019).

The impact of AUD on the brain is significant and complex. Alcohol related brain damage can occur through malnutrition, thiamine deficiency, and/or the neurotoxicity of alcohol itself. Chronic heavy use of alcohol has been associated with significant loss of grey matter in the prefrontal-cortex, posterior cingulate cortex, dorsal striatum, and the dorsal insula (Xiao et al., 2015). The loss of grey matter in these neuronal networks could cause changes in memory, emotions, decision making, and self-control.

At a neurochemical level, alcohol increases the stimulation of opioid receptors, increases the transmission of norepinephrine, and increases GABA activity. Additionally, through myelin reduction, the CNS structure and function can be adversely impacted by alcohol use. Myelin is essential to the function of neurons as it provides insulation and allows electrical signals to transmit quickly along the nerve cell. Demyelination can lead to changes in the functions of neural networks and cause changes in higher brain functions including those seen in schizophrenia, bipolar disorder, and multiple sclerosis (Yatham, 2015). Alcohol is thought to cause demyelination in different brain regions associated with deficits in cognition and emotion (Rice & Gu, 2019). However, more research is necessary to understand the depth of alcohol's impact on the brain.

Treatment for alcohol use can be difficult to access due to stigma, significant financial burden, lack of social support, or lack of access to accommodating treatment. It is estimated about one year after receiving treatment for AUD, 25% of people remained abstinent and 10% used a moderate amount of alcohol without significant problems (Miller, Walters, & Bennett, 2001). Another study estimated short term relapse rates (around 3 years) were reported to be between 20-50% in those who receive treatment (Moos & Moos, 2006). People who receive treatment are more likely to have lower relapse rates. However, in the United States, only about

6.7% of adults with AUD received treatment in the past year (Miller et al., 2001). This study includes participants currently receiving treatment for AUD while admitted to an inpatient unit located in the greater Washington, DC area. Inpatients typically received inpatient treatment for about 30 days then they are eligible for outpatient follow-up.

Psychological Processes Underlying AUD

The Koobian model of addiction depicts three distinct phases of the addiction cycle, preoccupation/anticipation, binge/intoxication, and withdrawal/negative affect as well as factors driving the cycle to include persistent desire, consuming larger amounts than expected, tolerance, withdrawal, compromised activities, preoccupation, and persistent health/psychological problems (Koob & Le Moal, 2008a). This study focuses on the larger amounts taken than expected which can also be described as impaired control.

Impaired Control and Alcohol Consumption

Impaired control is generally associated with substance use disorders, and some have used it as a marker of when to seek treatment. Impaired control describes "a breakdown of the intention to limit alcohol consumption in a particular situation" (Heather, Tebbutt, Mattick, & Zamir, 1993b), p.701). Impaired control is theorized to be a lapse of behavioral control, either to maintain abstinence or control alcohol consumption (Patock-Peckham, Cheong, Balhorn, & Nagoshi, 2001). The inability to limit alcohol consumption can also be described as a loss of control over drug intake, as described by Koob (2008). Impaired control is an important aspect of problem drinking and may be a marker of when those with AUD decide to seek treatment (Heather & Dawe, 2005).

Impaired control is a critical driver of escalation in alcohol consumption, especially in heavy drinkers (Wardell, Quilty, & Hendershot, 2016; Weafer et al., 2015). Impaired control is

assessed using three components: attempted control, failed control, and perceived control. Attempted control is typically measured over 6 months and describes the frequency of efforts to limit alcohol consumption. Failed control is measured over the past 6 months and describes placing limits on consumption but exceeding those limits. Perceived control is measured in the moment and asks participants to describe what control they have over drinking right now. Impaired control is theorized as an early marker of AUD (R. F. Leeman, Patock-Peckham, & Potenza, 2012). It is theorized that failed control is especially important because it shows inability to stick to drinking goals (Robert F. Leeman, Toll, Taylor, & Volpicelli, 2009).

Higher levels of impaired control may also be predictive of problem drinking in non-dependent drinkers (Hendershot et al., 2015; Robert F. Leeman et al., 2009). Impaired control has also shown a significant relationship to alcohol-related problems (Patock-Peckham et al., 2001; Patock-Peckham & Morgan-Lopez, 2006) and may be predictive of alcohol treatment outcomes. Failed control (Part 2 of the ICS) has been associated with relapse and has been shown to predict treatment outcomes in moderation oriented treatment for AUD (Heather & Dawe, 2005). Perceived control (part 3 of the ICS) has been shown to moderate the relationship between craving and alcohol use with $R^2 = 0.29$ (Remmerswaal, Jongerling, Jansen, Eielts, & Franken, 2019).

Impulsivity and Alcohol Consumption

Impulsivity is a multifaceted construct with many theoretical perspectives and types of measure (Dick et al., 2010). Impulsivity has been described as “a pre-disposition toward rapid, unplanned reactions to internal or external stimuli without regard for the negative consequences of these reactions” (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Some researchers argue impulsivity does not meet the criteria of a psychological construct, stating that

"impulsivity falls short of the theoretical specifications for hypothetical constructs by having meaning that is not compatible with psychometric, neuroscience, and clinical data" (p. 336, (Strickland & Johnson, 2021). While the psychological construct of impulsivity may be too broad in scope, there are specified and empirically supported facets of impulsivity that are highly relevant to alcohol use and AUD.

There are some differences in defining impulsivity with most definitions describing a rash behavior. Some definitions also include cognitive approaches in their definitions of impulsivity: "behavior without adequate thought, the tendency to act with less forethought than do most individuals of equal ability and knowledge, or a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions" (http://www.impulsivity.org/measurement).

Impulsivity, specifically impulsive behavior, is needed to diagnose several psychiatric conditions, including substance use disorders, attention deficit disorders, and mood disorders. Impulsivity as a broad construct has been linked to alcohol use. People diagnosed with AUD tend to have higher levels of impulsivity (Bjork, Hommer, Grant, & Danube, 2004; Duka, Townshend, Collier, & Stephens, 2003). These higher levels of impulsivity are indicative of more reactivity, either internal or external, without regard for negative consequences. In a longitudinal study, impulsivity was associated with the development of AUD (Rubio et al., 2008).

Impulsivity has been described as a personality trait as well as a state of mind. Trait impulsivity is measured by using questionnaires and likely reflects combinations of both affective and cognitive processes where state impulsivity is more related to specific cognitive processes and can be measured via performance on tasks (Dick et al., 2010). Generally,

behavioral tasks measuring state impulsivity and self-report questionnaires measuring trait impulsivity do not correlate well (Reynolds, 2006). This lack of correlation between state and trait impulsivity measures has been a topic of debate in the research field for several years. State or context related impulsivity is measured by using behavioral tasks like the BART, stop signal, go/go-no task. These task scores can be altered by different or changing mood states, largely these mood states are separated into two categories: positive and negative.

One conceptualization of measuring trait impulsivity is the Urgency, Premeditation, Perseverance, Sensation Seeking, and Positive Urgency (UPPS-P) scale where impulsivity is theorized to be multifaceted in each of these domains (Lynam, Smith, Whiteside, & Cyders, 2006). With an update to the scale, urgency was separated into positive and negative urgency. Negative urgency describes acting impulsively in response to negative emotions while positive urgency describes acting impulsively in response to positive emotions (Melissa A. Cyders et al., 2007). A more detailed description of the UPPS-P facets along with impaired control facets can be found in Table 1.

Both positive and negative urgency are particularly related to problematic alcohol use (Coskunpinar, Dir, & Cyders, 2013; M. A. Cyders et al., 2010; Stautz & Cooper, 2013). One hypothesis for this relationship is that "elevations in the urgency traits may influence attentional processes and may result in heightened expectancies that addictive behaviors provide reinforcement" (Smith & Cyders, 2016). It is theorized young adults may be more at risk for hazardous use of alcohol following times of positive or negative mood states (Bold et al., 2017).

In a sample of first year college students, increased positive urgency has predicted drinking quantity and this relationship was mediated by the expectancy of positive effects from alcohol (Settles, Cyders, & Smith, 2010). Studying positive urgency in an adult population of

those without AUD is an existing gap in the literature. However, a few studies have been conducted. In an emerging adult college-aged population, both positive and negative urgency predicted problematic alcohol use and alcohol related problems (Stamates & Lau-Barraco, 2017; Tran, Teese, & Gill, 2018). Positive Urgency has also been shown to correlate to attempted control in a population without AUD but with binge-type pattern of drinking (Vaughan et. al, 2019). In non-AUD populations it is theorized positive mood states predict increased alcohol use due to alcohol's effect on eliciting hedonic and positive emotions. More research is needed in this area to explore early predictors of problematic use of alcohol in these so-called "reward drinkers" (Verheul, van den Brink, & Geerlings, 1999).

Negative Urgency is defined by acting impulsively in response to negative mood states, particularly to cope with distress (Settles, Cyders, Smith, 2010). Negative urgency has been particularly connected to heavier alcohol consumption and alcohol dependence (Coskunpinar et al., 2013; M. A. Cyders et al., 2010). Increased negative urgency has also predicted an increase motivation to drink as a way to cope with distress (Settles et al., 2010).

Alcohol dependent individuals have shown poor impulse control by devaluating delayed rewards and have exhibited increased risky responses in risk taking paradigms (Bjork et al., 2004; Gilman et al., 2015; Gowin, Sloan, Swan, Momenan, & Ramchandani, 2019). Other research has shown higher levels of impulsivity were associated with an increased behavioral frequency of drunk driving (Moan, Norström, & Storvoll, 2013). Impulsivity and alcohol use is a dangerous combination that could have severe consequences.

Factors like impulsivity are important in understanding what drives consumption of alcohol. Understanding these underlying issues driving drinking behavior could help identify those more at risk for AUD, before they develop an addiction. Understanding more about the

connection between personality and addiction could also identify other mediating factors leading to problematic use of alcohol.

Impulsivity, Impaired Control, and Alcohol Consumption

Impaired control is hypothesized to mediate the relationship between impulsivity and alcohol consumption. Previous research in young adults has connected impaired control as a mediator of response impulsivity and alcohol consumption (Patock-Peckham & Morgan-Lopez, 2006; Wardell et al., 2016). It is theorized alcohol consumption shifts into AUD when impulsive use or reward driven drinking transitions to compulsive use to avoid negative states such as withdrawal and craving also known as relief-type drinking (Koob & Le Moal, 2008a; Verheul et al., 1999). Alcohol use becomes a means to reduce the negative symptoms of AUD including withdrawal, negative affect, and use of alcohol as a response to perceived or anticipated unfavorable events. To further explore the relationship between impulsivity, impaired control, and alcohol consumption we examined these relationships in two different samples: individuals who have never met diagnostic criteria for AUD (Never-AUD) and those who currently meet diagnostic criteria for AUD (Current-AUD).

It is important to study people who consume alcohol before they develop an AUD to find predictors of alcohol related problems leading to addiction. People who binge drink alcohol without having an AUD are thought to be using alcohol before their use transitions from impulsive use to compulsive use (Flores-Bonilla & Richardson, 2020). We focused on negative urgency and positive urgency because they have been shown to predict variance in alcohol use and related problems (M. A. Cyders & Smith, 2008). Negative urgency was used for the Current-AUD group while positive urgency was used for the Never-AUD group. The Koobian Model discusses light and dark sides of addiction, and it is theorized those without AUD drink alcohol

due to positive events or emotion states while those with AUD exhibit more relief-type drinking or drinking due to negative events or emotion states (Koob & Le Moal, 2008b). Under heightened emotion states people are more likely to engage in rash actions than other times, to include alcohol consumption and drug use (M. A. Cyders & Smith, 2008).

One study has shown a mediation between response impulsivity and alcohol use by perceived control in a sample of 300 young heavy drinkers (Wardell et al., 2016). Other research has also shown perceived control to be a mediator in the relationship between impulsivity and alcohol consumption (Patock-Peckham & Morgan-Lopez, 2006; Wardell, Quilty, & Hendershot, 2015). While perceived control was considered as a mediator in the analysis of the current study, one should note that perceived control enquires about respondents' perceptions "right now", whereas the alcohol outcome measure assessed drinking over the past three months. It is obviously not ideal for a mediator variable to assess experience occurring after the time period assessed by the outcome variable. Therefore, in the current study, we used attempted control (which assesses experience over the past six months) as a mediator in the Never-AUD group.

In our own work, impaired control (attempted control) has mediated the relationship between impulsivity (positive urgency) and alcohol consumption (peak BrAC) in a sample of non-AUD binge-type pattern drinkers during an IV alcohol infusion session (Vaughan et al., 2019). In this current study, we wanted to examine this relationship in a larger population to see if our findings would extend to a lighter drinking population..

A sample of Current-AUD individuals, including inpatients seeking treatment for alcohol use, was examined to further explore the relationship between impulsivity, impaired control, and alcohol consumption. It is theorized the Current-AUD population will have more negative urgency (impulsivity) as reward drinking has shifted to relief-type drinking seen in people with

current AUD to cope with things like negative emotions (Anthenien, Lembo, & Neighbors, 2017; Halcomb, Argyriou, & Cyders, 2019; VanderVeen et al., 2016). Current-AUD individuals have more failed attempts at controlling their drinking (Heather, Tebbutt, Mattick, & Zamir, 1993a), and in a population with clinical depression, negative urgency was associated with failed control (Zaso et al., 2021). We wanted to explore the extent of these relationships within a mediation model to include inpatients seeking treatment for AUD.

In this study, we examined measures of impulsivity, impaired control, and alcohol consumption in participants who have never met diagnostic criteria for AUD (Never-AUD) and those who currently meet diagnostic criteria for AUD (Current-AUD). Specifically, we hypothesized impaired control would mediate the relationship between impulsivity and alcohol consumption. We expect to replicate previous research findings and to show this relationship in participants with current AUD, to include inpatients seeking treatment for AUD. To our knowledge, this is the first study to examine this mediation that includes an inpatient population.

CHAPTER 2: SPECIFIC AIMS

Study Rationale

Although previous studies have examined the relationships between impulsivity, impaired control, and alcohol consumption in heavy social drinkers, no studies have examined these relationships in individuals with AUD. While much previous work has focused on using a convenience sample of college students, the current study had older participants, closer to middle adulthood, when people tend to seek treatment for alcohol-related problems. This study also had a control sample in our Never-AUD group, which allowed for between-group comparisons in ICS scores. To the best of our knowledge, this is the first study to examine differences in ICS scores between Current-AUD and Never-AUD populations.

Study Overview

The current study evaluated samples of individuals with a current diagnosis of AUD (Current-AUD) and a healthy population never diagnosed with an AUD (Never-AUD). Participants were recruited for clinical research and treatment studies in the intramural program of the National Institute on Alcohol Abuse and Alcoholism (NIAAA) at the National Institutes of Health's Clinical Center in Bethesda, MD. A healthy population never diagnosed with AUD, treatment seeking participants, and non-treatment seeking participants were recruited to participate in NIAAA's screening and natural history protocol to determine eligibility for clinical trials and other clinical research studies. Assessments included a psychological interview, personality questionnaires, measures of impaired control, and assessments of alcohol consumption.

SPECIFIC AIMS

Specific Aim 1: To examine the association between AUD status and impaired control.

Hypothesis 1.1: Participants with Current-AUD will self-report higher levels of impaired control on the ICS (Attempted, Failed, and Perceived Control subscales) than the Never-AUD sample.

Specific Aim 2: To examine if impaired control will mediate the relationship between impulsivity and drinking outcomes.

Hypothesis 2.1: In the Never-AUD sample, attempted control subscale of the ICS will mediate the relationship between positive urgency (UPPS-P) and total drinks (TLFB)

Hypothesis 2.2: In the Current-AUD sample, failed control subscale of the ICS will mediate the relationship between negative urgency (UPPS-P) and total drinks (TLFB).

CHAPTER 3: METHODS

Participants

Participants (N = 307) were recruited from across the greater Washington, D.C. area by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) intramural research program. NIAAA recruits a variety of participants including healthy controls, non-treatment seeking individuals with AUD, and treatment seeking individuals with AUD. A diagnosis was determined by the Structured Clinical Interview for DSM-5 (SCID). All participants completed an in-person screening visit as a part of the NIAAA Screening and Natural History Protocol (SNHP) approved by the NIH Intramural Institutional Review Board (IRB). The SNHP excludes individuals from the study if they were underage (less than 18 years), pregnant, breastfeeding, or if they were actively incarcerated. The SNHP is also used to determine eligibility before enrolment into experimental protocols conducted by the NIAAA intramural program.

Procedure

Participants completed a telephone interview and were invited to an in-person screening visit. The phone interview included assessments of drinking, medical history, psychiatric history, treatment seeking status, and demographic variables. Using the phone interview information, participants meeting eligibility criteria for other active protocols were invited for the in-person screening visit. During the in-person screening visit, participants were assessed for AUD, medical conditions, psychiatric diagnosis, impulsivity, and other measures.

Non-treatment seeking (outpatient) participants, including heavy drinkers and healthy sample never diagnosed with AUD, completed an approximately 8-hour study visit at the NIAAA located in Bethesda, MD. During this outpatient study visit, participants met with a nurse who assessed for alcohol withdrawal and suicidality (Figure 1). A physical examination

was completed to gather information on their physical health and provide information on eligibility for future research. Psychopathology was assessed using the Structured Clinical Interview for DSM-5, which was administered by a trained research assistant, nurse, or staff psychiatrist.

Patients with AUD seeking treatment began inpatient treatment upon admission to the NIAAA's inpatient unit. Often detoxification was required before research assessments could be collected. Inpatients initiated their participation in the NIAAA Screening and Natural History Protocol (SNHP) during or after detoxification. Upon completion of the screening protocol, they were enrolled into other studies where eligible. A typical inpatient stay lasted four weeks (Figure 2).

Table 2 summarizes the differences in procedures and assessments between the Never-AUD and Current-AUD groups.

Measures

Psychiatric Diagnosis

Each participant was given the Structured Clinical Interview for DSM-5 (SCID-5) which assessed for psychiatric disorders based upon DSM-5 criteria (First, Williams, Karg, & Spitzer, 2016). The SCID-5 has shown good reliability and validity. A study of 180 inpatient and outpatient psychiatric patients in Brazil using the Clinician version of the SCID-5 found *kappa* levels around 0.70 for a face-to-face interview to diagnose AUD while a clinician diagnosis of AUD had *kappa* levels of 0.84 (Osório et al., 2019). Another study recruited participants *n*=234 from community and mental health clinics in the Chicago, Illinois area used an adapted Research Version of the SCID-5 found a Cronbach's alpha of $\alpha = 0.88$ for a lifetime diagnosis of AUD and $\alpha = 0.78$ for a current (past 12-month) AUD diagnosis (Shankman et al., 2018).

For our study, each participant was given modules for mood disorders – major depression and bipolar disorder, obsessive-compulsive disorder, anxiety disorders, psychotic disorder (screening module only), substance use disorder, alcohol use disorder, eating disorder, and post-traumatic stress disorder. The SCID was administered by trained research-assistants, nurses, and master's level clinicians. All diagnoses were verified by a licensed psychiatrist or clinical psychologist. The SCID-5 was used to categorize participants into two groups: those never meeting criteria for AUD (Never-AUD) and those meeting criteria for AUD within the past year (Current-AUD). Some participants in the Current-AUD group had reduced recent consumption of alcohol, and therefore reported low levels of alcohol consumption in the last ninety days, but nonetheless met criteria for an AUD within the past year.

Impaired Control

The ICS assessed control over alcohol use (Heather et al., 1993b). This scale involves three parts: attempted control, failed control, and perceived control. Attempted control measured over six months, and it is the attempt to set limits for drinking. Attempted control is measured by five items on a five-point scale from 0-4: Never, Rarely, Sometimes, Often, and Always. The five items are summed to get the Part 1, attempted control score. Failed control is measured over the past six months, and it is setting limits for drinking but exceeding those limits. Part 2 failed control is measured by ten items on a five-point scale from 0-4: Never, Rarely, Sometimes, Often, and Always. There is also the option to choose "Does Not Apply," which does not accrue points to the Part 2 total score. The ten items were summed to get the Part 2, failed control score. Perceived control is in the moment and asked how much control participants think they have over their drinking. Part 3, perceived control was measured by ten items on a five-point scale from 0-4: Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree. The ten items were

summed to get the Part 3, perceived control score. Since this score asked about the current moment, the instructions differ slightly: "In this section, we are interested in what you think would happen with your drinking now."

The ICS scale is a reliable and valid measure, validated in treatment and non-treatment populations. A validation study of the ICS in a sample seeking treatment for alcohol use (n = 229) estimated reliabilities at α = 0.92 (AC scale), α = 0.83 (FC scale), and α = 0.83 (PC scale) (Heather, Booth, & Luce, 1998). Another study examined reliability using a sample of social drinkers (n = 357) and those seeking treatment for AUD (n = 137); α = 0.92 (AC for social drinkers), α = 0.95 (AC for treatment seekers); α = 0.91 (FC for social drinkers), treatment group α = 0.89 (FC for treatment seekers); α = 0.95 (PC for social drinkers), α = 0.95 (PC for treatment seekers) (Marsh, Smith, Saunders, & Piek, 2002). In the current study, the Current-AUD group's reliabilities were α = 0.94 (AC Scale), α = 0.92 (FC scale), and α = 0.92 (PC scale). The Never-AUD group's reliabilities were α = 0.91 (AC Scale), α = 0.60 (FC scale), and α = 0.67 (PC scale).

Impulsivity

Personality measures of impulsivity were assessed using the personality measure (Negative) Urgency, Premeditation, Perseverance, Sensation Seeking, and Positive Urgency (UPPS-P) scale (Lynam et a., 2006). The 59-item UPPS-P questionnaire used a four-item scale: Strongly Agree, Agree Some, Disagree Some, Strongly Disagree where higher scores indicated more impulsive behavior. Some items were reverse scored in each scale: Negative Urgency all items except one, Premeditation no items, Perseverance two items, Sensation Seeking all items, and Positive Urgency all items. The scale items were totaled, and a mean score was computed for each scale. In a study of 400 young adults, reliability measures were premeditation α = 0.91,

(negative) urgency α = 0.86, sensation seeking α = 0.90, and perseverance α = 0.80 (Whiteside & Lynam, 2001). In a sample of college students who drank alcohol and had a ADHD history, reliability measures (Cronbach's alpha) for the UPPS-P, to include positive and negative urgency, were above 0.75 (Halvorson et al., 2020).

Negative urgency describes the impulse to engage in risky behavior after a negative event occurs. Positive urgency is similar but occurs after a positive event. Lack of Perseverance describes the inability to focus on a task that may be difficult or boring. Lack of Premeditation describes the inability to take consequences of an action into account before participating in that action. Sensation Seeking is the tendency to pursue activities and experiences that are stimulating and openness to trying new experiences. The current study focused on positive and negative urgency, to assess for impulsive traits within heavy drinkers. In the current study, the reliabilities, measured by Cronbach's *alpha*, for the Never-AUD group were α = 0.90 (Positive Urgency scale) and α = 0.88 (Negative Urgency scale). The Current-AUD group reliabilities were α = 0.95 (Positive Urgency scale) and α = 0.91 (Negative Urgency scale).

Total Drinks (Over 90 Days)

The Timeline Followback (TLFB) is a measure developed to assess standard number of alcoholic drinks consumed each day (Sobell et al., 1996). We used the 90-day Timeline Followback to assess recent drinking history. The TLFB is an empirically validated measure, developed for and used in alcohol research for over 25 years. In a validation study using Ecological Momentary Assessment (EMA), the 90-day TLFB and daily reports of drinks from EMA were found to be highly correlated, while the TLFB may underestimate drinking days (Krenek, Lyons, & Simpson, 2016). Daily values were collected in standard drinks. The TLFB was collected in person to validate the participant understands the definition and recalls their

drinking in standard drinks. This will be our main outcome measure and will assess for drinking pattern over the past three months in heavy drinkers. Total drinks was used as the main drinking outcome measure as it provided adequate variability and is a good, standardized measure for alcohol consumption across a range of drinking patterns.

Participants who reported at least one drink of alcohol in the past 90 days were included in this analysis. Similar to other studies (Corbin, Berey, Waddell, & Leeman, 2020), participants who reported no drinking in the past 90 days were excluded from analysis as the study focuses on individuals who are currently drinking alcohol. The current AUD group used a ceiling of 100 drinks per day, as used in past research (Kapoor et al., 2013; Pan et al., 2013). No participants in the current AUD group were excluded for exceeding the 100 drink per day limit. The internal split-half reliability was calculated for total drinks from the TLFB by computing the mean score for both "odd" and "even" days separately, then correlating the two means. The Never-AUD group had a Pearson *r* between total drinks on even and odd days of $r = .964$, corresponding to a split-half correlation of .982 when using the Spearman-Brown correction. The Current-AUD group had a Pearson *r* between total drinks on even and odd days of $r = .999$, corresponding to a split-half correlation of .999 when using the Spearman-Brown correction.

Demographic Variables

Age, sex, race, years of education, and household income were collected through computerized self-report questionnaires.

DATA ANALYSIS

Two groups of participants were identified in the study: "Never-AUD", defined as those never meeting criteria for an AUD in the past or present, and "Current-AUD", defined as diagnosed with an AUD in the past 12 months (see Figure 3 for Consort Chart).

To examine differences in demographic, personality, and alcohol consumption variables, Pearson Chi Squared tests (categorical variables) or 1-way between-subject ANOVA (continuous variables) were used.

Hypothesis 1.1: Participants with Current-AUD will self-report higher levels of impaired control on the ICS of Attempted, Failed, and Perceived Control than the Never-AUD sample.

To test Hypothesis 1.1, an ANCOVA was completed with an ICS scale as the dependent variable and Group (Never-AUD vs Current-AUD) as the independent variable. Each ICS scale was tested in a separate ANCOVA. As described later, age and sex were included as covariates in analyses because they were associated with Group (Current-AUD vs Never-AUD), and race was included because it was associated with scores on the ICS.

Hypothesis 2.1: In the sample never diagnosed with AUD, attempted control (ICS) will mediate the relationship between positive urgency (UPPS-P) and total drinks (TLFB)

Hypothesis 2.2: In the AUD sample, failed control (ICS) will mediate the relationship between negative urgency (UPPS-P) and total drinks (TLFB).

For mediation analysis (Hypotheses 2.1 and 2.2), up to three methods were used to evaluate if an ICS scale mediated the relationship between negative/positive urgency and total drinks: 1) The joint test of significance, which assesses the significance of the a and b paths, as described by Baron and Kenny (1986) (Baron & Kenny, 1986), 2) Sobel's (1982) test of the significance of the indirect effect, 3) The bootstrapping method to generate confidence intervals for the indirect effect. The Sobel and bootstrapping tests were conducted using software provided by Preacher and Leonardelli (2001) and Hayes (2015) respectively (Andrew F. Hayes, 2015; Preacher & Leonardelli, 2001). All mediation analysis included sex as a covariate. Race and Age were not included in mediation models as they were not significantly associated with urgency,

ICS scores, or total drinks in either the Current-AUD or Never-AUD group, and inclusion of these variables in mediation analyses did not change the findings.

The text below describes testing mediation for Hypothesis 2.2, although the same methods were used for Hypothesis 2.1. For the Baron and Kenny (1986) method, simultaneous linear regressions were run (Baron & Kenny, 1986). For the analyses, negative urgency was designated as the independent variable, X, total drinks was the dependent variable, Y, and the failed control score was the mediator, M. (As noted above, sex was included as a covariate in all models.) For the "c path," termed the "total effect", negative urgency was entered as the predictor, and total drinks was the dependent variable. For the "a path" negative urgency was entered as the predictor, and failed control was the dependent variable. For the "b path" failed control and negative urgency were entered as predictors, and total drinks was the dependent variable. The b path corresponds to the coefficient for the relationship between failed control and total drinks, when controlling for negative urgency. For the "c' path" the "direct effect", negative urgency was evaluated when controlling for the mediator (failed control). The c' path corresponds to the coefficient for the relationship between negative urgency and total drinks, when controlling for failed control. According to the joint test of significance, if both the a path and the b path are significant, there evidence for mediation. This method is widely used for assessing mediation, but is known to have relatively low power to detect total (c) and direct (c') effects, when compared to the a and b paths (Andrew F. Hayes, 2009; MacKinnon, Fairchild, & Fritz, 2006), though the joint test of significance emphasizes the significance of the a and b paths, rather than the c path.

The product of the a and b paths represents the indirect effect (a.b). The Sobel test was used to estimate the magnitude of the indirect effect by using the product of the a and b

coefficients. The product of a and b (a.b) is then divided by an estimate of the standard error of a.b to yield the *z* statistic, which is then evaluated for significance.

Although the Sobel test is easy to compute and widely used, it does not take into account the non-normality of the sampling distribution for a.b. Bootstrapping is a method to calculate a confidence interval for the indirect effect which takes into account the non-normality of the sampling distribution of the indirect effect. By resampling 5000 estimates of the indirect effect using the Hayes (2015) macro in SPSS, 95% confidence intervals for the indirect effect can be constructed. If the upper and lower confidence limits do not encompass 0, then the researcher can reject the null hypothesis that the indirect effect is equal to zero in the population.

SPSS version 25 was used for analyses. All tests used $\alpha = .05$ and were 2-tailed.

Power

Power analyses were conducted with PASS Version 12 and G*Power Version 3.1.9.2 (Faul et al., 2007). All tests were 2-tailed. For Specific Aim 1, with sample sizes of n=112 and n=195, using ANCOVA, power = .99 to detect a medium effect size (Cohen's $d = 0.50$), and power = .81 to detect a small-to-medium effect size (Cohen's $d = 0.30$), assuming 4 covariates that have a combined *R-squared* of 0.20 with the dependent variable. For Hypothesis 2.1, with n=112, using linear regression power = .84 to detect a regression coefficient corresponding to small-to-medium effect size (Cohen's $f^2 = 0.08$) for the a path, assuming 1 covariate (sex), and power = .84 to detect a regression coefficient corresponding to a small-to-medium effect size (Cohen's $f^2 = 0.08$) for the b path, assuming 2 covariates (sex, urgency). For Hypothesis 2.2, with n=195, power = .98 to detect a regression coefficient corresponding to small-to-medium effect size (Cohen's $f^2 = 0.08$) for the a path, assuming 1 covariate, and power = .98 to detect a

regression coefficient corresponding to a small-to-medium effect size (Cohen's $f^2 = 0.15$) for the b path, assuming 2 covariates.

CHAPTER 4: RESULTS

Demographic data are presented in Table 3. The average age for each group was: Never-AUD - 36.1 years (*SD*=13.63); Current-AUD - 43.6 years (*SD*=12.75). The sex breakdown in each group was: Never-AUD - Male 50.9%, Female 49.1%; Current-AUD - Male 66.7%, Female 33.3%. The breakdown of race within each group was: Never-AUD - White 4.6%, Black 36.6%, Other 18.9%; Current-AUD - White 45.1%, Black 40.0%, Other 14.9%.

As expected, the Current-AUD group reported consuming many more drinks than the Never-AUD group, with means of 942.04 (*SD*=940.94) and 36.00 (*SD*=44.98) respectively (Table 3). Table 3 also reports that the two groups differed significantly on a number of other variables related to alcohol consumption, as well as on UPPS scales.

A 1-way ANOVA indicated that the Never-AUD and Current-AUD groups differed in age, and a Chi Square test indicated that that the two groups differed in sex (Table 3). Sex and age were used as covariates in analyses for Specific Aim 1, which examined group differences in impaired control. Race (White; Black; Other) was significantly associated with Perceived Control, $F(2, 306) = 3.49$, $p = .03$, and marginally associated with Failed Control, $F(2, 306) = 2.77$, $p = .06$. Therefore, race was also included as a covariate for Specific Aim 1.

Specific Aim 1

Specific Aim 1 examined the relationship between AUD and impaired control. Hypothesis 1.1 tested whether participants with AUD self-reported higher levels of impaired control on the ICS than the Never-AUD sample. ANOVA and ANCOVA revealed that ICS scores were significantly higher in the Current-AUD group (Table 3). The between-group difference was very large effect size for all three ICS scales.

Specific Aim 2

Specific Aim 2 examined whether impaired control score mediates the relationship between impulsivity and drinking outcomes.

Hypothesis 2.1 tested whether attempted control (ICS) mediated the relationship between positive urgency (UPPS-P) and total drinks (TLFB) in the Never-AUD sample. The mediation results for the Never-AUD group (Table 4, Figure 4) were as follows. There was no significant relationship between positive urgency and total drinks, as indicated by the non-significant c path, or total effect. Although the a path relating positive urgency and attempted control was significant, the b path relating attempted control to total drinks was not significant. Therefore, according to the joint test of significance, there was no evidence for mediation. A Sobel Test (*Test Statistic* = 0.24, $p = .81$) confirmed that the indirect effect (a.b) was not significant.

Hypothesis 2.2 tested whether, in the AUD sample, Failed Control (ICS) mediated the relationship between Negative Urgency (UPPS-P) and Total Drinks (TLFB). The mediation results for the AUD sample (Table 5; Figure 5) were as follows. There was a significant relationship between Negative Urgency and Total Drinks, as indicated by the significant c path, or total effect. Both the a path, the positive association between Negative Urgency and Failed Control and b path between Failed Control and Total Drinks, were significant, providing evidence for mediation, according to the joint test of significance. A Sobel Test (*Test Statistic* = 5.16, $p < .001$) confirmed that the indirect effect (a.b) was significant. In addition, when using Bootstrapping, the 95% confidence intervals for the indirect effect (95% *CI*s, 239.7, 484.9) did not overlap with 0, providing further evidence for mediation (A.F. Hayes, 2017). The direct effect, the c' path, was not significant, consistent with complete mediation.

Sensitivity Analyses

For Hypothesis 1, controlling for Years of Education and Income (in addition to Age, Sex, Race) did not change any of the results (all group differences were still highly significant).

One participant in the Current-AUD group reported 7200 drinks over the 90-day period, which corresponds to 80 drinks per day. Although the rate of drinking was below 100 drinks per day (the cut-off used for excluding participants), mediation analyses for Hypothesis 2.2 were conducted when excluding this outlier (6.65 *SD*s above the mean of the Current-AUDs). No other outliers were removed from analyses. The results did not change. When excluding this participant, the a path was significant, $PE = 7.08$, $SE = 0.92$, $t = 7.74$, $p < .001$, and the b path was significant, $PE = 48.11$, $SE = 6.08$, $t = 7.92$, $p < .001$, consistent with mediation. The c' path, the direct effect, remained non-significant, $PE = -81.07$, $SE = 88.10$, $t = -0.92$, $p = .359$. The indirect effect was significant whether tested using the Sobel test or through bootstrapping.

The study involved testing multiple null hypotheses for each hypothesis. When a false discovery rate procedure was applied to data from each hypothesis (i.e., 3 *p* values from Hypothesis 1.1, 4 *p* values from Hypothesis 2.1 corresponding to the a, b, c, and c' paths, and 4 *p* values from Hypothesis 2.2), using *Q* (false discovery rate) = .05, all of the significant *p* values reported are designated as "discoveries".

Exploratory Analyses

Previous studies have shown perceived control to mediate the relationship between impulsivity and drinking in a non-dependent sample (Patock-Peckham et al., 2001; Wardell et al., 2016). When perceived control (ICS) was used to examine the mediation of positive urgency and alcohol consumption, there was no evidence of mediation.

In exploratory analyses, we tested a mediation model of the Never-AUD group when using negative urgency (rather than positive urgency) as the predictor variable and failed control (rather than attempted control) as the mediator (i.e., we "tested" Hypothesis 2.2 for the Never-AUD group). As can be seen from Table 6, there was no evidence of a significant a path and no evidence of a significant b path. Therefore, using the joint test of significance, there is no evidence for mediation. Additional tests using the Sobel test and bootstrapping (not shown in table) also revealed that there was no evidence for mediation.

In addition, we tested a mediation model of the AUD group when using Positive Urgency (rather than Negative Urgency) as the predictor variable and attempted control (rather than failed control) as the mediator (i.e., we "tested" Hypothesis 2.1 for the AUD group). As can be seen from Table 7, there was no evidence of a significant a path and no evidence of a significant b path. Therefore, using the joint test of significance, there is no evidence for mediation. Additional tests using the Sobel test and bootstrapping (not shown in table) also revealed that there was no evidence for mediation.

CHAPTER 5: DISCUSSION

The main results of this study were as follows. First, individuals with a current AUD had higher scores on attempted control, failed control, and perceived control scales of the ICS than individuals who never had an AUD. Second, in individuals who never had an AUD, there was no evidence that an association between positive urgency and alcohol consumption was mediated by attempted control. Third, among those with AUD, there was evidence that the association between negative urgency and alcohol consumption was mediated by failed control. The results for each specific aim are discussed below.

Consistent with Hypothesis 1.1, individuals with Current-AUD self-reported much higher levels of impaired control on the ICS compared to participants who have never had an AUD. For the Current-AUD group, mean scores on the attempted control (mean = 9.2), failed control (mean = 24.7), and perceived control (mean = 21.5) scales were similar with those reported in previous research in a sample with AUD: attempted control (mean = 9.2), failed control (mean = 26.3), and perceived control (mean = 23.0) (Heather et al., 1998). Our Never-AUD sample reported low average scores on attempted control (mean = 2.51), failed control (mean = 2.17), and perceived control (mean = 2.07). The average item score for attempted control was 0.50 (0-4 scale) and the average item score of failed control was 0.22 (0-4 scale). These data suggest that Never-AUDs have low levels of both attempted and failed control but reported fewer failed attempts at controlling their drinking than attempts to control their drinking. This finding suggests that Never-AUD populations consuming lower amounts of alcohol often do not attempt to control their drinking to begin with, and if they do, they often adhere to these limits.

Contrary to our Hypothesis 2.1, attempted control was not a mediator between impulsivity and alcohol consumption. A potential explanation for a lack of mediation in our Never-AUD population was low levels of self-reported alcohol consumption among the Never-AUD group. Relatively low levels of variability in the dependent variable presumably makes it more difficult to detect an association between failed control and alcohol consumption, as well as between positive urgency and alcohol consumption. The Never-AUD sample also reported low scores on the ICS suggesting this sample may not often attempt to control their drinking but when they do, they often succeed.

The findings for the non-AUD group are interesting given attempted control mediated an association between positive urgency and alcohol consumption in a binge drinking sample without AUD (Vaughan et al., 2019). In this previous study, the average total drinks was 70.4 (42.2), the average attempted control score was 5.9, and the average failed control score was 5.8 (Vaughan et al., 2019). As noted above, our Never-AUD sample reported lower average scores on total drinks 35.99 (45.00), attempted control (mean = 2.51), and failed control (mean = 2.17) parts of the ICS. Variability in ICS scores, as well as Total Drinks, was also limited in the Never-AUD group in the current study, presumably making it more difficult to find significant associations. On the other hand, a significant association between positive urgency and attempted control was documented (Table 4).

Attempted control is a concept that needs further study. A fair amount of literature has focused on pairing failed control with AUD and perceived control with non-dependent drinking. However, attempted control was not significantly related to drinking in this light drinking never-AUD group. This could be due to the lack of a binge drinking population previously used in Vaughan et al. 2019. Attempts to control drinking may be indicative of a positive, adaptive

behavior to limit alcohol consumption in both non-AUD populations and current-AUD populations. Our study also had an older population than most studies who use convenience samples of undergraduates. Along with age, people learn more about their personal limits consuming alcohol, thus lessening the need for conscious attempts to control drinking. However, these questions need to be addressed with further research.

Consistent with Hypothesis 2.2, data from the Current-AUD sample supported the hypothesis that failed control would mediate the relationship between trait impulsivity and alcohol consumption. These data support previous findings on these relationships but extend them to individuals with AUD (Vaughan et al., 2019). One might argue that impaired control is relatively understudied in alcohol and other addiction literature considering its importance in addiction and diagnosing alcohol and substance use disorders. As noted earlier, impaired control, measured by the ICS, has been shown to be an indication of risk for developing an AUD (Robert F. Leeman et al., 2009).

Failed control is an essential part of addiction, and, as discussed further below, can be considered a target for intervention. Failed control is a good marker for assessing AUD and overall impaired control over an addiction. Failed control might potentially be improved with methods used to improve executive control, as well as decision making skills and cognitive flexibility (Sofuoglu, DeVito, Waters, & Carroll, 2013). If a just in time intervention or ways to reduce impaired control can be implemented before a person fails to control their drinking, it could intervene on the cycle of addiction and help improve treatment outcomes.

Limitations

This study had some limitations. First, the study relied exclusively on self-report data, which has limitations relating to recall bias. Second, the study design was cross-sectional which

limits the ability to make statements on the causal relationships between impulsivity, impaired control, and alcohol consumption. Researchers have noted the limitations of mediation analyses conducted on cross-sectional data and cautioned that researchers should use longitudinal designs for testing mediation (Maxwell & Cole, 2007). As has been noted, the results of mediation analysis are only valid if the causal paths specified by the mediation models are correct. If the causal pathways specified by the model are not correct (i.e., in the current case the causal pathways between urgency, impaired control, and drinking) then the path estimates are likely biased. Moreover, the use of cross-sectional data can produce biased path estimates even with a correctly specified causal model, and so the mediation analyses should be treated with caution pending replication in a longitudinal dataset. Third, as noted earlier, control participants reported relatively low levels of impaired control and alcohol consumption, together with limited variability in these measures, and the relatively limited variability on study measures may have diminished the chances of observing associations in this group. Finally, the Never-AUD and Current-AUD groups differed significantly in terms of years of education and socioeconomic status, potentially complicating interpretation between group differences.

Strengths

There were strengths to this study. First, this is the first study per our knowledge to test the mediation of impulsivity, impaired control, and alcohol consumption using a heavy drinking population - including inpatients seeking treatment for AUD. While much previous work has focused on using a convenience sample of college students, the current study had older participants, closer to middle adulthood, when people tend to seek treatment for alcohol-related problems. This study contributes new information about associations between impulsivity, impaired control, and alcohol consumption in individuals seeking treatment for AUD. Second,

this study also had a control sample in our Never-AUD group, which allowed for between-group comparisons in ICS scores. To the best of our knowledge, this is the first study to examine differences in ICS scores between Current-AUD and Never-AUD populations.

Future Directions

Results from this study suggest several future directions. First, a longitudinal study would allow us to infer causal relationships between the variables of impulsivity, impaired control, and alcohol consumption. One way to examine this relationship longitudinally is to extrapolate data on impaired control using measures like the Alcohol Dependence Scale (ADS) or the Structured Clinical Interview (SCID) that assess impaired control in a larger sample of participants.

Second, the study suggests that interventions that target failed control may be useful for addressing problematic alcohol use. To the best of our knowledge, no studies have examined the effect of interventions on the ICS failed control scale. A way to address failed control is through cognitive, pharmacological, behavioral interventions, or through transcranial magnetic stimulation (TMS). Cognitive deficits in attention, working memory, and response inhibition are all associated with chronic addiction (Le Berre, Fama, & Sullivan, 2017). Potential targets of intervention related to failed control are inhibitory and executive control. Executive control comes from two networks of the prefrontal cortex the orbitofrontal limbic network and the dorsolateral executive network. It is responsible for response inhibition, working memory and attention (de Wit, 2009; Grégoire, Rivalan, Le Moine, & Dellu-Hagedorn, 2012). Some previous work has explored the relationship between response inhibition and impaired control, finding alcohol related changes to reduced response inhibition and impaired control were both predictors of alcohol related problems (Corbin et al., 2020). Understanding changes in the executive and inhibitory network from addiction allows for these targeted cognitive interventions.

Medication has also been used to try to improve cognition in those with addiction. Drugs like galantamine, varenicline, modafinil, and atomoxetine target acetylcholine and monoamine transporters target sustained attention, working memory, and response inhibition (Sofuoglu et al., 2013). Some of these medications also have mood-boosting effects and the impact of the medication could contribute to the positive effects of the medication on cognition (Dell'Osso, Palazzo, Oldani, & Altamura, 2011; Mitchell & Phillips, 2007). Behavioral treatments are also a way to improve cognition to increase favorable outcomes for addiction. When Cognitive Behavioral Therapy (CBT) is applied to addiction it focuses on strategies to improve cognition over learned problematic behavioral patterns and strategies to reduce impulsive responses to craving. In some studies, computer-based CBT has provided psychoeducation and skill implementation to improve retention and implementation of CBT skills (Carroll et al., 2008).

A potential way to address changes in the brain due to AUD is transcranial magnetic stimulation (TMS). TMS involves stimulation of the brain using a brief high-intensity magnetic field using a current passing through a coil. This method has been used in research for about thirty years and has been applied to major depressive disorder, obsessive-compulsive disorder, Alzheimer's disease, stroke, and a host of other disorders associated with the brain. It is thought the therapeutic effect comes from the low frequency stimulation reducing neural activity while the high frequency excites neural activity (Hallett, 2007). The therapeutic effect stimulates neurons, but it is also thought to help oligodendrocytes, in the CNS, which make the myelin sheath surrounding an axon.

Several studies have examined the potential impact of TMS on alcohol use. One study examining both binge-type patterns and alcohol dependent individuals found abnormal preparatory activity in the motor system of binge-type pattern drinkers where alcohol-dependent

individuals showed the same effect scaled with risk of relapse (Grandjean & Duque, 2020). Some evidence has suggested targeting inflexible responses can also offer a treatment strategy to prevent relapse (Witkiewitz, Lustyk, & Bowen, 2013). Further research along with combined methods are necessary to further understand underlying mechanisms of TMS and AUD.

Conclusions

To the best of our knowledge, this study is the first to report that the association between impulsivity (negative urgency) and alcohol consumption is mediated by impaired control (failed control) in a population of heavy drinkers, including inpatients seeking treatment for alcohol use. In addition, the study is the first to report differences in ICS scores between Current-AUD and Never-AUD populations. Overall, this study provides further evidence impaired control is an important marker of addiction, and a potential target for interventions.

Table 1. Impulsivity and Impaired Control Measures and Descriptions

Impulsivity Measure	**Impulsivity Measure Description**	**Impaired Control**	**Impaired Control Measure Description**
Negative Urgency*	Acting impulsively in response to negative emotions	ICS Attempted Control*	Describes the frequency of efforts to limit alcohol consumption
Positive Urgency*	Acting impulsively in response to positive emotions	ICS Failed Control*	Placing limits on consumption but exceeding those limits
(Lack of) Premeditation	Inability to take consequences of an action into account before participating in that action	ICS Perceived Control	Describes control they have over drinking right now, in the moment
(Lack of) Perseverance	Inability to focus on a task that may be difficult or boring		
Sensation Seeking	Tendency to pursue activities and experiences that are stimulating and openness to trying new experiences		

Table Note. Summary of impulsivity and impaired control measures relevant to the study.
*Primary Measures in analyses

Table 2. Never-AUD and Current-AUD Populations

	Never-AUD	**Current-AUD**
Patient Population	Outpatients	Outpatients not seeking treatment; Inpatients seeking treatment
Duration	1-2 days	1-30 days
Computerized Assessments	Demographics, UPPS-P Impulsivity Scale, Impaired Control Scale, Timeline Follow-Back	Demographics, UPPS-P Impulsivity Scale, Impaired Control Scale, Timeline Follow-Back
Interview Assessments	Structured Clinical Interview for DSM-5	Structured Clinical Interview for DSM-5
Treatment	None	None; withdrawal medications; vitamin supplementation; psychotherapy
Other assessments not included in this thesis	Withdrawal, CSSR-S, NEO Personality Inventory, Intelligence Testing	

Table Note. Characteristics and Assessments of participants in the Never-AUD and Current-AUD group.

Table 3. Summary Statistics

Variable ↓	**All**		**Never-AUD**	**Current-AUD**		***H***	***F* Value of ANOVA; t/χ^2**	***df***	***p*-value**	**Effect Size***	***F*-value ANCOVA**	***p*-value ANCOVA**
	***N*=307**		***n*=112**	***n*=195**								
Age	40.86 (13.55)		36.10 (13.63)	43.59 (12.75)			-4.83	305	.000	0.530	n/a	n/a
Sex (%)							9.16	1	.003	0.158	n/a	n/a
Male	60.3		50.9	66.7								
Female	39.7		49.1	33.3								
Race (%)							0.87	2	.647	0.046	n/a	n/a
White	45.0		44.6	45.1								
Black	38.8		36.6	40.0								
Other*	16.3		18.9	14.9								
Years of Education	14.59 (2.96)		16.34 (2.11)	13.59 (2.92)			9.51	288.67	.000	0.201	n/a	n/a
Household Income	6 [3, 8]		7 [5, 9]	4 [2, 7]			22180.5	n/a	.000	0.379	n/a	n/a
UPPS												
Negative Urgency	2.21 (0.77)		1.62 (0.52)	2.56 (0.67)			-13.64	278.7	.000	1.533	162.09	.000
Premeditation	1.89 (0.52)		1.65 (0.40)	2.02 (0.54)			-6.97	284.6	.000	0.849	60.52	.000
Perseverance	1.89 (0.50)		1.65 (0.39)	2.01 (0.51)			-8.92	268.1	.000	0.808	65.68	.000
Sensation Seeking	2.68 (0.67)		2.65 (0.65)	2.70 (0.68)			-0.60	305	.548	0.072	2.36	.126
Positive Urgency	1.86 (0.76)		1.35 (0.44)	2.15 (0.75)			-11.82	304.9	.000	1.220	93.70	.000
Alcohol Consumption												

TLFB Total Drinks	611.50 (867.69)		35.99 (45.00)	942.04 (940.94)			-13.42	195.54	.000	1.836	85.50	.000
TLFB Ave. Drinks Per Drinking Day	8.70 (9.64)		2.06 (1.12)	12.51 (10.29)			-14.04	201.97	.000	1.910	98.03	.000
TLFB Heavy Drinking Days	38.33 (37.06)		1.50 (3.65)	59.48 (30.42)			-26.29	203.60	.000	3.273	347.87	.000
AUDIT Consumption	7.12 (3.99)		2.73 (1.60)	9.64 (2.48)			-29.60	301.02	.000	3.397	662.58	.000
AUDIT Total	16.08 (12.31)		2.94 (2.07)	23.63 (8.93)			-30.95	228.43	.000	4.166	560.71	.000
ICS												
Attempted Control	6.78 (5.92)		2.51 (4.44)	9.24 (5.23)		1.1	-11.96	305	.000	1.142	111.21	.000
Failed Control	16.47 (13.44)		2.17 (3.47)	24.69 (9.60)		1.1	-29.57	268.15	.000	3.086	523.91	.000
Perceived Control	14.42 (12.44)		2.07 (3.41)	21.52 (9.95)		1.1	-24.88	262.27	.000	2.606	362.11	.000

Table Note. Data are *Mean* (*SD*) unless otherwise noted; *H* = Hypothesis; Household income was assessed with the following scale: 1=< $5000; 2=$5000-$9999; 3=$10000-$19999; 4=$20000-$29999; 5=$30000-$39999; 6=$40000-$49999; 7=$50000-$74999 (data reported are *Median* [*IQR*]; 8=$75000-$100000; 9=>$100000 *******Partial eta square* for ANOVAs; *Phi* for Sex, *Cramer's V* for Race; *r* for Household Income. Other Race Group included: Multiracial, Native Hawaiian or Other Pacific Islander, Unknown Race Unanswered, American Indian/Alaska Native, Asian. ANCOVAs control for Age, Sex (binary variable), and Race (multinomial variable with 3 levels). For household income, *n*=194 for Current-AUD group.

Table 4**.** Regression results for Mediation Model for Never-AUD Group (*n*=112)

DV →		***Attempted Control***							***Total Drinks***					
IV↓	Path	*df*	*B*	*SE*	*Beta*	*t*	*p*		*df*	*B*	*SE*	*Beta*	*t*	*p*
Positive Urgency	a	108	2.537	0.939	0.250	2.702	.008		.	.	.	.	.	.
Attempted Control	-								108	0.416	0.955	0.046	0.483	.630
Attempted Control controlling Positive Urgency	b	.	.	.	.	.	.		107	0.234	0.988	0.023	0.237	.813
Positive Urgency controlling Attempted Control	c’	.	.	.	.	.	.		107	9.175	10.00	0.089	0.917	.361
Positive Urgency	c	.	.	.	.	.	.		108	9.770	9.639	0.095	1.014	.313

Table Note. All results reflect results from models when including Sex as a covariate (coefficients for Sex not reported in table). a path reflects coefficient for the path between Positive Urgency (X) and Attempted Control (M); b path reflects coefficient for the path between Attempted Control (M) and Total Drinks (Y) controlling for Positive Urgency (X); c’ path reflects the coefficient for the path between Positive Urgency (X) and Total Drinks (Y) controlling for Attempted Control (M); c path reflects coefficient for the path between Positive Urgency (X) and Total Drinks (Y). The path labelled “-“ reflects the coefficient between Attempted Control and Total Drinks when not controlling for Positive Urgency.

Table 5**.** Regression results for Mediation Model for Current-AUD Group (*n*=195)

DV →		***Failed Control***							***Total Drinks***					
IV↓	Path	*df*	*B*	*SE*	*Beta*	*t*	*P*		*df*	*B*	*SE*	*Beta*	*t*	*p*
Negative Urgency	a	192	7.101	0.904	0.498	7.857	0.001		.	.	.	.	.	.
Failed Control	-								192	48.855	6.147	0.498	7.948	0.001
Failed Control controlling Negative Urgency	b	.	.	.	.	.	.		191	48.652	7.085	0.496	6.867	0.001
Negative Urgency controlling Failed Control	c’	.	.	.	.	.	.		191	5.938	102.000	0.004	0.058	0.954
Negative Urgency	c	.	.	.	.	.	.		192	351.43	98.819	0.251	3.556	0.001

Table Note. All results reflect results from models when including Sex as a covariate (coefficients for Sex not reported in table). a path reflects coefficient for the path between Negative Urgency (X) and Failed Control (M); b path reflects coefficient for the path between Failed Control (M) and Total Drinks (Y) controlling for Negative Urgency (X); c’ path reflects the coefficient for the path between Negative Urgency (X) and Total Drinks (Y) controlling for Failed Control (M); c path reflects coefficient for the path between Negative Urgency (X) and Total Drinks (Y). The path labelled “-“ reflects the coefficient between Failed Control and Total Drinks when not controlling for Negative Urgency.

Table 6: Regression Results for Mediation Model for Never-AUD Group Using Alternative Specification (*n*=112)

DV →		***Failed Control***							***Total Drinks***					
IV↓	Path	*df*	*B*	*SE*	*Beta*	*t*	*p*		*df*	*B*	*SE*	*Beta*	*t*	*p*
Negative Urgency	a	109	0.82	0.63	0.12	1.30	.197		.	.	.	.	.	.
Failed Control	-								109	0.68	1.24	0.05	0.55	.585
Failed Control controlling Negative Urgency	b	.	.	.	.	.	.		108	0.39	1.23	0.03	0.31	.746
Negative Urgency controlling Failed Control	c’	.	.	.	.	.	.		108	15.65	8.17	0.18	1.92	.058
Negative Urgency	c	.	.	.	.	.	.		109	15.97	8.07	0.19	1.98	.050

Table Note. Models shown reflect results for the Never-AUD group when using Negative Urgency (rather than Positive Urgency) as the predictor variable and Failed Control (rather than Attempted Control) as the Mediator. All results reflects results from models when including Sex as a covariate (coefficients for Sex not reported in table). a path reflects coefficient for the path between Negative Urgency (X) and Failed Control (M); b path reflects coefficient for the path between Failed Control (M) and Total Drinks (Y) controlling for Negative Urgency (X); c’ path reflects the coefficient for the path between Negative Urgency (X) and Total Drinks (Y) controlling for Failed Control (M); c path reflects coefficient for the path between Negative Urgency (X) and Total Drinks (Y). The path labelled “-“ reflects the coefficient between Failed Control and Total Drinks when not controlling for Negative Urgency.

Table 7: Regression Results for Mediation Model for Current-AUD Group Using Alternative Specification (*n*=195)

DV →		***Attempted Control***							***Total Drinks***					
IV↓	Path	*df*	*B*	*SE*	*Beta*	*t*	*p*		*df*	*B*	*SE*	*Beta*	*t*	*p*
Positive Urgency	a	192	0.066	0.502	0.01	0.13	.896		.	.	.	.	.	.
Attempted Control	-								192	-12.63	13.01	-0.07	-0.97	.333
Attempted Control controlling Positive Urgency	b	.	.	.	.	.	.		191	-12.97	12.77	-0.07	-1.02	.311
Positive Urgency controlling Attempted Control	c’	.	.	.	.	.	.		191	257.83	88.76	0.21	2.90	.004
Positive Urgency	c	.	.	.	.	.	.		192	256.98	88.76	0.20	2.90	.004

Table Note. Models shown reflect results for the Current-AUD group when using Positive Urgency (rather than Negative Urgency) as the predictor variable and Attempted Control (rather than Failed Control) as the Mediator. All results reflect results from models when including Sex as a covariate (coefficients for Sex not reported in table). a path reflects coefficient for the path between Positive Urgency (X) and Attempted Control (M); b path reflects coefficient for the path between Attempted Control (M) and Total Drinks (Y) controlling for Positive Urgency (X); c’ path reflects the coefficient for the path between Positive Urgency (X) and Total Drinks (Y) controlling for Attempted Control (M); c path reflects coefficient for the path between Positive Urgency (X) and Total Drinks (Y). The path labelled “-“ reflects the coefficient between Attempted Control and Total Drinks when not controlling for Positive Urgency.

Figure 1. Procedures for Outpatients

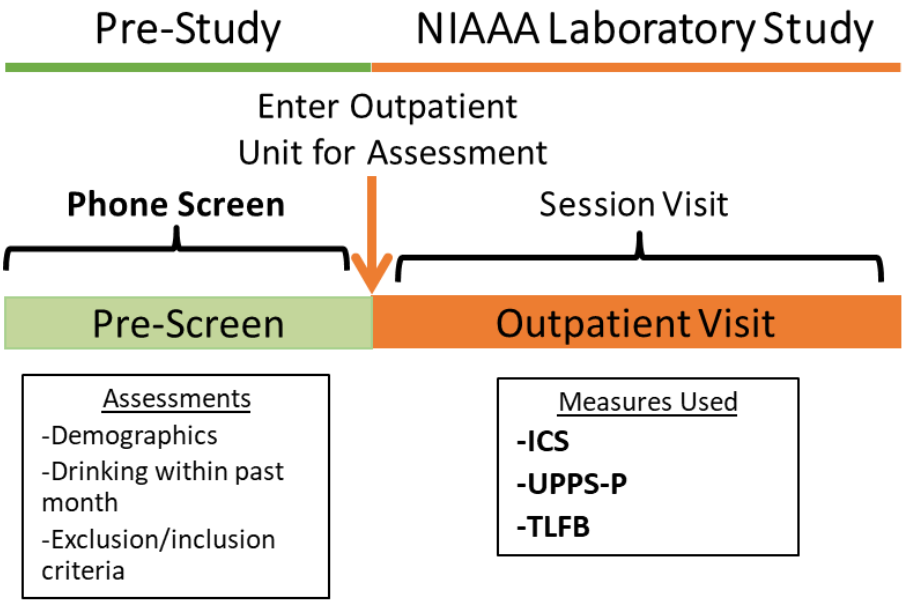

Figure Note. Outpatient participants were either a healthy population never diagnosed with AUD or people with AUD not seeking treatment. The in-person screening visit was completed in one to two visits where study measures were collected.

Figure 2. Procedures for Inpatients

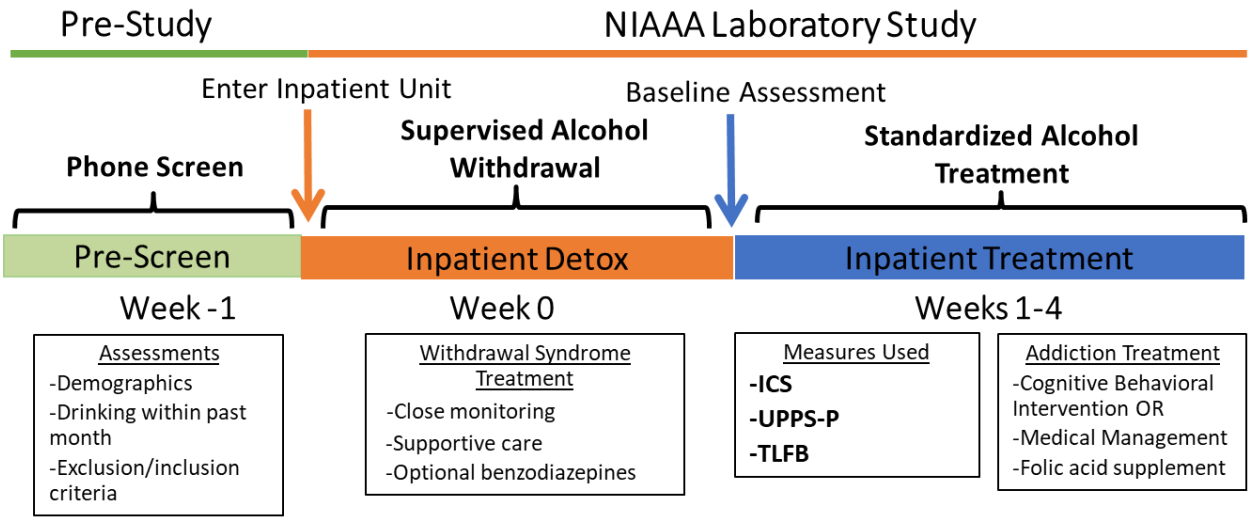

Figure Note. Inpatient participants received standardized treatment for AUD which lasted about 30 days. Measures were collected after the withdrawal period, which lasted approximately one week. Inpatients were administered standard doses of benzodiazepines when clinically indicated for alcohol withdrawal. About one week into treatment, the study measures were collected.

Figure 3. Consort Chart

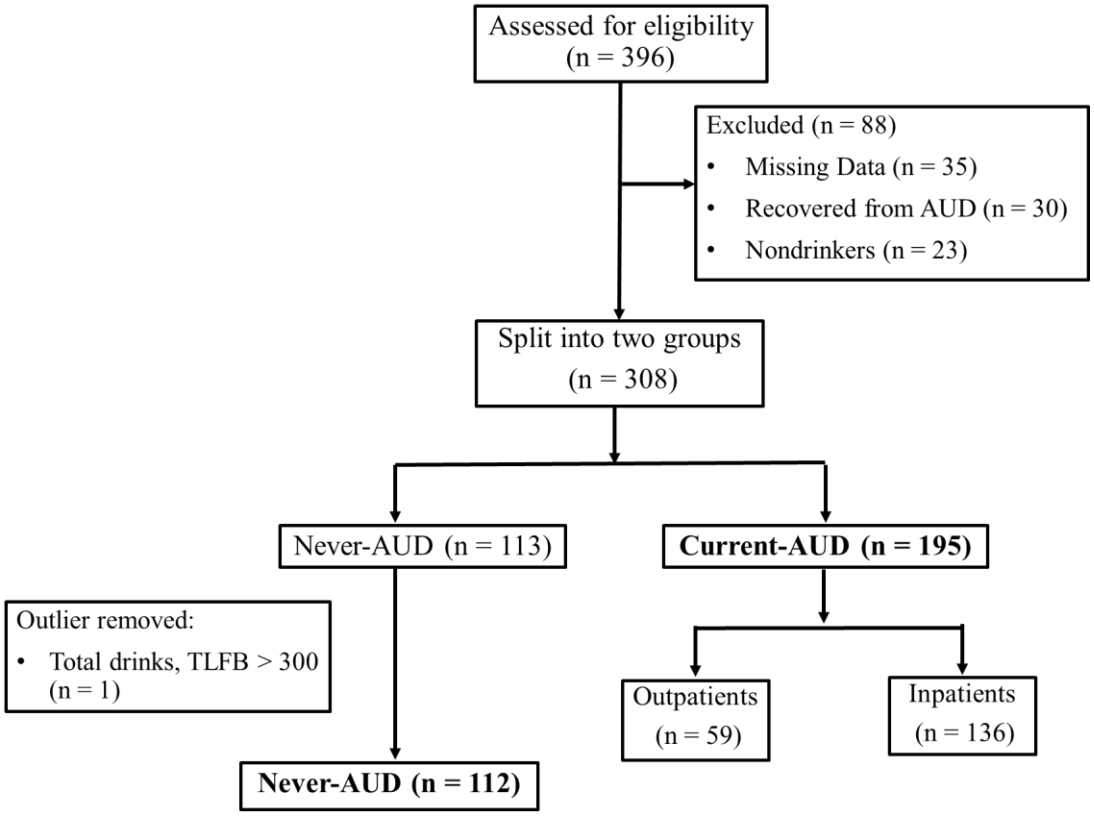

Figure Note. For the study, 396 participants were assessed for eligibility and 88 were excluded for missing data, recovered from AUD, or non-drinkers. The remaining 308 participants were split into two groups, Never-AUD (*n*=113) and Current-AUD (*n*=195; 59 outpatients and 136 inpatients). One outlier was removed from the Never-AUD group, this person consumed over 300 drinks over the past 90 days which left the Never-AUD group with 112 participants.

Figure 4. Mediation Analysis for Never-AUD Group

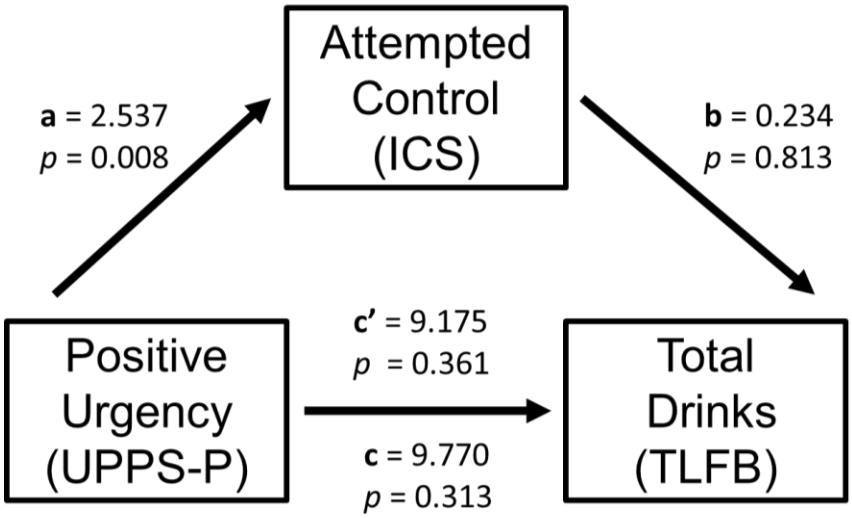

Figure Note. There was a significant positive association between positive urgency and attempted control, but the association between attempted control and total drinks was not significant.

Figure 5. Mediation for Current-AUD Group

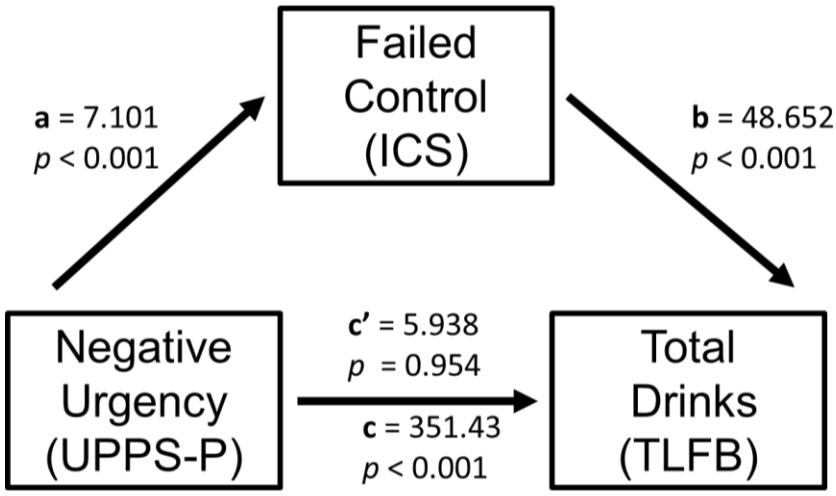

Figure Note. There was a significant positive association between negative urgency and failed control, and between failed control and total drinks. The direct effect, the c prime path, was not significant, consistent with complete mediation.

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Appendix

Impaired Control Scale (ICS)

Part 1 (Attempted Control)

Please tick the alternative, which best describes how often the following items have applied to you **during the last six months**.

1. During the last six months, I tried to limit the amount I drank.
2. During the last six months, I tried to resist the opportunity to start drinking.
3. During the last six months, I tried to slow down my drinking.
4. During the last six months, I tried to cut down my drinking (i.e. drink less)
5. During the last six months, I tried to stop drinking for a period of time.

Responses: Never, Rarely, Sometimes, Often, Always

Part 2 (Failed Control)

Tick the alternative which best describes how often you have experienced the following situations or feelings during the last six months. Please note - we are not interested in what you believe about your drinking, but what you have actually done in the last six months. If a statement does not apply because you have made no attempt to limit your drinking in the situation described in the last six months, please tick "Does not apply".

For example, it might ask you how often in the last six months you were able to resist drinking when you saw your favourite drink. If you did not try to resist drinking when you found yourself in this situation in the last six months, you would tick "Does not apply". You would only tick "Never" if you tried to resist drinking but were never able to manage to do so. Please use "Does not apply" as often as you think necessary. If you have any problems with these instructions, please ask the questionnaire administrator.

1. During the last six months, I found it difficult to limit the amount I drank.
2. During the last six months, I started drinking even after deciding not to.
3. During the last six months, even when I intended having only one or two drinks, I ended up having many more.
4. During the last six months, I was able to cut down on my drinking (i.e. drink less) when I wanted to.
5. During the last six months, I started drinking at times when I knew it would cause me problems (e.g. problems at work, with family or friends, with the police etc.)
6. During the last six months, I was able to stop drinking easily after one or two drinks.
7. During the last six months, I was able to stop drinking before becoming completely drunk.

8. During the last six months, I had an irresistible urge to continue drinking once I had started.
9. During the last six months, I found it difficult to resist drinking, even for a single day.
10. During the last six months, I was able to slow down my drinking when I wanted to.

Responses: Never, Rarely, Sometimes, Often, Always, Does not apply

Part 3 (Perceived Control)

In the previous section we asked you about what actually happened with your drinking over the last six months. In this section we are interested in what you think would happen with your drinking **now**. (Please assume that you have not decided to give up completely.)

1. I would find it difficult to limit the amount I drink.
2. I would start to drink, even after deciding not to.
3. Even if I intended having only one or two drinks, I would end up having many more
4. I could cut down on my drinking (i.e. drink less) if I wanted to.
5. I would start drinking at times when I knew it would cause me problems (e.g. problems at work, with family/friends or with the police etc.).
6. I could stop drinking easily after one or two drinks.
7. I could stop drinking before becoming completely drunk.
8. I would have an irresistible urge to continue drinking once I started.
9. I would find it difficult to resist drinking, even for a single day.
10. I could slow down my drinking if I wanted to.

Responses: Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree