

**Exploring the Relationship between Alcohol Availability and Craving in Individuals
with Alcohol Use Disorder in Treatment: An Experience Sampling Study over 100 Days**

Nina Böcher

Faculty of Behavioural, Management, and Social Sciences

Department of Psychology, University of Twente

202001489: MSc Thesis Positive Clinical Psychology and Technology

First Supervisor: Dr. Marcel Pieterse

Second Supervisor: Dr. Jannis T. Kraiss

May 27, 2024

Abstract

Background: Alcohol availability significantly influences craving in individuals with Alcohol Use Disorder (AUD) during recovery, but there is limited research on the temporal dynamics of this relationship. This study aimed to (a) investigate the concurrent association between alcohol availability and craving over time; (b) whether the prospective, 3-hours lagged alcohol availability is associated with craving over time; (c) whether the concurrent relationship between alcohol availability and craving is reciprocal over time. Further, lapses were found to occur frequently during the recovery journey. Accordingly, this study aimed to investigate (d) whether including lapses as a covariate influences the relationship between alcohol availability and craving over time. Positive affect (PA) and negative affect (NA) appear to further strengthen the relationship between alcohol and availability. Thus, this study examined (e) whether PA and NA moderate the relationship between alcohol availability and craving over time.

Method: Experience Sampling Methodology (ESM) was utilized to investigate the association between alcohol availability and craving over 100 consecutive days ($N = 10$, $M_{Age} = 40$, 40 % women). Participants received questionnaires 8 times per day concerning their craving, PA, NA, and alcohol availability. Lapses were measured twice, once in the morning for the previous day and once in the evening. Linear Mixed Models were applied to test the associations.

Results: Results revealed a positive significant relationship between alcohol availability and craving, concurrently and prospectively, as well as a reciprocal, concurrently, positive relationship between the variables. Lapses were found to be influential on craving and alcohol availability. PA and NA moderated the relationship between alcohol availability and craving. N=1 analysis revealed individual differences in craving responses to alcohol availability and lapses.

Conclusion: The present study extends existing literature by shedding light on the persisting influence of alcohol availability on craving over 100 days in AUD patients. Future research is needed to delve deeper into the influence of alcohol availability to help in developing treatment interventions to effectively target craving responses to alcohol availability, PA, NA, and lapses in AUD patients.

Keywords: Alcohol Availability, Positive Affect, Negative Affect, Lapses, Craving, Alcohol Use Disorder, AUD, Experience Sampling Methodology

Exploring the Relationship between Alcohol Availability and Craving in Individuals with Alcohol Use Disorder in Treatment: An Experience Sampling Study over 100 Days

Introduction

Alcohol is a psychoactive substance that is commonly consumed by many individuals globally. It is seen as a socially accepted method for relaxing, socializing, and stress management. However, the widespread use of alcohol can have serious implications. Annually, approximately 3 million people die due to alcohol abuse and its consequences worldwide (Hanson, 2023). Some of the consequences of problematic drinking include severe health issues such as liver cirrhosis and cardiovascular diseases (Grønbaek, 2009). Problematic drinking is further associated with major impacts on social and economic levels and seen as a public health concern (Connor et al., 2016). One manifestation of problematic alcohol use is Alcohol Use Disorder (AUD), which is characterized by patterns of increased alcohol consumption and is associated with physiological and psychological disorders, as well as higher mortality rates (Kendler et al., 2016). AUD affects 5.1% of the global population and is associated with detrimental impacts on social and health levels. For instance, research conducted on the life expectancy of individuals with AUD in Nordic countries revealed that the lifespan of those addicted is approximately 24 to 28 years shorter than that of the broader population (Westman et al., 2015). Further, AUD correlates with impaired interpersonal relations, susceptibility to infections, cancer, and violent behavior (Grant et al., 2017).

The general goals in AUD treatment are to reduce symptoms and to improve overall functioning. One of the targets include maintaining abstinence or achieving controlled drinking. However, research has shown that treatments typically result in short-term improvements, with lapses and relapses being common (Rehm & Shield, 2019; Connor et al., 2016). For instance, Andersson et al. (2019) found that within three months from post-treatment discharge, 44 % of individuals experienced a relapse. Understanding the factors triggering (re)lapses, craving is a relevant predictor in the maintenance of AUD and is widely acknowledged as a precipitant of relapses (Schlauch et al., 2019).

Craving

In general, craving can be described as a compelling urge to consume alcohol. It has been consistently recognized as an obstacle in attaining long-term abstinence in people recovering from AUD (Drummond, 2001). For instance, Law et al. (2016) found that higher craving levels are associated with lapses in a 3-month outpatient treatment of alcohol dependent individuals. Additionally, research by Subbaraman & Witbrodt (2013) showed that

approximately half of the improvement in the number of days individuals stayed abstinent during treatment was due to craving decreases. The concept of craving has sparked considerable interest in prior research and has been established as a primary aim of treatment (Bartoli et al., 2015). Several theoretical frameworks have been developed that attempt to explain the nature of craving and its role in the recovery of AUD (Skinner & Aubin, 2010).

Exemplary, the *Incentive Sensitization Theory of Addiction* (ISTA) by Robinson & Berridge (1993) offers insight into the mechanism behind craving, suggesting it stems from classical conditioning. Through initial, repeated drug consumption, originally neutral cues (e.g., seeing an alcoholic beverage) become associated with the rewarding psychological and physiological effects of alcohol on the brains' rewards circuitry, ultimately increasing the motivation to consume alcohol (Robinson & Berridge, 2008; van Lier et al., 2018). Consequently, external alcohol-related cues can activate the brain's reward system, leading to increased craving, even in the absence of direct pleasure from consuming alcohol (Volkow et al., 2012). This automatic process, commonly described as cue reactivity, can be seen as a permanent alteration in the brain and leaves individuals in a constant state of vulnerability, even years after quitting alcohol consumption (van Lier et al., 2018; Robinson & Berridge, 2008). This helps to understand why craving persists although a clear abstinence goal is set, emphasizing the crucial role of external stimuli in the induction and maintenance of craving (Cofresi et al., 2019).

According to the ISTA, exposure to environments or stimuli linked with substance use often increases craving due to their rewarding properties (Robert & Berridge, 2008). Various sensory cues, including smell, sight, or taste of a beverage, can trigger craving. Research by Weinstein et al. (1998) have shown that alcohol images and in vivo exposure are sufficient to increase craving. Anticipation of nicotine availability not only heightened craving but also decreased the time before individuals started to smoke (Carter & Tiffany, 2001). In a treatment-seeking alcohol-dependent sample, Witteman et al. (2015) found that being exposed to visual representations of alcohol increased craving levels. Taken together, it is suggested that craving is likely more pronounced when individuals with AUD are in environments where alcohol is available. On the other side, MacKillop & Lisman (2005) reported that it is the perceived unavailability of alcohol, instead of availability, that is associated with higher levels of craving. Other literature has not found a relationship between perceived availability and craving (Davidson et al., 2003). Some research found individual differences in the association between alcohol availability and craving. How individuals respond to alcohol availability depends on whether the stimuli are linked to initial alcohol consumption or have

limited or no association (Drummond, 2000). These conflicting findings underlie the complex association between alcohol availability and craving and highlighting interindividual variability in this association.

Concerning the temporal relationship between alcohol availability and craving, Drummond (2001) proposed that perceived substance availability may serve as a more distal stimulus that increases craving. For instance, it was found that within a four-hour alcohol cues increased craving levels (Fatseas et al., 2015). Other research indicates a concurrent relationship between alcohol availability and craving (Volkow et al., 2012; Witteman et al., 2015). However, there is limited research on the temporal relationship between these variables over time, and it remains an underexplored area in the literature. Further, the relationship between alcohol availability and craving may create a self-reinforcing loop. Through repeated alcohol consumption, individuals with AUD may develop incentive salience towards alcohol-related stimuli, resulting in an attentional bias towards these cues (Bollen et al., 2022). Accordingly, Individuals with AUD allocate more attention to substance-related cues, leading to increased craving levels, which in turn increases their focus on these cues (Ryan, 2002; Franken, 2003). Consequently, a reciprocal cycle seems to emerge between alcohol availability and craving: alcohol stimuli capture attention, increase craving levels, thereby enhancing the salience of these cues, and fostering a perception of increased alcohol availability (Field et al., 2008). Despite abstinence goals and motivation to remain abstinent, individuals with AUD may still find themselves caught in this cycle. However, previous research has not thoroughly investigated the temporal association over longer recovery periods.

Further, it was found that reactions to alcohol-related stimuli can fade away over time without additional reinforcement (Conklin & Tiffany, 2002). However, drinking lapses are found to be frequent in the recovery process of AUD (Walton et al., 1994). A lapse can be described as a resumption of drinking following a period of abstinence or reduced consumption, often indicating a setback in recovery from alcohol addiction (Larimer et al., 2004). It can be suggested that incidents of lapses influence craving. For instance, Law et al. (2016) found that lapses led to heightened craving in a group of individuals seeking treatment for alcohol dependence over 12 weeks. In addition, when an individual lapse and consumes alcohol, alcohol availability automatically is more pronounced. It can be expected that alcohol cues would be more frequently observed following drinking episodes than during periods of abstinence, potentially further influencing craving (Cofresí et al., 2023). This, in turn, implies that it is crucial to account for alcohol lapses to control for variability in craving that might be

due to lapses in the relationship between alcohol availability and craving. This is required to comprehend the association between alcohol availability and craving in AUD patients across time.

The Moderating Effect of Positive and Negative Affect

It was found that the capacity of external stimuli in eliciting craving in everyday life is particularly pronounced in specific contexts such as when individuals find themselves in emotional states (Marlatt, 1996, Sinha, 2022). In general, it is widely recognised that affective states play a major role in AUD, potentially evoking alcohol craving due to classical conditioning. This occurs when initial alcohol consumption coincides with a specific mood, or when consuming alcohol serves as a coping mechanism to reduce negative affect (Sinha et al., 2009). Consequently, negative affect may serve as an interoceptive cue that elicits conditioned craving (Poulos et al., 1981). This is supported in a study by Sinha et al. (2009) who found a positive relationship between negative affect and craving in alcohol-dependent individuals. In abstinent individuals, negative affect can further manifest as guilt when an individual, who is trying to stay abstinent, experiences craving (Kavanagh et al., 2005).

Cue-reactivity theoretical frameworks have provided insights into the interplay between affective states, craving, and external cues, but found contradictory results. Accordingly, negative affect has been identified as an additional risk factor, both in naturalistic (Marlatt & Gordon, 2007), and in laboratory observations (Litt et al., 1990). For instance, Cooney et al. (1997) pointed out that negative affect (NA) could establish the affective context wherein the salience of external alcohol cues is intensified, consequently leading to enhanced levels of craving. On the contrary, a study by Mason et al. (2008) examined the interacting effect of both alcohol exposure and affective states on craving but could not find supportive evidence. However, one limitation of this study was the inclusion of only non-treatment-seeking dependent volunteers. It remains unclear how the interaction between NA and alcohol availability influences craving in AUD patients aiming to stay abstinent.

A few studies have found positive affect (PA) to be associated with craving in AUD patients, too. The motivational model of alcohol, states that individuals not only drink alcohol to cope with negative affect, but also to enhance positive affect, and that this behavior is influenced by factors such as sensation seeking (Mason et al., 2008). Positive Affect is seen as both leading to craving (Baker et al., 1986) and resulting from it. Research by Fox et al. (2007) revealed that alcohol-cue-induced craving was associated with decreases in positive affect. In combination with substance-associated cues, craving increased (Veilleux et al.,

2013). Accordingly, as PA and NA appear to play an important role in individuals who try to stay abstinent, the relationship between PA and NA and cue exposure in AUD patients who may still encounter alcohol stimuli in their daily lives is a salient issue that requires investigation. Therefore, NA and PA may potentiate the effect of other environmental stimuli linked to alcohol seeking, which was found in an animal study by Overstreet et al. (2005). Consequently, it becomes crucial to identify and monitor situations involving positive and negative affect, as well as alcohol availability over time, in order to develop effective treatments (Rohsenow & Monti, 1999).

Taken together, previous research suggests that alcohol cues may serve as an important, both distal and proximal predictor for craving and present a significant challenge in AUD patients' recovery process, and that this relationship may be two-sided. This presents a significant challenge for individuals with AUD when treatment resources are not readily available (van Lier et al., 2022). Additionally, considering the substantial influence of PA and NA on craving, it is vital to consider affective states when examining the relationship between alcohol availability and craving. However, past studies have primarily focused on laboratory settings or nicotine addiction. This lacks ecological validity and generalizability to individuals with Alcohol Use Disorder. Furthermore, there is a gap in understanding of how this relationship evolves over time in individuals seeking treatment. Given the omnipresence of alcohol in Western societies and its frequent presence in social settings, it is suggested that abstaining from alcohol becomes particularly challenging (Mellentin et al., 2017). There is a need for research employing alternative methodological approaches to explore how the impact of alcohol availability on craving fluctuates over extended periods. These methodologies are required to identify high-risk situations that allow development for treatment strategies that provide support and guidance in situations when individuals need them.

Experience Sampling Method

One methodology that allows for identifying high-risk situations is called Experience Sampling Method (ESM). It enables the assessment of individual experiences in real-world environments over time. This method allows for the investigation of temporal relationships between variables by repeatedly gathering data over time, and in the individuals' everyday environment (Myin-Germeys & Kuppens, 2022). Typically, participants can utilize their phones to collect data during this process, which enhances ecological validity (Conner & Lehman, 2012). For the present study, ESM offers multiple advantages: (1) It enables the investigation of between-person and within-person variability of alcohol availability and craving in individuals' everyday life (2) It provides a method to investigate the temporal

relationship between alcohol availability and craving, accounting for distal and proximal effects of alcohol availability on craving (3) It reduces recall bias by collecting the data as it occurs.

The Aim of the Present Study

This study aimed to investigate the relationship between alcohol availability, craving and lapse in AUD patients in in-person treatment who are trying to stay abstinent. Further, PA and NA are included as potential moderators. Thus, the following research questions and hypotheses were formulated:

Research Question 1 (RQ1): How are alcohol availability and craving associated overtime in AUD patients aiming to stay abstinent?

H1: Alcohol availability and craving are associated with each other concurrently in both directions over 100 days. The presence of alcohol availability increases levels of craving.

H2: Heightened levels of craving are associated concurrently with increased prevalence of alcohol availability.

H3: Alcohol availability 3 hours prior to the onset of craving will result in heightened craving levels over 100 days.

Research Question 2 (RQ2): How are alcohol availability, lapses and craving associated over time in AUD patients aiming to stay abstinent?

H4: The occurrence of lapses is associated with a significant increase in craving intensity and heightened frequency of alcohol availability. In addition, it is anticipated that there are individual differences in the association between alcohol availability, lapses and craving.

Research Question 3 (RQ3): Is the association between alcohol availability and craving moderated by Positive and Negative Affect in AUD patients aiming to stay abstinent?

H5: Increases in negative affect is associated with higher levels of craving when alcohol availability is present over 100 days.

H6: Increases in positive affect is associated with higher levels of craving when alcohol availability is present over 100 days.

Methods

Study Design

The present study utilizes existing data from a broader study that examined the

relationship between physiology, alcohol craving and lapses during one hundred days of life monitoring (van Lier et al., 2022). Therefore, other variables, such as coping skills or social activities, were investigated, however they were not addressed and will not be mentioned within the scope of the present study. Experience Sampling Methodology (ESM) was used to explore the relationship between alcohol availability, craving, lapses, PA and NA in the AUD patients' daily environment.

The Ethical Committee of the faculty Behavioural, Management and Social Sciences (BMS) of the University of Twente provided ethical approval on February 16, 2024 (request number: 240050). A 100-day data collection period was chosen. This choice aligns with previous literature indicating a 60 % risk of relapse within this timeframe, diminishing to nearly zero thereafter. Accordingly, patients maintaining abstinence beyond 100 days are likely to sustain it for one year or longer. Consequently, a testing period beyond 100 days is unlikely to yield additional insights (Kirshenbaum et al., 2009).

Participants carried their smartphones to answer the questions, increasing ecological validity as it allows for real-time and naturally occurring data collection (Bolger & Laurenceau, 2013). Participants were prompted the questionnaires at regular intervals throughout the day (time-contingent design). During a previous conducted pilot study with the same set of questions in four AUD patients, the time-contingent design was found to place the lowest burden on the participants (van Lier et al., 2017). Additionally, the wording of the questions was adjusted to avoid potentially triggering additional craving.

Participants

Participants were individuals undergoing treatment for Alcohol Use Disorder (AUD) and were recruited between September 2016 and March 2017 from both online (alcoholdebaas.nl) and in-person programs at an addiction care center in the Netherlands. As craving was predicted to be less salient without a clear abstinence goal, participants started the study upon establishing their primary treatment objective of being alcohol abstinent or drinking less, typically six weeks into treatment.

Participants had to agree to the informed consent to be able to participate in the study. Further inclusion criteria were (1) being older than 18 years old, (2) having a moderately or severely DSM-5 diagnosis of use disorder, (3) possessing willingness to participate in the *alcoholdebaas* online or face-to-face treatment, (4) aiming for abstinence or less drinking, (5) owning a smartphone. Exclusion criteria included (1) diagnosis of a psychiatric, schizophrenic, or panic disorder and suicidality, (2) the use of multiple substances excluding nicotine, (3) suffering from epilepsy, (4) cardiovascular or pulmonary disease, (5) pregnancy.

A total of 11 AUD patients participated in the present study. However, one participant withdrew within the first week due to technical challenges.

Materials

Alcohol Availability

Participants were asked to indicate their alcohol availability with three answer options: (1) Not available (2) With difficulty (3) Easily.

Self-reported Craving

To reduce the participants' burden, a single-item questionnaire was used to measure self-reported craving ("*How strong is your craving currently?*"). Participants answered this question on a 0-10 Likert Scale ranging from 0 (No Craving) and 10 (High Craving). The single-item questionnaire was found to be highly correlated with more expansive measurements (Ooteman et al., 2006).

Negative and Positive Affect

To measure participants' positive and negative affect, a valence-arousal scale was used. Participants indicated their valence from negative to positive on the x-axis (-50 to 50) and their arousal from low to high energy on the y-axis (-50 to 50).

Lapse

Lapses were measured as drinking moments and were administered twice daily. The first administration was prompted at the end of every day, where participants were asked to report their activities following any instances of craving, including the option of consuming alcohol. The second registration cue was in the morning, allowing participants to report any drinking episodes. In the case of an individual who had lapsed, they were asked to indicate how many drinks they consumed, however, this information was not used in the present study.

Procedure

In the beginning, participants were asked to provide demographic information. At the end of the study, participants concluded an evaluation interview. Participants had to agree to an informed consent prior to participating in the study. Participants were invited to begin the study after they had established their primary treatment goal of abstinence. This occurred typically six weeks into their treatment, as this was when cravings were anticipated to start occurring (van Lier et al., 2022). Accordingly, participants started the study on different days.

In accordance with the recommendations of the Handbook of Research Methods Studying Daily Living (Csikszentmihalyi, 2011), participants received the questionnaires to

measure alcohol availability, positive and negative affect, self-reported craving, eight times a day at 7, 10, 13, 16, 19, 22, 1 and 4 o'clock. All the questionnaires remained accessible to the participants for one hour. A daily cumulative micro incentive of 1 euro was provided for completing each questionnaire to promote compliance.

Data Analysis

The results were analyzed using the statistical program RStudio (version 2023.3.1.446). The separate individual datasets were merged into one single dataset. Further, the dataset was cleaned. This involved excluding the variables that were not relevant for the present study, deleting duplicates, as well as introducing a binary coding variable for alcohol availability with (1) Available, and (0) Not Available. In addition, positive and negative affect were dichotomized for moderation analysis. Scores below 0 on the x-axis indicated negative affect, while scores above 0 indicated positive affect. For the time variable, a cut-off point of 100 days was introduced to ensure that all participants were examined over the same study duration. Subsequently, to assess the lagged relationship between alcohol availability and craving, a lagged alcohol availability variable (t-1) was created. Furthermore, two participants were considered for exclusion from the analysis due to their low compliance rate. However, sensitivity analysis revealed that removing them did not lead to significant differences in the results. Therefore, it was decided to keep them in the sample. Lastly, descriptive statistics were calculated.

For testing the hypotheses, four two-level linear mixed models (LMMs) using the package “nlme” in R with a first-order autoregressive covariance structure were used. LMMs can handle randomly missing data and account for hierarchical structure of the data (level 1) nested within individuals (level 2). Thus, the first-order autoregressive covariance is included due to its ability to account for the underlying correlation of repeated observations (Viechtbauer, 2022). Thus, the repeated measurements (Time and Participant variable) were treated as random effects in all LMMs, using a random intercept model. The statistical significance of regression estimates was determined using a threshold of $p < .05$.

To test the first hypothesis (H1), alcohol availability was set as the independent variable and craving as the dependent variable. For the second hypothesis (H2) craving was set as the independent variable and alcohol availability as the dependent variable. For the third hypothesis (H3), the lagged variable of alcohol availability (t-1) was set as the independent variable and craving as the dependent variable. For the fourth hypothesis (H4), alcohol availability and lapse were set as independent variables and craving as the dependent variable. For the fifth hypothesis (H5), alcohol availability, positive affect, as well as their interaction

effect were included as independent variables, and craving was set as the dependent variable. For the sixth hypothesis (H6), alcohol availability, negative affect, as well as their interaction effect were included as independent variables, and craving was set as the dependent variable.

Results

Descriptive Statistics

The final sample consisted of 10 participants ($M_{Age} = 40$, $SD_{Age} = 11$), with six male and four female individuals. Table 1 displays the participants' descriptive statistics for their frequency and percentage of compliance, as well as their frequency of lapses and alcohol availability, the average and standard deviation scores for craving and mood. The sample showed diversity in experiences with craving, positive and negative affect, and alcohol availability. For instance, Participant 5 experienced an average craving score of 3.89, a mood score of 31.7 and encountered Alcohol Availability 11 times over time. Whereas Participant 7 experienced a craving score of 1.17, a NA score of 20.4 and encountered alcohol availability 291 times.

Table 1

Overview of Sample Characteristics (N=10)

Participant	Compliance	No. Lapses	No. Alcohol Availability	Mean (SD) Craving	Mean (SD) Mood
1	141 (28.2%)	0	66	1.51 (2.49)	6.25 (17.3)
2	79 (15.8%)	0	77	0.51 (1.40)	2.34 (3.34)
3	330 (66%)	6	187	1.58 (2.78)	14.1 (10.8)
4	282 (56.4%)	6	16	0.37 (1.45)	35.7 (6.36)
5	106 (21.2%)	20	11	3.89 (2.35)	31.7 (18.7)
6	229 (45.8%)	0	174	2.84 (2.90)	3.52 (26.9)
7	440 (88%)	26	291	1.17 (2.82)	20.4 (17.1)
8	331 (66.2%)	16	47	0.81 (1.85)	28.3 (22.2)
9	406 (81.6%)	0	0	0.47 (1.54)	38.6 (21)

10	426 (85.2%)	27	411	1.09 (1.18)	0.07 (21.9)
----	----------------	----	-----	-------------	-------------

H1: The Association between Alcohol Availability (IV) and Craving (DV)

Results revealed a significant, positive association between alcohol availability and craving ($b = 1.43$; $p < .001$, CI [1.17, 1.64]) (Table 2). In Figure 1, a clear trend emerges: in the absence of alcohol, craving steadily declines from 1.3 to zero over the course of 100 days in AUD patients. Conversely, when alcohol is available, there is a slight decrease in craving from 2 to 1.7 on the craving scale across the same time span.

Figure 1

Craving over time by Alcohol Availability across time

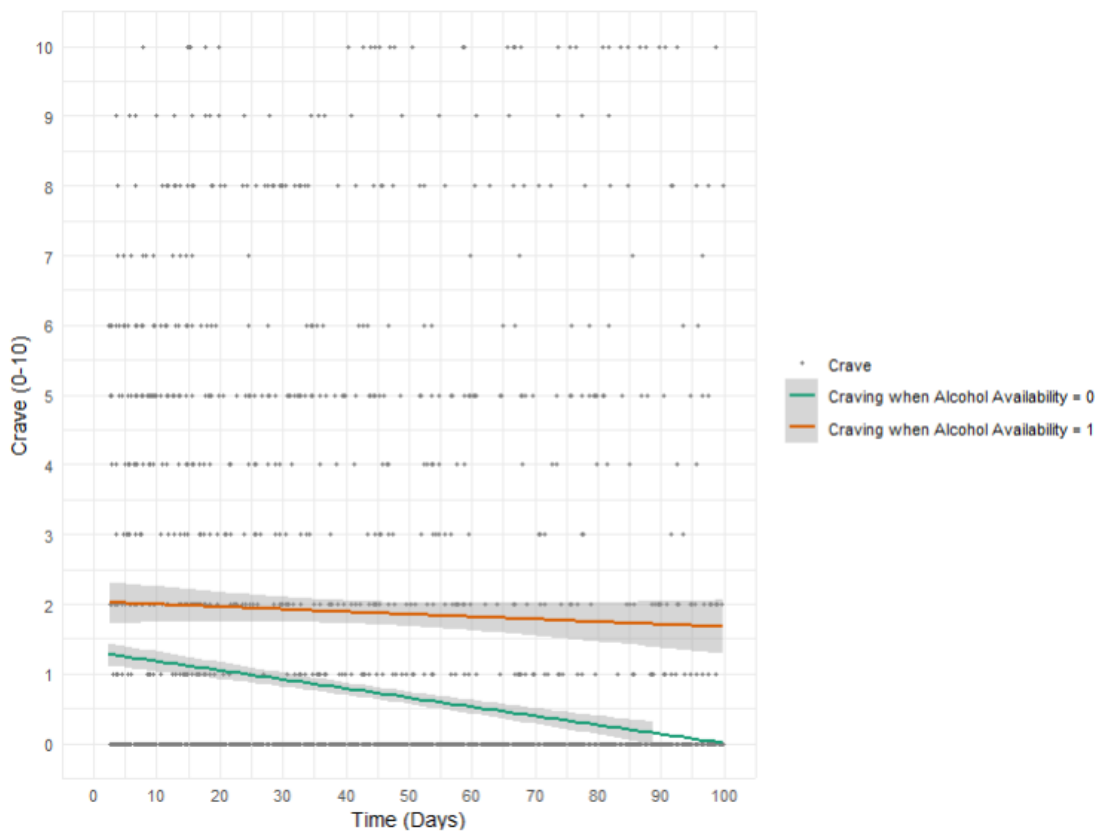


Table 2

Summary of the Results of the Models per Hypothesis

Parameter	Estimate	SE	df	t	p	95% CI	
						LL	CL
H1:							
Availability	1.43	.12	1987	12.18	< .001	1.20	1.66
H2:							

Crave	.04	.00	1987	12.4	< .001	.03	.04
H3:							
Availability t-1	.89	.14	1013	6.06	< .001	.60	1.18
H4:							
Availability	1.25	.11	1986	11.14	< .001	1.03	1.47
Lapse	3.99	.23	1986	17.1	< .001	3.54	4.45
H5:							
Availability	.31	.23	1976	1.37	.171	-0.13	.75
Positive Affect	-1.25	.20	1976	-6.31	.000	-1.64	-0.86
Availability*	.90	.24	1976	3.71	.0002	.42	1.37
Positive Affect							
H6:							
Availability	1.16	.10	1976	11.21	.000	.96	1.36
Negative	1.46	.22	1976	6.78	.000	1.04	1.88
Affect							
Availability*	-.78	.26	1976	-2.97	.0032	-1.28	-0.26
Negative							
Affect							

Note. CI = Confidence Interval; LL = Lower Limit; UL = Upper Limit

H2: The Association between Craving (IV) and Alcohol Availability (DV)

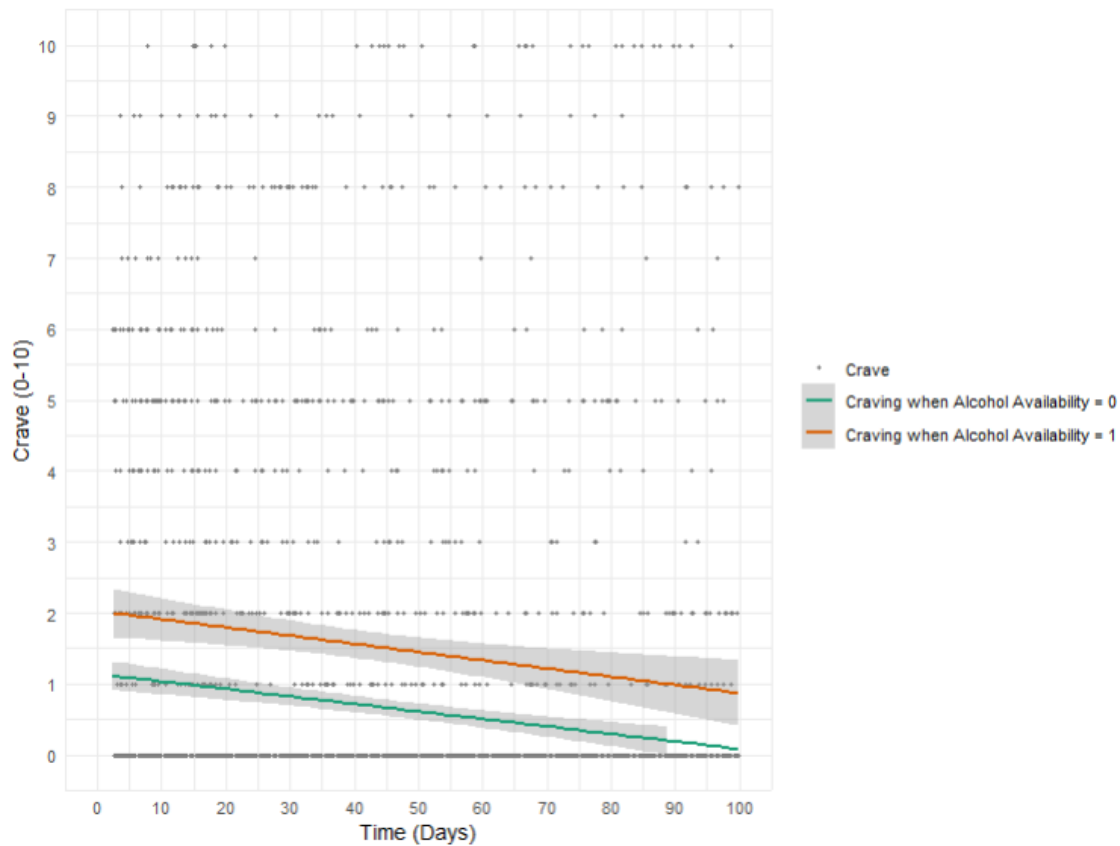
The relationship between craving (IV) and alcohol availability (DV) as the outcome variable was tested. The results indicate a significant relationship ($b = .04$, $p < .001$, CI [0.03, 0.04]) (Table 2).

H3: The lagged Association between Alcohol Availability (t-1) and Craving

Results revealed that alcohol availability three hours prior craving has a positive, significant influence on craving ($b = 0.89$, $p < .001$, CI [0.60, 1.18]) (Table 2). In Figure 2, it is evident that craving decreases over time, both when alcohol was available and absent 3 hours prior.

Figure 2

Craving over time by lagged Alcohol Availability (t-1) across time

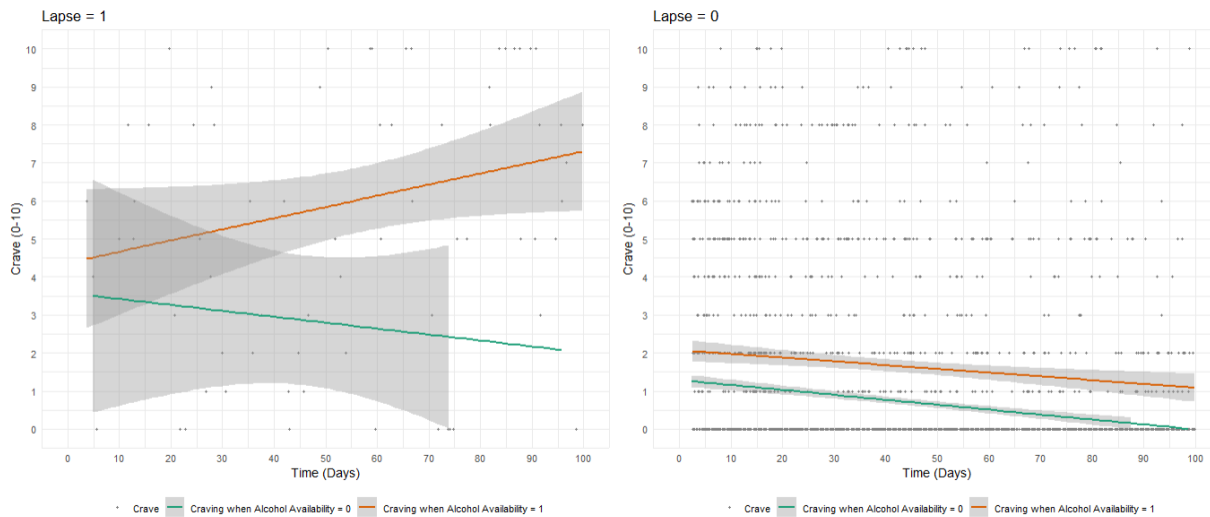


H4: The Association between Alcohol Availability, Lapse and Craving

Including lapses as a covariate in the relationship between alcohol availability (IV) and craving (DV) revealed that lapses had a stronger effect on craving, evident in a 3.99 estimate, compared to alcohol availability ($b = 3.99$, $p < .001$, CI [3.54, 4.45]). Alcohol availability retains its significance as a predictor of craving, despite its effect slightly diminished from 1.40 to 1.25 when including lapse as a covariate (Table 2). In a lapse, craving levels were higher and increased when alcohol was available (Figure 3).

Figure 3

Craving over time by Alcohol Availability when Lapse = 1 and = 0 across time



Within-Person Exploration: Individual Plots

Two participants were chosen to further explore the relationship between alcohol availability and craving on an individual level. The choice was based on their comparably high compliance rate, and their differences in the frequency of alcohol availability.

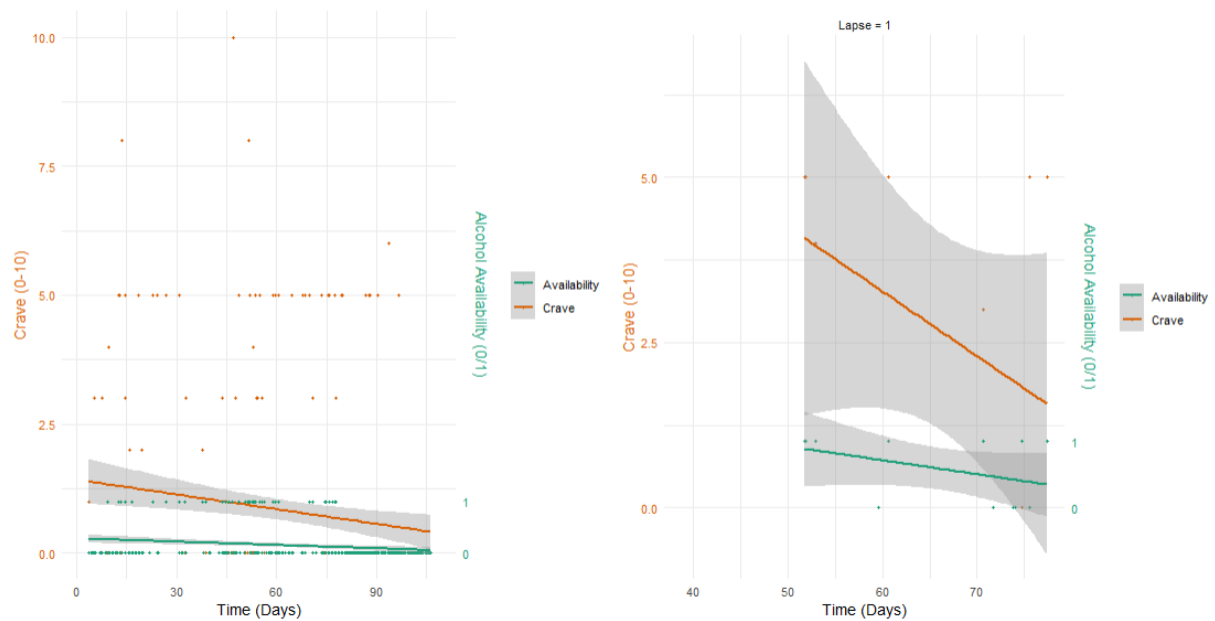
Participant 8

In general, participant 8 demonstrates a mean craving score of 0.81 (SD = 1.85), suggesting relatively low levels of craving compared to the average of the sample. They encountered alcohol availability 47 times over time and had 16 drinking episodes throughout the study. Figure 4 illustrates that this individual's craving decreases alongside a reduced frequency of alcohol availability over time. During periods of relapse, occurring between day 50 and 75, there was a notable decrease in craving alongside a decrease in alcohol availability.

Figure 4

The Relationship between Alcohol Availability and Craving for Participant 8 over time (left),

including Lapse = 1 (right)

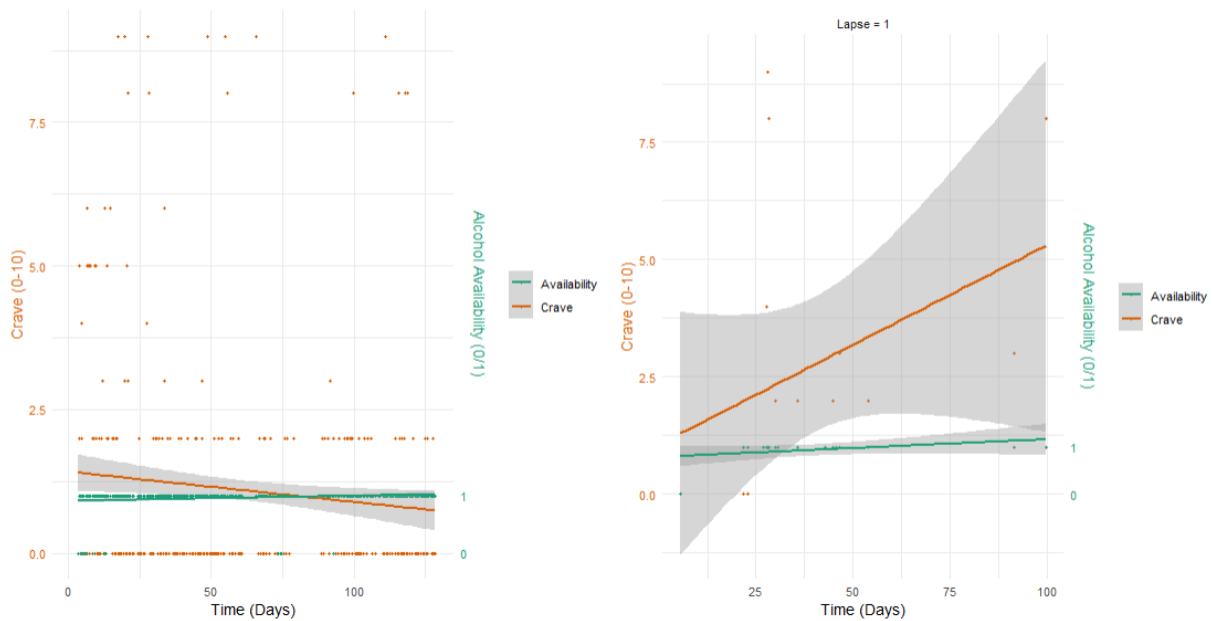


Participant 10

This individual had an average score of craving of 1.09 ($SD = 1.18$) throughout the observation period, slightly lower than the overall sample mean ($M = 1.21$, $SD = 2.37$). They encountered alcohol availability 411 times, the highest count in the sample, with a lapse rate of 27, also the highest. Over the course of this study, this individual encountered alcohol availability frequently and continuously over time, whereas his craving levels decreased gradually from approximately 1.28 to 0.8 on the 0-10 craving scale. Over time, the frequency of alcohol availability seems to increase over time (Figure 5). In times when this individual experienced a lapse, his craving levels increase significantly, and alcohol availability becomes more prevalent.

Figure 5

The Relationship between Alcohol Availability and Craving for Participant 10 over time (left), including Lapse = 1 (right)



H5: The Moderating Effect of Positive Affect

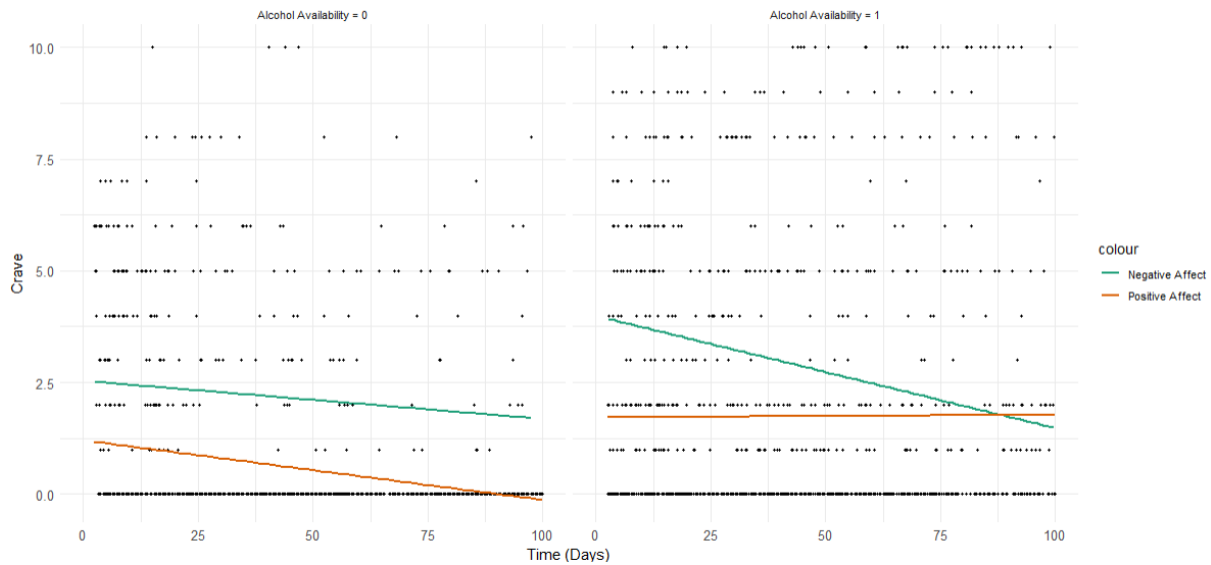
The results of the moderation analysis indicate a significant effect of positive affect as a moderator on the association between alcohol availability and craving ($b = .90$, CI [0.42, 1.37], $p = .0002$) (Table 2). In the presence of alcohol, positive affect marginally increases over 100 days. When alcohol was not available, positive affect decreases to almost zero over time (Figure 6).

H6: The Moderating Effect of Negative Affect

The results of the moderation analysis indicate a significant effect of negative affect as a moderator on the association between alcohol availability and craving ($b = -.78$, CI [-1.28, -0.26], $p = .0032$) (Table 2). In the presence of alcohol availability, negative affect appear to be more pronounced at the start, but gradually decrease over time. When alcohol was not available, negative affect decreased (Figure 6).

Figure 6

The Moderating Effect of PA and NA on the Association between Alcohol Availability and Craving across time



Discussion

The primary focus of this study was to investigate the role of alcohol availability in the dynamics of lapses, craving, and positive and negative affect among individuals with AUD striving for abstinence and undergoing treatment during 100 days. Specifically, it was anticipated that alcohol availability significantly increases craving levels both concurrently and prospectively with a 3-hour lag. Moreover, it was hypothesized that the concurrent relationship between alcohol availability and craving is reciprocal. Further, lapses were controlled for in the concurrent relationship between alcohol availability and craving to provide a clearer understanding of the impact of alcohol availability on craving. Finally, it was anticipated that negative and positive affect moderate the concurrent relationship between alcohol availability and craving.

The Association between Alcohol Availability and Craving

The results of this study found evidence for a positive concurrent association between alcohol availability and craving over a period of 100 days in individuals with Alcohol Use Disorder (AUD) aiming to stay abstinent and undergoing treatment. Alcohol availability increased craving levels in AUD patients concurrently, with participants scoring on average 1.4 points higher on craving when alcohol was available. The present results are consistent with previous research. Witteman et al. (2015) found that among severely alcohol-dependent individuals from the Netherlands, who were enrolled in a detoxification program, exposure to alcohol cues, such as visual depictions of alcohol, resulted in increased levels of craving. However, Witteman et al.'s (2015) findings were limited by experimental manipulation and focused only on alcohol availability depicted in advertisements. The present results extend

previous research by providing an understanding of how individuals with AUD experience craving in their everyday environments.

The present study further supports that alcohol availability has a prolonged and robust effect on craving levels, as observed 3 hours after initial exposure. Accordingly, participants who encountered alcohol availability experienced a notable increase of 0.89 points in their craving levels within this timeframe. While this finding is novel, it partly aligns with previous EMA research by Fatseas et al. (2015). They found that alcohol cues heightened craving levels within a four-hour window over a 2-week period in out-patients undergoing alcohol treatment. Fatseas et al. (2015) distinguished between substance-specific cues (e.g. sight or smell of the substance) and person-specific cues (e.g. factors associated with their substance use history) and only found person-specific alcohol cues to be prospectively associated with increased craving levels. In contrast, the finding of this study suggests that the mere availability of alcohol in patients' environment can already significantly impact craving levels three hours prior and this remains present over a 100 days period. Although the average frequency of alcohol availability and levels of craving decrease, the sensitivity remains. It is worth noting that the strength of the association between Alcohol Availability and Craving in a 3-hour lag is weaker compared to the concurrent association. This indicates that the more time passes from the initial exposure to alcohol availability, the weaker the craving response becomes. However, alcohol availability continues to impact craving levels in patients with AUD three hours after exposure. This is a novel finding and has not been addressed in previous literature, underscoring the importance of considering this prolonged influence when developing treatment strategies.

In addition, the present findings discovered a reciprocal relationship between alcohol availability and craving, however marginally associated with an effect size of 0.3. This suggests that higher craving levels may increase the frequency of encountering alcohol availability in daily life. This novel observation implies that craving may drive alcohol-seeking behavior, possibly leading individuals to unconsciously seek out environments where alcohol is available (Franken, 2003; Field & Cox, 2008). This may be influenced by an attentional bias, a phenomenon seen in individuals with AUD that directs attention towards alcohol-related stimuli due to their associated rewarding nature (Field & Cox, 2008). Franken (2003) suggested that craving induces attentional bias, causing individuals to involuntarily focus on alcohol-related cues. Consequently, they might be more likely to self-select environments containing alcohol cues more frequently, which could further increase their craving levels (Kohen et al., 2023). However, this study did not investigate attentional bias

explicitly, therefore, future research could investigate its role in the association between craving and alcohol availability. Further, considering the weak association between craving and alcohol available, the present finding should be interpreted with caution.

The present outcomes shed light on the persistent impact of alcohol availability on increased craving levels over time among individuals in AUD treatment. Consequently, the concurrent association between alcohol availability and craving remains significant after 100 days. Previous research has not explored or identified this relationship within this timeframe. It may be suggested that individuals acquired incentive salience through repeated alcohol intake, which eventually made individuals more responsive to alcohol-related cues (Berridge & Robinson, 1993). Based on the present findings, it can be inferred that this mechanism persists and continues to impact patients throughout their recovery journey. This underscores the importance of addressing alcohol availability early and throughout the recovery journey of individuals with AUD. Further, this study found that alcohol availability three hours prior affects craving over time, but this influence diminished gradually from 2 to 0.9 on the craving scale over 100 days. It can be suggested that sensitivity to alcohol availability shifts as recovery and treatment progresses, possibly due to the development of alternative coping mechanisms or the association between alcohol availability and craving extinct without reinforcement (Conklin & Tiffany, 2002). Further research is needed to explore this relationship.

The present study provided evidence for a positive relationship between alcohol availability, lapse, and craving. In a lapse, craving levels were higher. When alcohol was available, craving levels increased over time, whereas in the absence of alcohol availability, craving decreased. It is noteworthy that lapses had a stronger effect on craving compared to alcohol availability. However, alcohol availability retains its significance as an influence on craving, despite its effect slightly diminished when including lapse as a covariate. This is in line with previous research by Kohen et al. (2023) who conducted a 21-day EMA study investigating alcohol craving in everyday life. It was found that craving for alcohol significantly increased when participants encountered alcohol cues, such as the sight of alcoholic beverages, throughout a drinking event. However, Kohen et al. (2023) study focused on a sample of healthy young adults, whereas this study examined AUD patients in recovery. The present finding extends existing literature by demonstrating the relevance of the relationships between alcohol availability, lapses and craving within the context of AUD recovery. Therefore, it is worth noting that lapses not only independently influence craving levels but may also alter alcohol availability in the environment. It can be expected that

alcohol availability is more frequent during drinking episodes than during abstinent periods due to lapses' nature (Marlatt & Donovan, 2007). It can be inferred that the relationship between alcohol availability, craving and lapses might be more complex and thus, requires more research on possible mediating or moderating effects of lapses in the association between alcohol availability and craving. This is particularly crucial given the prevalence of lapses during AUD recovery.

Individual observations revealed that participants differed in their craving responses to alcohol availability and lapses. For participant 8, the association between alcohol availability and craving decreased over the course of 100 days. In periods of lapses, craving levels and the frequency of alcohol availability were initially higher but decreased over time. For participant 10, craving levels decreased over time, whereas the frequency of alcohol availability increased. In periods of lapses, both craving and alcohol availability increased over time. Accordingly, this implies that there are individual differences in how alcohol availability and lapses influence craving levels. One possible explanation might be that the context in which alcohol is available influences individuals' craving levels. Accordingly, it was found that the place in which alcohol was consumed might serve as an additional stimulus that further elicits craving. This is highly individual and depends on the specific person who consumed alcohol in a specific context (Valyear et al., 2017). Alcohol availability in terms of depictions in advertisements may differ compared to alcohol availability more physically proximal to the individual, such as seeing a beer bottle on the table. Further, it might be that individuals differ in their coping mechanisms in how to deal with such high-risk situations. Further, experiencing lapses early in the recovery phase might further influence the course of alcohol availability and craving (Law et al., 2016).

The Moderating Effect of Positive and Negative Affect

Further, the present findings indicate that positive and negative affect moderate the relationship between alcohol availability and craving. Firstly, this study observed a relationship between negative affect and higher craving levels in the presence of alcohol availability, consistent with prior research by Sinha et al. (2009). They found that being exposed to alcohol-related stimuli enhanced negative affect that was associated with increased craving levels in alcohol-dependent patients without access to alcohol. Their study, however, was conducted in a controlled laboratory setting with patients lacking regular access to alcohol, resulting in limited applicability to real-world environments. The present outcomes extend existing literature by revealing the influence on momentary alcohol availability and negative affect on craving in AUD patients' real life. These results can be linked to the

premise that the presence of alcohol in the external environment, along with negative emotions as internal indicators, can result in a "high-risk situation". Individuals in this circumstance are more likely to encounter greater alcohol cravings and relapse (motivational model; Tucker et al., 1991). Following this, the model suggests that individuals lack alternative activities and resources to cope with such "high-risk" situations, leading them to regard substance use as the only available and accessible solution (Tucker et al., 1991).

It is worth noting that the interplay between alcohol availability and negative affect decreased over time, unveiling a novel perspective on the dynamic influence of alcohol availability and negative affect on craving. The gradual decrease in this impact over time suggests a positive trend. It indicated that individuals may have developed more effective coping mechanisms for managing negative affect, alcohol availability and craving as they progress through treatment and gain experience with alcohol availability (Witkiewitz et al., 2019). However, more research is needed to identify potential protective factors in the association between alcohol availability, negative affect and craving.

Further, the present findings indicate that, across time, positive affect is associated with higher craving levels when alcohol is available compared to when alcohol is not available. Over time, it minimally increases. This relationship was not observed in AUD samples before and presents an interplay between positive affect and alcohol availability in increasing craving. While prior research by Mason et al. (2008) found a link between positive affect and craving, they did not observe an interaction effect of positive affect and exposure to alcohol cues. However, their study was limited to non-treatment-seeking alcoholics in a lab setting. It is possible that real-life alcohol availability adds complexity to his dynamic. Niaura (2000) suggested that positive affect is linked to an expectation of reward through consumption of this substance. It may be, when alcohol is available and a positive reward is expected, individuals' craving levels increase. However, the effect size of 0.01 in this study suggests a minimal association, therefore this finding needs to be interpreted with caution.

Strengths and Limitations

This study has been the first study that investigated the dynamic relationship between alcohol availability, craving, lapses, and negative and positive affect in treatment-seeking individuals with Alcohol Use Disorder using ESM over 100 days, accounting for fluctuations and exploring within-person variability in the abstinence period. Its design addresses a gap in previous research by examining these variables' temporal and dynamic associations.

However, the study also demonstrated some limitations. First, the small sample size of 10 participants may limit its generalizability to the broader population. Additionally,

participants in this study were recruited from the Netherlands, and therefore, the findings might be affected by cultural factors (Stockwell & Gruenewald, 2004). For instance, alcohol availability as alcohol policies and cultural norms differ across various countries and societies. Whereas in countries such as Germany and Netherlands, alcohol is readily available to purchase in supermarkets or petrol stations, selling alcohol in Australia has been more controlled, leading to a decline in overall alcohol consumption (Stockwell & Gruenewald, 2004). To ensure generalizability, diversity in cultural norms should be accounted for in future research.

Another limitation is the measurement of alcohol availability as a dichotomous construct, which may overlook its complexity, including duration, intensity, and context of exposure (Kohen et al., 2023). This study also relied on self-reported lapses, measured only twice daily, which are subject to recall and social desirability biases. This could potentially lead to inaccuracies. Furthermore, the fixed schedule might cause reactivity, altering participants' behaviour. Lastly, the study measured the relationship between alcohol availability and craving with a 3-hour lag, while craving responses to alcohol cues can be brief, only lasting a few minutes (Drummond, 2001). Future research should consider more frequent assessments over shorter intervals.

Future Directions

Future research should include more questions regarding contextual factors in investigating the relationship between alcohol availability and craving. Hence, participants may be further asked about their social interactions, presence in social environments, or the timing of their activities throughout the day. This would increase the understanding of the multifaceted origin of alcohol availability in daily lives and it could have a positive impact on modifying treatment plans by identifying high-risk situations for individuals recovering from AUD. In addition to this, it would be of great value to investigate the relationship in other cultural contexts to account for differences in cultural norms and policies regarding alcohol purchase and consumption. In relation to that a larger sample size would further increase the generalizability of the findings.

Conclusion

Concluding, it can be inferred that the alcohol availability acts as both an immediate and delayed trigger for craving. Further, a reciprocal relationship between craving and alcohol availability was observed, suggesting that craving may drive individuals to seek out alcohol-containing environments. Furthermore, the study revealed that negative and positive affect strengthen the association between alcohol availability and craving over time. Further, lapses

appear to play a confounding role in the association between alcohol availability and craving. These discoveries shed light on the dynamic nature of these connections, and highlight the persisting influence of alcohol availability on craving over 100 days. Understanding this is crucial for effectively supporting individuals with alcohol use disorder (AUD) who are striving for abstinence and for incorporating it into future treatment strategies. By addressing cravings triggered by alcohol availability during therapy, individuals can experience better management of their cravings, negative affect, and their response to alcohol availability.

References

- Andersson, H., Wenaas, M., & Nordfjærn, T. (2019). Relapse after inpatient substance use treatment: A prospective cohort study among users of illicit substances. *Addictive Behaviors*, 90, 222-228. <https://doi.org/10.1016/j.addbeh.2018.11.008>
- Baker, T. B., Morse, E., & Sherman, J. E. (1986, January). The motivation to use drugs: a psychobiological analysis of urges. In *Nebraska Symposium on Motivation*. Nebraska Symposium on Motivation (Vol. 34, pp. 257-323).
- Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. Guilford press.
- Carter, B. L., & Tiffany, S. T. (2001). The cue-availability paradigm: the effects of cigarette availability on cue reactivity in smokers. *Experimental and clinical psychopharmacology*, 9(2), 183.
- Cofresí, R. U., Bartholow, B. D., & Piasecki, T. M. (2019). Evidence for incentive salience sensitization as a pathway to alcohol use disorder. *Neuroscience & Biobehavioral Reviews*, 107, 897-926. <https://doi.org/10.1016/j.neubiorev.2019.10.009>
- Conklin, C. A., & Tiffany, S. T. (2002). Applying extinction research and theory to cue-exposure addiction treatments. *Addiction*, 97(2), 155-167. <https://doi.org/10.1046/j.1360-0443.2002.00014.x>
- Conner, T. S., & Lehman, B. J. (2012). *Getting started: Launching a study in daily life*.
- Connor, J. P., Haber, P. S., & Hall, W. D. (2016). Alcohol use disorders. *The Lancet*, 387(10022), 988-998.
- Cooney, N. L., Litt, M. D., Morse, P. A., Bauer, L. O., & Gaupp, L. (1997). Alcohol cue reactivity, negative-mood reactivity, and relapse in treated alcoholic men. *Journal of abnormal psychology*, 106(2), 243.
- Csikszentmihalyi, M. (2011). *Handbook of research methods for studying daily life*. Guilford Press.
- Davidson, D., Tiffany, S. T., Johnston, W., Flury, L., & Li, T. K. (2003). Using the cue-availability paradigm to assess cue reactivity. *Alcoholism: Clinical and Experimental Research*, 27(8), 1251-1256. <https://doi.org/10.1097/01.ALC.0000080666.89573.73>

- Drummond, D. C. (2001). Theories of drug craving, ancient and modern. *Addiction*, 96(1), 33-46.
- Drummond, D. C. (2000). What does cue-reactivity have to offer clinical research?. *Addiction*, 95(8s2), 129-144. <https://doi.org/10.1046/j.1360-0443.95.8s2.2.x>
- Fatseas, M., Serre, F., Alexandre, J. M., Debrabant, R., Auriacombe, M., & Swendsen, J. (2015). Craving and substance use among patients with alcohol, tobacco, cannabis or heroin addiction: A comparison of substance-and person-specific cues. *Addiction*, 110(6), 1035-1042. <https://doi.org/10.1111/add.12882>
- Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: a review of its development, causes, and consequences. *Drug and alcohol dependence*, 97(1-2), 1-20. <https://doi.org/10.1016/j.drugalcdep.2008.03.030>
- Field, M., Schoenmakers, T., & Wiers, R. W. (2008). Cognitive processes in alcohol binges: a review and research agenda. *Current drug abuse reviews*, 1(3), 263-279. <https://doi.org/10.2174/1874473710801030263>
- Fox, H. C., Bergquist, K. L., Hong, K. I., & Sinha, R. (2007). Stress-induced and alcohol cue-induced craving in recently abstinent alcohol-dependent individuals. *Alcoholism: Clinical and Experimental Research*, 31(3), 395-403. <https://doi.org/10.1111/j.1530-0277.2006.00320.x>
- Franken, I. H. (2003). Drug craving and addiction: integrating psychological and neuropsychopharmacological approaches. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 27(4), 563-579. [https://doi.org/10.1016/S0278-5846\(03\)00081-2](https://doi.org/10.1016/S0278-5846(03)00081-2)
- Grant, B. F., Chou, S. P., Saha, T. D., Pickering, R. P., Kerridge, B. T., Ruan, W. J., ... & Hasin, D. S. (2017). Prevalence of 12-month alcohol use, high-risk drinking, and DSM-IV alcohol use disorder in the United States, 2001-2002 to 2012-2013: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *JAMA psychiatry*, 74(9), 911-923.
- Grønbaek, M. (2009). The positive and negative health effects of alcohol-and the public health implications. *Journal of internal medicine*, 265(4), 407-420. <https://doi.org/10.1111/j.1365-2796.2009.02082.x>

- Hanson, M. (2023, January 1). Alcohol Abuse Statistics [2023]: National + State Data - NCDAS. NCDAS. <https://drugabusestatistics.org/alcohol-abuse-statistics/>
- Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: the elaborated intrusion theory of desire. *Psychological Review*, 112(2), 446–467. <https://doi.org/10.1037/0033-295x.112.2.446>
- Kendler, K. S., Ohlsson, H., Sundquist, J., & Sundquist, K. (2016). Alcohol use disorder and mortality across the lifespan: a longitudinal cohort and co-relative analysis. *JAMA psychiatry*, 73(6), 575-581.
- Kirshenbaum, A. P., Olsen, D. M., & Bickel, W. K. (2009). A quantitative review of the ubiquitous relapse curve. *Journal of substance abuse treatment*, 36(1), 8-17. <https://doi.org/10.1016/j.jsat.2008.04.001>
- Kohen, C. B., Cofresí, R. U., Bartholow, B. D., & Piasecki, T. M. (2023). Alcohol craving in the natural environment: Moderating roles of cue exposure, drinking, and alcohol sensitivity. *Experimental and clinical psychopharmacology*, 31(1), 57. <https://doi.org/10.1037/pha0000540>
- Larimer, M. E., Palmer, R. S., & Marlatt, G. A. (2004). Relapse prevention: An overview of Marlatt's cognitive-behavioral model. *Psychosocial treatments*, 1-18.
- Law, B., Gullo, M. J., Daghli, M., Kavanagh, D. J., Feeney, G. F., Young, R. M., & Connor, J. P. (2016). Craving mediates stress in predicting lapse during alcohol dependence treatment. *Alcoholism: Clinical and Experimental Research*, 40(5), 1058-1064. <https://doi.org/10.1111/acer.13034>
- Litt, M. D., Cooney, N. L., Kadden, R. M., & Gaupp, L. (1990). Reactivity to alcohol cues and induced moods in alcoholics. *Addictive behaviors*, 15(2), 137-146.
- MacKillop, J., & Lisman, S. A. (2005). Reactivity to alcohol cues: isolating the role of perceived availability. *Experimental and Clinical Psychopharmacology*, 13(3), 229. <https://doi.org/10.1037/1064-1297.13.3.229>
- Marlatt, G. A. (1996). Taxonomy of high-risk situations for alcohol relapse: evolution and development of a. *Addiction*, 91(12s1), 37-50. <https://doi.org/10.1046/j.1360-0443.91.12s1.15.x>

- Marlatt, G. A., & Donovan, D. M. (Eds.). (2007). *Relapse prevention: Maintenance strategies in the treatment of addictive behaviors*. Guilford press.
- Mason, B. J., Light, J. M., Escher, T., & Drobles, D. J. (2008). Effect of positive and negative affective stimuli and beverage cues on measures of craving in non treatment-seeking alcoholics. *Psychopharmacology*, 200, 141-150.
<https://doi.org/10.1007/s00213-008-1192-x>
- Mellentin, A. I., Skøt, L., Nielsen, B., Schippers, G. M., Nielsen, A. S., Stenager, E., & Juhl, C. (2017). Cue exposure therapy for the treatment of alcohol use disorders: a meta-analytic review. *Clinical psychology review*, 57, 195-207.
<https://doi.org/10.1016/j.cpr.2017.07.006>
- Myin-Germeys, I. & Kuppens, P. (2022). *The Open Handbook of Experience Sampling Methodology: A Step-by-Step Guide to Designing, Conducting, and Analyzing ESM Studies* (2nd ed.). Leuven: Center for Research on Experience Sampling and Ambulatory Methods Leuven
- Niaura R (2000) Cognitive social learning and related perspectives on drug craving. *Addiction* 95:S155–S163 <https://doi.org/10.1080/09652140050111726>
- Ooteman, W., Koeter, M. W., Vserheul, R., Schippers, G. M., & van den Brink, W. (2006). Measuring craving: an attempt to connect subjective craving with cue reactivity. *Alcoholism: Clinical and Experimental Research*, 30(1), 57-69.
<https://doi.org/10.1111/j.1530-0277.2006.00019.x>
- Overstreet, D. H., Knapp, D. J., & Breese, G. R. (2005). Pharmacological modulation of repeated ethanol withdrawal-induced anxiety-like behavior differs in alcohol-preferring P and Sprague–Dawley rats. *Pharmacology Biochemistry and Behavior*, 81(1), 122-130. <https://doi.org/10.1016/j.pbb.2005.03.006>
- Poulos, C.X.; Hinxon, R. & Siegel, S. The role of Pavlovian processes in drug tolerance and dependence: Implications for treatment. *Addictive Behaviors* 6:205–211, 1981.
- Rehm, J., & Shield, K. D. (2019). Global burden of disease and the impact of mental and addictive disorders. *Current psychiatry reports*, 21, 1-7.
<https://doi.org/10.1007/s11920-019-0997-0>

- Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain research reviews*, 18(3), 247-291.
- Robinson, T. E., & Berridge, K. C. (2008). The incentive sensitization theory of addiction: some current issues. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1507), 3137-3146. <https://doi.org/10.1098/rstb.2008.0093>
- Rohsenow, D. J., & Monti, P. M. (1999). Does urge to drink predict relapse after treatment?. *Alcohol Research & Health*, 23(3), 225.
- Ryan, F. (2002). Attentional bias and alcohol dependence: A controlled study using the modified Stroop paradigm. *Addictive behaviors*, 27(4), 471-482. [https://doi.org/10.1016/S0306-4603\(01\)00183-6](https://doi.org/10.1016/S0306-4603(01)00183-6)
- Schlauch, R. C., Crane, C. A., Connors, G. J., Dearing, R. L., & Maisto, S. A. (2019). The role of craving in the treatment of alcohol use disorders: The importance of competing desires and pretreatment changes in drinking. *Drug and alcohol dependence*, 199, 144-150.
- Sinha, R., Fox, H. C., Hong, K. A., Bergquist, K., Bhagwagar, Z., & Siedlarz, K. M. (2009). Enhanced negative emotion and alcohol craving, and altered physiological responses following stress and cue exposure in alcohol dependent individuals. *Neuropsychopharmacology*, 34(5), 1198-1208.
- Stockwell, T., & Gruenewald, P. J. (2004). Controls on the physical availability of alcohol. *The essential handbook of treatment and prevention of alcohol problems*, 213-234.
- Subbaraman, M. S., & Witbrodt, J. (2014). Differences between abstinent and non-abstinent individuals in recovery from alcohol use disorders. *Addictive behaviors*, 39(12), 1730-1735. <https://doi.org/10.1016/j.addbeh.2014.07.010>
- Tucker, J. A., Vuchinich, R. E., & Gladsjo, J. A. (1991). Environmental influences on relapse in substance use disorders. *International Journal of the Addictions*, 25(sup7), 1017-1050. <https://doi.org/10.3109/10826089109071032>
- van Lier, H. G., Oberhagemann, M., Stroes, J. D., Enewoldsen, N. M., Pieterse, M. E., Schraagen, J. M. C., ... & Noordzij, M. L. (2017). Design decisions for a real time, alcohol craving study using physio-and psychological measures. In *Persuasive Technology: Development and Implementation of Personalized Technologies to Change Attitudes and Behaviors: 12th International Conference, PERSUASIVE 2017*,

- Amsterdam, The Netherlands, April 4–6, 2017, Proceedings 12 (pp. 3-15). Springer International Publishing.
- van Lier, H. G., Pieterse, M. E., Schraagen, J. M. C., Postel, M. G., Vollenbroek-Hutten, M. M., de Haan, H. A., & Noordzij, M. L. (2018). Identifying viable theoretical frameworks with essential parameters for real-time and real world alcohol craving research: a systematic review of craving models. *Addiction Research & Theory*, 26(1), 35-51.
- van Lier, H. G., Noordzij, M. L., Pieterse, M. E., Postel, M. G., Vollenbroek-Hutten, M. M., de Haan, H. A., & Schraagen, J. M. C. (2022). An ideographic study into physiology, alcohol craving and lapses during one hundred days of daily life monitoring. *Addictive Behaviors Reports*, 16, 100443.
- Veilleux, J. C., Conrad, M., & Kassel, J. D. (2013). Cue-induced cigarette craving and mixed emotions: a role for positive affect in the craving process. *Addictive Behaviors*, 38(4), 1881-1889.
- Volkow, N. D., Wang, G. J., Fowler, J. S., & Tomasi, D. (2012). Addiction circuitry in the human brain. *Annual review of pharmacology and toxicology*, 52, 321-336.
<https://doi.org/10.1016/j.addbeh.2012.12.006>
- Walton, M. A., Castro, F. G., & Barrington, E. H. (1994). The role of attributions in abstinence, lapse, and relapse following substance abuse treatment. *Addictive Behaviors*, 19(3), 319-331. [https://doi.org/10.1016/0306-4603\(94\)90033-7](https://doi.org/10.1016/0306-4603(94)90033-7)
- Weinstein, A., Lingford-Hughes, A., Martinez-Raga, J., & Marshall, J. (1998). What makes alcohol-dependent individuals early in abstinence crave for alcohol: exposure to the drink, images of drinking, or remembrance of drinks past?. *Alcoholism: Clinical and Experimental Research*, 22(6), 1376-1381.
<https://doi.org/10.1111/j.1530-0277.1998.tb03922.x>
- Westman, J., Wahlbeck, K., Laursen, T. M., Gissler, M., Nordentoft, M., Hällgren, J., ... & Ösby, U. (2015). Mortality and life expectancy of people with alcohol use disorder in Denmark, Finland and Sweden. *Acta Psychiatrica Scandinavica*, 131(4), 297-306.
- Witkiewitz, K., Litten, R. Z., & Leggio, L. (2019). Advances in the science and treatment of alcohol use disorder. *Science advances*, 5(9), eaax4043.
<https://doi.org/10.1126/sciadv.aax4043>

Witteman, J., Post, H., Tarvainen, M., de Bruijn, A., Perna, E. D. S. F., Ramaekers, J. G., & Wiers, R. W. (2015). Cue reactivity and its relation to craving and relapse in alcohol dependence: a combined laboratory and field study. *Psychopharmacology*, 232, 3685-3696. <https://doi.org/0.1007/s00213-015-4027-6>