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Instituto de Psicologia
Departamento de Processos Psicológicos Básicos
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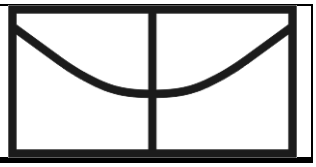

Weight Change During Recovery of Substance Use Disorder: The Role of Delay-Discounting Rate.

Mudança de peso durante recuperação de transtorno por uso de substância: o papel da taxa de desconto de atraso.

Bruna Maria Barbosa da Silva França

Brasília, April 03, 2025

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Resumo

Comportamentos aditivos geram numerosos custos sociais (por exemplo, absentismo e rotatividade no local de trabalho, despesas com os cuidados públicos e despesas com a segurança social). A reabilitação de indivíduos com transtornos por uso de substâncias (TUS) abrange abordagens diversas, como práticas de atividade física, tratamentos psicológicos e farmacológicos, e uma alimentação saudável. A nutrição, em particular, desempenha um papel crucial nesse processo, podendo ser tanto foco do comportamento aditivo quanto uma substituição para outros comportamentos aditivos. Este estudo investiga a relação entre desconto temporal e variação de peso em indivíduos em recuperação de TUS, dividido em duas partes: uma revisão sistemática da literatura e um experimento. A revisão sistemática avalia como a dependência alimentar pode influenciar a recuperação de TUS, contribuindo para o ganho de peso e afetando a probabilidade de remissão. O Experimento analisa a associação entre ganho de peso durante a recuperação, desconto temporal, demanda e status de remissão, utilizando dados de 404 adultos em recuperação (participantes do IQRR). Os resultados indicam que indivíduos que ganharam peso durante a recuperação apresentaram maior demanda máxima (Omax) por alimentos, sugerindo uma maior motivação ou desejo por comida. Além disso, foi encontrado um efeito significativo da taxa de desconto temporal no índice de massa corporal (IMC) para indivíduos com dependência alimentar leve e grave, sugerindo uma relação entre dependência alimentar, desconto temporal e IMC. Esses achados sugerem que a recuperação de TUS pode estar associada a padrões específicos de comportamento alimentar e tomada de decisão econômica, reforçando a necessidade de estratégias que considerem a interação entre esses fatores. Pesquisas futuras devem explorar a interação entre comportamento alimentar, demanda por comida, desconto temporal e mudanças comportamentais associadas ao TUS, em investigações longitudinais da mudança de peso, com o objetivo de aprofundar o entendimento dessas relações.

Palavras-chave: adição por comida, demanda, desconto temporal, obesidade e reabilitação

Abstract

Addictive behaviors yield numerous societal costs (e.g., workplace absenteeism and turnover, public healthcare expenditure, and social security spending). The rehabilitation of individuals with substance use disorders (SUD) encompasses various facets, including engagement in physical activities, psychological and pharmacological treatments, and maintaining a healthy diet. Nutrition, in particular, plays a delicate role in this context, as it can often be the focus of addictive behavior or used as a means to substitute other addictive behaviors. This study aims to investigate the relationship between delay discounting and weight variation in individuals recovering from SUD and is divided into two parts: a systematic review and an experiment. The systematic review examines whether food addiction contributes to the exacerbation of dysfunctional eating patterns, promoting weight fluctuations and negatively impacting the outcomes of SUD recovery. Experiment 1 investigates whether weight gain during recovery is associated with delay discounting, demand, and remission status. Data from 404 adults recovering from SUD, participants in the IQRR, were analyzed. The results indicate that individuals who gained weight during recovery showed a marginally significant increase in maximum expenditure (Omax) for food, suggesting a greater motivation or desire for their favorite snacks. Furthermore, there was a statistically significant effect of delay discounting on body mass index (BMI) for individuals with mild and severe Food Addiction, suggesting a potential link between food addiction, delay discounting, and BMI. These findings suggest that SUD recovery may be associated with specific patterns of economic decision-making, reinforcing the need for strategies that consider the interaction between eating behavior and the decision-making process. Future research should explore the interaction between eating behavior, food-demand, delay discounting in recovery, and behavioral changes associated with SUD, in longitudinal investigations of weight changes, to better elucidate these relationships.

Keywords: food addiction, food demand, delay discounting, obesity, and recovery

Addiction: Definition and Symptoms

The concept of "addiction" has been a topic of considerable discussion and has garnered significant attention throughout human history. Recognized as a critical public health issue with profound psychological and behavioral implications (Gardner, 2011; Ndasauka et al., 2016), addiction encompasses complex interactions between biological, psychological, and social factors that affect decision-making, self-control, and how individuals manage behaviors. These characteristics are particularly relevant to the study of delay discounting, impulsivity, and weight gain during recovery from substance use disorders (Bickel et. al., 2011), which are central themes of this thesis. By understanding the underlying mechanisms of addiction, it becomes possible to investigate how such mechanisms may generalize to other maladaptive behaviors, such as compulsive eating. These interconnections will be explored in greater depth in the following sections.

From a biological standpoint, addiction is often considered a chronic brain disease affecting the reward, motivation, and memory systems (Ndasauka et al., 2016). Gardner (2011) highlights the role of genetic variations that can alter brain reward mechanisms, increasing vulnerability to addiction. Researchers are actively investigating the brain regions involved in addiction and exploring various technologies and procedures to treat, manage, or mitigate its effects (Coussens et al., 2019). Technological advancements have led to interventions like the implantation of electrodes or medication to reduce cravings, depending on the specific substance involved (Wolfe & Saucier, 2021).

The psychological perspective focuses on the enduring use of substances despite their detrimental effects and the self-rules that one cannot function without them (Ndasauka et al., 2016). Building upon this perspective, Clay et al. (2008) characterize addiction as a maladaptive pattern of engaging in substances that induce euphoria, leading to compulsive

and uncontrollable consumption. This description emphasizes the loss of control over substance use and the profound disruption it can cause in a person's life.

The socio-cultural approach complements these perspectives by examining addiction patterns and models within social contexts (Milkman & Sunderwirth, 1995; Ndasauka et al., 2016). Namely, the environment plays a significant role in the development of addiction, as readily available and legal substances like alcohol and tobacco profoundly impact individuals lives (Carvalho et al., 2019; Zou et al., 2017).

This multidimensional perspective provides the theoretical foundation for the present thesis, which investigates how addiction-related mechanisms are associated with decision-making and weight change during recovery from substance use disorders.

Ndasauka et al. (2016) contribute to understanding addiction by highlighting its associated symptoms. These symptoms encompass an inability to consistently abstain from addictive behavior, diminished control over one's behavior, reduced ability to recognize the severity of the problem, intense cravings, and dysfunctional emotional responses. Such symptoms underscore the complex nature of addiction and its impact on various facets of an individual's life. For example, individuals with a family history of addiction, or who are exposed to social and medical vulnerabilities (Moss, 2013), may experience even greater difficulties recognizing the consequences of their behavior, thereby intensifying cycles of compulsive use and emotional dysregulation.

Understanding these vulnerabilities is crucial for exploring how addictive behaviors may manifest beyond drug use, particularly concerning compulsive eating behaviors, which will be addressed in the next section.

Compulsive eating behavior as an addiction

Addiction research efforts are dedicated to understanding different types of addiction, including alcohol use disorders (Moss, 2013; Wang et al., 2020), tobacco (Aonso-Diego et al.,

2021; Freitas-Lemos et al., 2023), opioid misuse (Coussens et al., 2019), and other Substance Use Disorders (SUD) as described in the Diagnostic and Statistical Manual of Mental Disorders, DSM-V (American Psychiatric Association [APA], 2013). However, recent scientific efforts have expanded this framework, suggesting that the addictive potential is not restricted to pharmacological agents but may also apply to highly processed and hyperpalatable foods, which can activate similar neurobiological and behavioral mechanisms (Gearhardt & DiFeliceantonio, 2023; Vasiliu, 2022).

This perspective supports the classification of compulsive eating behavior within an addiction model. Although the term Food Addiction (FA) is not formally recognized in the DSM-V, multiple studies have described parallels between eating patterns and substance use disorders (Eichen et al., 2012; Fletcher & Kenny, 2018; Gearhardt & Schulte, 2021; Gordon et al., 2018), since it was mentioned by Randolph (1956). Individuals with FA often exhibit cravings, loss of control, continued use despite adverse consequences, and tolerance—criteria that mirror those used for diagnosing SUDs (LaFata et al., 2024; Murphy et al., 2014).

Crucially, these behaviors are not solely explained by cultural norms or psychological factors; they reflect a deeper disruption in reward-based decision-making systems. Such mechanisms, traditionally studied in the addiction area, are increasingly applied to understand how some individuals struggle to resist immediate food rewards even in the face of long-term health consequences (Meule & Gearhardt, 2014; Ferrario, 2017). This overlap strengthens the argument that the concept of "addiction" can be expanded to include ultra-processed foods as reinforcing agents, guided by both positive (e.g., pleasure-seeking) and negative reinforcement (e.g., relief from emotional distress or withdrawal-like symptoms) processes (Gearhardt & DiFeliceantonio, 2023). Understanding these maladaptive patterns requires more than a diagnostic label; it calls for an integrative framework that encompasses

neurobiological, cognitive, and social dimensions to clarify how impulsivity, altered reward valuation, and decision-making deficits contribute to compulsive eating (Gordon et al., 2018)

FA can be analyzed as part of a broader spectrum of behaviors and is associated with eating disorders (i.e., clinical diagnoses with specific diagnostic criteria) such as bulimia nervosa (Hauck et al., 2020; Meule & Gearhardt, 2014; Vries & Meule, 2016), anorexia (Granero et al., 2014; Sanchez et al., 2022), and obesity (Ferrario, 2017). The concept of FA has been fueled by the notion that certain foods may possess addictive properties, supported by animal and human research (Avena et al., 2012; Meule & Gearhardt, 2014; Gearhardt & Schulte, 2021; LaFata et al., 2024; Vasiliu, 2022).

By situating FA within the broader addiction framework, this thesis explores how food-related decision-making may reflect altered reward valuation. To investigate these addictive-like eating behaviors more systematically, researchers have developed instruments such as the Yale Food Addiction Scale (YFAS), which is discussed in the following section.

Food addiction: the Yale Food Addiction Scale (YFAS)

FA is defined by behavioral patterns that resemble substance use disorders (SUDs), such as compulsive consumption despite negative consequences, craving tolerance, and withdrawal-like symptoms (Fletcher & Kenny, 2018). These patterns reflect a dysregulation in self-control and reward processing that mirrors addictive behavior. To systematically assess these behaviors, Gearhardt et al. (2009) developed the Yale Food Addiction Scale (YFAS) as a measuring tool for FA based on the DSM-IV criteria with two scoring options: food addiction and diagnosis (see Appendix I). The authors explored the translation of SUD concepts to overeating and discussed future directions (Gearhardt et al., 2009, 2012).

Subsequent studies have utilized the YFAS to investigate FA in various populations. For example, Eichen et al. (2012) examined the prevalence of FA using the YFAS in individual weight-loss treatment-seeking samples utilizing the "diagnostic" and dimensional symptom count. The authors modified the scale to look for symptoms presented over the previous month rather than the previous year to obtain more recent information. A diagnosis was given when an individual had three or more of the seven listed symptoms related to at least one of two questions about an impairment over the previous month. Eichen et al. (2012) reported that fifteen percent of individuals seeking weight loss treatment met the YFAS criteria for FA.

In a complementary study, Murphy et al. (2014) conducted a study to examine the interrelationships between FA, body index-associated impulsive personality traits, and binge eating. The study involved 233 participants who completed the YFAS to assess patterns of FA and the UPPS-P Impulsive Behavior Scale, which measures five domains of impulsivity (Lack of Perseverance, Lack of Premeditation, Sensation Seeking, Positive Urgency, and Negative Urgency). The results revealed that individuals who reported experiencing intense emotions, as measured by the Positive and Negative Urgency subscales, demonstrated more symptoms of binge eating. High impulsivity in youth was found to predict binge eating traits, similar to how impulsivity is associated with various risky behaviors, including substance abuse.

Basso et al. (2022) and Bickel et al. (2018) highlighted the importance of providing individuals the opportunity for self-controlled choice and delayed rewards, which aligns with the delay discounting approach stemming from behavioral economics. Delay discounting refers to the decrease in the perceived value of a reinforcer as the waiting time to receive it increases. In other words, the longer the delay in the delivery of a reinforcer, the lower its subjective value for the individual. (Johnson & Bickel, 2008).

Together, these studies support the utility of the YFAS in capturing addiction-like eating patterns and highlight the relevance of emotional and personality factors in the manifestation of FA.

Food addiction: the Reinforcer Pathology Theory

To better understand the overconsumption of both food and drugs, whether legal (such as alcohol) or illegal (such as cocaine), the Reinforcer Pathology theory (RP), as proposed by Bickel et al. (2011), offers valuable insights. RP theory revolves around two interacting components: demand and delay discounting. According to this theory, individuals with a strong inclination towards smaller, immediate rewards over larger, delayed rewards, in situations where it would be advantageous to receive the larger ones, and with a high demand for unhealthy commodities, are particularly susceptible to experiencing poor health outcomes[1] (Bickel et al., 2023)

The two components of RP, namely demand and delay discounting, play a crucial role in understanding individuals' behaviors, suggesting that FA and SUD share underlying patterns of decision-making. (Deshpande et al., 2019; Epstein et al., 2010; 2021). Studies have shown that individuals who are obese or overweight tend to exhibit a high demand for food commodities, indicating a preference for immediate consumption (Deshpande et al., 2019).

To assess delay discounting, researchers commonly employ multiple-choice trials presenting hypothetical alternatives, varying amounts, and delays (Basso et al., 2022; Bickel et al., 2020; Deshpande et al., 2019). The delay-discounting rate can be determined by examining choices between smaller, immediate, and larger, delayed rewards. Studies with human participants have demonstrated the relevance of delay discounting in understanding

[1] Preferring the smaller, immediate rewards is not necessarily incorrect or disadvantageous, for it depends on the values of the alternatives presented (e.g., preference for U$500 now over U$501 in 6 months is not a maladaptive choice).

temporal decision-making and choices among individuals with substance use disorders (Bickel et al., 2021).

Delay discounting (DD) has been associated with both SUD and conditions characterized by compulsive overeating, indicating a tendency for the value of reinforcers to decrease with increasing delays (Kekic et al., 2020). Individuals with overeating behavior tend to exhibit steeper rates of DD, indicating a high inclination to immediate rewards over delayed benefits, which may contribute to increased energy intake (Basso et al., 2022; Kekic et al., 2020).

Furthermore, DD and FA symptoms have been investigated to understand the relationship between overweight or obesity outcomes during recovery of SUD (Basso et al., 2022; Hodgkins et al., 2003). Studies have suggested that discount rates increase over time during recovery, and individuals with a history of substance use tend to discount delayed rewards to a greater extent than individuals without such a history (Sheffer et al., 2014).

In a study conducted by Basso et al. (2022), the authors investigated the factors influencing the attraction to palatable foods in individuals in recovery from substance use compared to those with no history of substance misuse. The study included 211 participants, with 97 individuals having no substance use disorder (non-SUD) and 114 individuals in recovery. Participants reported their quit date to calculate the number of days in abstinence upon registration and three-monthly assessments to understand recovery phenotypes. They completed assessments monthly, including the YFAS, a hedonic hunger scale, and a delay discounting task. The study's results revealed that recovery patients demonstrated improved outcomes regarding decreased delay discounting, hedonic hunger, and food addiction symptoms compared to the non-SUD group. These findings suggest that recovery from substance misuse may positively influence individuals' decision-making regarding food choices and reduce their susceptibility to hedonic hunger and food addiction symptoms.

Additionally, Basso et al. (2022) examined the relationship between recovery status, body index mass (BMI), delay discounting, and body weight, building upon previous studies by Nolan (2013) and Tang et al. (2019). However, the authors found no significant difference between BMI and delay discounting in the control and recovery groups. Interestingly, both groups exhibited a BMI considered overweight, indicating that BMI alone may not be strongly predicted by delay discounting or recovery status. Although the results suggest that people in recovery often make healthier food choices, there is interest in understanding why some individuals also in recovery make poor food choices, resulting in weight gain during the substance recovery process. In the current study, one of the research inquiries is focused on examining the connection between weight gain following recovery from substance use considering two factors: delay discounting and remission status. Remission status is defined as either complete absence of the substance intake or not meeting diagnostic criteria for substance abuse or dependence, measured by a specified period, such as a minimum of six months, and the duration of follow-up (Fleury et al., 2016).

In the present study, we aim to explore whether FA is also observed in individuals in recovery from substance use disorders (SUDs). Some theories propose that food addiction may represent a transference of addiction from other substances, but consistent data supporting this theory are lacking (Adams et al., 2019; Sussman & Black, 2008).

The present research consists of two key components: a systematic literature review and an experiment. The systematic review aims to examine the relationship between food addiction (FA) and changes in body mass index (BMI) in individuals recovering from substance use disorders (SUDs). Specifically, the review will focus on understanding how FA might influence the recovery process, potentially contributing to weight gain and affecting the likelihood of achieving remission.

The experiment aims to investigate whether weight gain following recovery from SUDs is associated with delay discounting and remission status. The hypothesis is that individuals who experience weight gain after recovery will exhibit greater delay discounting, indicating a propensity to devalue delayed rewards and a lower likelihood of achieving remission. This experiment explores whether weight gain in recovery is linked to altered decision-making processes, particularly in terms of delay discounting.

By conducting the experiment, we aim to gain insights into the relationship between weight gain and delay discounting in SUD recovery. The findings may contribute to a better understanding of the behavioral processes underlying food addiction and inform the development of interventions targeting addictive eating behaviors.

Weight Changes during Recovery of Substance Use Disorder: Systematic Literature Review

SUD presents a significant public health challenge characterized by compulsive substance use despite adverse consequences. While the primary goal of SUD treatment is substance cessation, recovery often presents new challenges, including the emergence or exacerbation of disordered eating behaviors (Rohsenow et al., 2005). These maladaptive patterns, such as food addiction, can complicate recovery and influence both physical and psychological outcomes (Imperatori et al., 2017; Kofman et al., 2010).

A growing body of literature has examined the overlap between substance use and eating disorders, particularly food addiction, which shares neurobiological and behavioral pathways. For instance, highly palatable and calorie-dense foods may activate reward systems similar to those engaged by addictive substances, particularly via dopaminergic signaling (Lutter & Nestler, 2009; Mahboub et al., 2023). Evidence suggests that sugar-rich foods stimulate basic survival-related brain processes, activating reward systems similar to those triggered by substances of abuse (Kenny, 2011; Krupa et al., 2024). These parallels have

raised interest in phenomena such as "addiction transfer" or "cross-addiction," in which food cravings and compulsive eating behaviors emerge as substitutes for drug use, particularly in early recovery phases (Moreno et al., 2009). Notably, these shifts are not solely due to psychological compensation but may also reflect a return of homeostatic hunger after prolonged appetite suppression caused by certain substances (e.g., stimulants).

Moreover, common issues among individuals with SUD, such as nutritional deficiencies, body composition alterations, and hormonal imbalances, also affect food preferences and consumption patterns. Consequently, changes in eating behavior during recovery may be driven by a combination of physiological normalization, psychological dysregulation, and maladaptive reward processing (Moreno et al., 2009).

The Role of Weight Status and Psychological Factors

The relationship between SUD recovery and eating behavior is nuanced and often mediated by weight status. Individuals with higher body mass indices (BMI) may experience recovery differently, with weight influencing their approach to eating behaviors in the absence of substances. For example, those with preexisting overweight or obesity may already have a predisposition to disordered eating, which could worsen during recovery (Cowan & Devine, 2007). Conversely, individuals with lower BMIs might experience weight gain during recovery, potentially triggering or intensifying body dissatisfaction and unhealthy compensatory behaviors.

Eichen et al. (2012) identified that adolescents with normal weight may adopt restrictive eating behaviors during recovery. In contrast, overweight adolescents often exhibit more complex associations depending on the substance previously used and the specific eating behaviors adopted. These distinctions suggest that both weight status and the type of substance involved influence how eating behaviors emerge or shift during recovery.

Psychological factors, such as stress, emotional dysregulation, and trauma history, are central to understanding these dynamic processes (Hardy et al., 2017). For example, individuals with comorbid SUD and post-traumatic stress disorder (PTSD) often report eating disorder symptoms, particularly those linked to weight and shape concerns (Killeen et al., 2015). Depressive symptoms also appear play a key role, particularly among women. Clum et al. (2013) found that depression has been associated with an increased BMI in women, mediated by emotional eating and reduced exercise self-efficacy for physical activity.

Altogether, these findings underscore the importance of considering psychological and weight-related factors in tandem when assessing recovery trajectories, rather than viewing weight gain solely as a consequence of food addiction.

To understand how SUD recovery, eating behavior, and BMI interact requires not only empirical observations but also robust theoretical frameworks for interpretation. The evidence discussed above demonstrates the intersection of biological, psychological, and weight-related factors during recovery. However, frameworks such as Reinforcer Pathology (RP) and Delay Discounting (DD) are useful to gain deeper insights.

Theoretical Framework: Reinforcer Pathology

Understanding the mechanisms that underlie shifts in eating behavior during recovery requires engagement with theoretical models that go beyond descriptions. The Reinforcer Pathology (RP) framework offers a model that characterizes addiction as a disorder that alters reward valuation, leading to a heightened preference for immediate gratification at the expense of long-term well-being (Bickel et al., 2011). A key component of RP is delay discounting (DD), which in turn, measures how individuals devalue delayed rewards, a tendency amplified in those with addictive behaviors. For example, a person in early recovery might prioritize immediate rewards, such as consuming high-calorie snacks, over the delayed gratification of maintaining a balanced diet and a healthy body mass index (BMI). RP helps

contextualize why individuals in recovery might replace substances with other immediately rewarding behaviors, such as overeating (Mellis et al., 2017; Pritschmann et al., 2021).

From a theoretical perspective, this shift toward food-related reinforcement can be seen as a form of behavioral substitution driven by the same altered valuation processes that underlie substance use (DeHart et al., 2020). When the source of immediate reward (e.g., drugs or alcohol) is removed, individuals with high delay discounting may be more likely to seek alternative sources of rapid gratification - like food - due to the persistence of their preference for immediacy. In this sense, maladaptive eating behaviors during recovery may reflect a rechanneling of the same reinforcer pathology that initially sustained substance use (DeHart et al., 2020).

Recognizing this connection has important implications for treatment planning. Approaches targeting emotional regulation and stress management can reduce reliance on immediately reinforcing behaviors, such as overeating, by addressing underlying psychological triggers (Moore et al., 2018; Turton et al., 2017). Additionally, incorporating delay discounting exercises into recovery programs can help individuals to prioritize long-term health over immediate gratification, fostering sustainable recovery outcomes (Moore et al., 2018).

Despite a growing body of evidence, key questions remain unanswered regarding how the mechanisms described in Reinforcer Pathology - such as heightened delay discounting and increased valuation of immediate rewards – contribute to a change in eating behavior during SUD recovery. Specifically, it is unclear whether the shift away from substance use leads to a compensatory reliance on food-related reinforcement, particularly in individuals prone to immediate reward-seeking tendencies. Understanding this mechanism is crucial, as maladaptive eating patterns may, in turn, impact long-term recovery outcomes.

There is a critical unmet need for targeted interventions that address the dual challenges of SUD recovery and eating disorders. Specifically, integrated treatment programs that concurrently address substance cessation and the prevention or treatment of disordered eating behavior, tailored to individuals' weight status and psychological needs, are lacking. This systematic review aimed to explore the literature on the impact of substance use disorder recovery on disordered eating behaviors and associated weight changes.

Given the complex interplay between addiction recovery and Food Addiction, this review seeks to clarify whether drug recovery induces or exacerbates maladaptive eating patterns and contributes to weight fluctuations. By synthesizing the available evidence, this review aims to better understand the potential mechanisms linking substance use recovery with food-related dysfunction and how these may influence long-term recovery outcomes.

Methods

2.1. Literature Search

The search was conducted across Google Scholar, PubMed (National Library of Medicine and National Institutes of Health), Literatura Latino-Americana em Ciências de Saúde (*LILACS*), Embase, Scopus, and Web of Science up until August 20, 2024. The search strategy included the keywords “food addiction,” or “compulsive eating,” or “changes in BMI”, and “substance use disorder,” or “substance use,” or “recovery in SUD.” Studies were included if they reported on (i) substance use disorder recovery outcomes, (ii) diagnoses of Food Addiction or investigating eating disorders, (iii) the association between SUD recovery and eating behaviors, and (iv) any measures related to SUD recovery and changes in BMI. After removing duplicates, 217 studies remained. Titles and abstracts were screened by two independent reviewers (E.S.B. and A.B.B.S.), and 205 studies were excluded at this stage. In total, 12 studies met the inclusion criteria for the review.

2.2. Type of Studies

The review focused on observational and cross-sectional studies, which reported on the recovery outcomes of individuals with substance use disorders (SUD). The review included in the studies ranged from individuals in early recovery to those with long-term abstinence. The primary instruments used for data collection in the selected studies included standardized diagnostic tools for SUD, or the Yale Food Addiction Scale (YFAS) for diagnosing Food Addiction, or self-report questionnaires assessing eating behaviors, cravings, and weight changes (Bunio et al., 2020; Mahboub et al., 2023). Additionally, some studies used biomarkers and clinical assessments of weight and BMI as secondary measures.

To ensure the review captured contemporary research, only studies published within the last five years were included. Studies were limited to peer-reviewed articles published in English. Systematic reviews, editorials, case reports, case series, and findings from clinical trials were excluded to focus on more generalizable data.

2.3. Methodological Challenges and Limitations

While this review provides a focused synthesis of the available literature, several methodological challenges warrant discussion. The exclusion of non-English studies may have limited the scope of findings, potentially excluding valuable insights from non-English-speaking regions. Moreover, the reliance on self-report questionnaires introduces the possibility of response bias, which may affect the reliability of reported eating behaviors and weight changes. Finally, the heterogeneity among studies regarding sample size, study design, and measurement tools posed challenges in directly comparing findings across studies. Acknowledging these limitations is essential for contextualizing the review's conclusions and identifying areas for future research.

Results

The following table summarizes the key studies in this systematic review, including the author(s) and year of publication, study objectives, methodologies employed, and primary findings. Table one offers a clear overview of the evidence base, allowing readers to quickly reference the studies and understand their contribution to the review's conclusions.

Table 1.

Summary of Research That Associated Food Addiction with Recovery from Substance Use Disorder and BMI Change

Author / Year	**Aim**	**Population**	**Methods**	**Independent Variables**	**Dependent Variables**	**Results**	**Effect Sizes/Significance**
Abrantes et al. (2021)	Examine real-time associations between alcohol cravings, sweet cravings, and sweet consumption using EMA.	25 adults (56% women; M age = 40, SD = 10.68) recently discharged from an AUD program.	EMA for 21 days with 4 prompts/day via a mobile app. Mixed linear models tested alcohol and sweet cravings' contemporaneous effects and predictions.	Prompt in different moment of the day to alcohol cravings, sweet cravings, sweet consumption.	Alcohol cravings, sweet consumption.	Alcohol cravings are positively associated with sweet cravings (both between-person and within-person). Sweet consumption predicted higher alcohol cravings later.	$p < .001$ (alcohol and sweet cravings); $p = .008$ (between-person sweet consumption predicting alcohol cravings).

Basso et al. (2022)	Investigate changes in temporal discounting, hedonic hunger, and food addiction during SUD recovery.	101 participants recovering from SUD.	Longitudinal design with pre- and post-recovery assessments of temporal discounting, hedonic hunger, and FA symptoms.	Temporal discounting, hedonic hunger.	Food addiction, SUD recovery.	SUD recovery improved temporal discounting, hedonic hunger, and FA symptoms. Recovery predicted lower FA symptoms and hedonic hunger.	$p < .01$ for changes in FA symptoms and temporal discounting pre- and post-recovery.
Buscemi et al. (2021)	Identify alcohol consumption patterns and obesity-related factors, including economic behavior.	602 emerging adults (M age = 22.63; 47% white, 41.5% black).	Latent profile analysis with anthropometric measures and questionnaires on alcohol, food addiction, and	Alcohol consumption, food addiction symptoms, BMI, impulsivity, environmental	Alcohol consumption patterns, obesity, impulsivity, alcohol demand.	Four profiles identified, with Profile 4 showing high alcohol demand, impulsivity, and reinforcement, linked to severe alcohol and obesity issues.	$p < .001$ (Profile 4 alcohol demand and impulsivity effects).

			economic behavior factors.	reward deprivation, alcohol demand.			
Cabral et al. (2024)	Investigate BMI and negative emotional states (NES) during SUD recovery.	54 men (M age = 34.48, SD = 8.60) in SUD recovery centers.	Univariate and multivariate linear regressions analyzed BMI and NES (stress, anxiety, depression), adjusting for confounders like age and VO2max.	BMI, age, VO2max.	Stress, anxiety, depression.	BMI positively associated with NES. Age and VO2max predicted stress and depression.	$p < .001$ (BMI for stress, anxiety); $p = .002$ (BMI for depression).

Gottfredson & Sokol (2019)	To explore mechanisms behind excessive weight gain during early recovery, testing two hypotheses: the Addiction Transfer Hypothesis and the Propensity for Behavioral Addiction Hypothesis.	111 individuals receiving treatment for substance use disorder (SUD), mean abstinence = 12 months.	Ecological Momentary Assessment (EMA) combined with 24-hour dietary recall; Linear mixed models for testing hypotheses.	Addiction propensity, cravings, substance use history.	Caloric intake, added sugar consumption, weight gain, appetite.	No support for Addiction Transfer Hypothesis; modest support for Propensity for Behavioral Addiction Hypothesis. Addiction propensity predicted increased calorie consumption and added sugar intake, and was associated with increased weight gain and appetite.	Addiction propensity was associated with increased calorie consumption (B = 113.14, SE = 67.20) and weight gain odds (OR = 63.43).

Koball et al. (2018)	To examine addiction shift from substances to food during residential treatment for SUD.	44 participants in residential SUD treatment.	Pre- and post-treatment measures of cravings, impulsivity, depression, anxiety, and food addiction using validated scales.	Pre- and post-treatment cravings, impulsivity, food addiction, BMI.	BMI, YFAS, Food Cravings (FCQ-T), Alcohol Craving (ACQ-SFR), Impulsive Behavior (SUPPS-P), Distress (DTS), PHQ-9, Anxiety Disorder-7 (GAD-7)	Significant decreases in alcohol cravings and depression; no significant changes in food addiction/cravings. BMI increased significantly.	BMI increase $p < .001$; significant reductions in ACQ-SFR ($p < .001$), PHQ-9 ($p < .001$). No change in YFAS or FCQ-T.

Mahboub et al. (2023)	Examine patterns and determinants of weight gain in drug users under rehabilitation in Lebanon.	172 male drug users in rehabilitation or OST.	Multivariate regression analysis adjusting for confounders.	Pre-treatment BMI, lifestyle practices, food addiction.	Weight gain, BMI changes, physical activity, nutrition.	65.1% gained weight; rehabilitation patients showed more weight gain than OST patients. Weight gain negatively associated with pre-treatment BMI and prior treatment attempts.	Significant results for weight gain predictors: pre-treatment BMI ($p = 0.016$) and prior attempts ($p < .001$).
Nolan (2019)	To examine the relationship between SUD treatment status and food selection, and to explore mediators like food craving, emotional eating	212 men and women (104 in SUD treatment, 108 controls)	Online survey where participants chose from 16 food images in a buffet scenario. Analysis of food cravings, emotional eating, impulsivity, and	SUD treatment status, Reward Responsiveness (RR)	Energy selected from food images, BMI	Those in SUD treatment selected more energy from food images ($M = 2655.10$ kcal) compared to controls ($M = 2221.52$ kcal), $t(188) = -2.25$, $p = 0.026$. No significant difference in BMI. SUD treatment status and RR	Small to medium effect sizes for impulsivity, food craving, emotional eating, and number of drugs used. SUD treatment status and RR were significant

	(EE), impulsivity, and reward responsiveness (RR).		drug use as mediators, and RR as a moderator.			were significant predictors of energy selected.	predictors for energy selection (β = 419.58, p = 0.029 for SUD treatment, β = 39.23, p = 0.016 for RR).
Nolan (2024)	To identify mediators between SUD recovery and food selection, and test reward responsiveness.	216 participants (109 in recovery from SUD).	Online buffet scenario assessing food selection, impulsivity, cravings, and psychological mediators.	SUD recovery, impulsivity, food cravings, irrational food beliefs.	Food preferences, energy from selected foods.	Breadth of drug use mediated the relationship between recovery and food selection, impulsivity mediated energy intake. Reward responsiveness was not significant.	Cohen's d for energy intake (0.19), savory preference (0.28); statistically significant p-values for mediating variables (e.g., Sensation Seeking: p = 0.003).

Sinclair et al. (2021)	To examine substitute behaviors, relapse, and abstinence following residential treatment in South Africa.	137 participants (63.5% male; mean age 32.1).	Prospective study with pre- and post-treatment assessments.	Employment status, recovery capital, substance use.	Relapse, abstinence, substitute behaviors.	36.5% engaged in substitute behaviors; 23.4% relapsed. Employment status, living situation, and recovery capital significantly predicted outcomes.	Significant predictors: recovery capital ($\chi2 = 8.96$, $p = 0.011$), employment status ($\chi2 = 6.03$, $p = 0.049$).
Tavares et al. (2021)	To investigate if overweight/obesity influences inhibitory control in patients undergoing treatment for substance use disorder (SUD).	62 adult men under treatment for SUD; mean age: 31.17±8.79; divided by BMI into normal weight (NW,	ANCOVA to compare drug-specific and general commission errors and reaction times, controlling for age, duration of drug use,	BMI (Normal weight vs. Overweight/Obese); Drug-specific and general inhibitory control tasks.	Drug-specific reaction time; General reaction time; Commission errors.	No differences in commission errors. OB group had slower reaction time during drug-specific tasks (520.65±71.39 ms vs. NW: 486.07±51.75 ms, $p=0.03$, $f^2=0.09$).	Drug-specific reaction time: significant ($p=0.03$, $f^2=0.09$); General reaction time and commission errors: not significant. Depression

n=39) and overweight/obese (OB, n=23) groups.	anxiety, and depression	associated with general commission errors ($p=0.004$, $f^2=0.15$).

Urhan & Karadağ, 2023	To evaluate the nutritional status, prevalence of malnutrition, dietary habits, and taste perception in men with substance use disorder (SUD).	90 men with SUD (78 heroin users, 12 cocaine users) and 32 non-users. Conducted at Manisa AMATEM, Turkey.	24-hour food recall, Subjective Global Assessment (SGA), anthropometric measures, and taste detection/recognition thresholds for five basic tastes.	Substance use (heroin/cocaine)	Nutritional status, BMI, diet quality, and taste perception.	50% of SUD participants exhibited mild to moderate malnutrition (SGA-B). Diet quality (MAR: 54.7%) and BMI (21.2) were significantly lower in SUD participants compared to non-users (93.5% MAR, BMI 24.1). SUD group also scored lower in taste recognition thresholds, particularly for sweet and umami tastes. No significant differences in taste detection/recognition thresholds or anthropometric measures between heroin and cocaine users.	Significant differences: BMI ($p < 0.001$), MAR ($p < 0.001$), taste thresholds for most tastes except bitter ($p < 0.05$).

Note. $P < .05$ indicates statistical significance, $p < .01$ indicates strong statistical significance, and $p < .001$ indicates a highly significant association. AUD refers to Alcohol Use Disorder, EMA refers to Ecological Momentary Assessment, VO2max refers to Maximal Oxygen Uptake, YFAS refers to the Yale Food Addiction Scale, EDE-Q refers to the Eating Disorder Examination-Questionnaire, DASS refers to the Depression Anxiety Stress Scales, FCQ-T refers to the Food Cravings Questionnaire-Trait, ACQ-SFR refers to the Alcohol Craving Questionnaire - Short Form Revised, SUPPS-P refers to the Short UPPS Impulsive Behavior Scale, DTS refers to the Distress Tolerance Scale, PHQ-9 refers to the Patient Health Questionnaire-9, GAD-7 refers to the Generalized Anxiety Disorder-7, MAR refers to the Mean Adequacy Ratio, and SGA refers to the Subjective Global Assessment.

Several studies investigate the relationship between substance use and changes in eating behavior, such as weight gain and specific food consumption, during recovery from substance use disorders (SUD). Abrantes et al. (2021) and Gottfredson & Sokol (2019) analyzed the association between alcohol cravings and sweet foods, with both suggesting that sweet food consumption may influence alcohol cravings during recovery. In contrast, Mahboub et al. (2023) and Cabral et al. (2024) addressed weight gain during recovery, identifying factors such as BMI before treatment and negative emotional states as significant predictors of weight gain. Additionally, researchers like Nolan (2019; 2024) and Tavares et al. (2021) explored psychological mediators such as impulsivity and irrational beliefs about food that influence food selection during the recovery process.

Research consistently highlights the complex relationship between substance use disorder (SUD) recovery and food addiction (FA), particularly the role of delay discounting (DD) as a predictor of maladaptive eating behaviors, alongside impulsivity that hinders self-control in both disorders. (Reynolds et al., 2008). Delay discounting, defined as the preference for immediate rewards over delayed gratification, is heightened in individuals with SUD. This behavioral bias is particularly significant when exploring food choices during recovery, as it may predispose individuals to select immediate, reward-rich foods, a propensity that may persist even after recovery begins.

Basso et al. (2022) found that SUD recovery led to improvements in delay discounting and reductions in FA symptoms, suggesting a link between behavioral recovery and reduced maladaptive eating behaviors. Furthermore, changes in hedonic hunger and delay discounting were observed pre- and post-recovery, reinforcing the role of reward-related decision-making in FA behaviors. This indicates that heightened delay discounting

can predispose individuals to maladaptive eating patterns, and the relationship may be bidirectional, with FA potentially reinforcing the preference for immediate rewards.

Another area of interest explores emotional dysregulation and impulsivity as mediating factors in individuals with eating disorders and substance use disorders. For instance, Nolan (2019) found that individuals undergoing SUD treatment selected significantly higher caloric intake in food selection tasks compared to controls, with impulsivity and food cravings emerging as significant mediators of this behavior. This aligns with the findings by Basso et al. (2022), who highlighted the relationship between improved recovery outcomes and reductions in impulsive and hedonic-driven behaviors.

Compounding this issue are decision-making deficits observed in individuals with SUD, which can exacerbate FA and related behaviors. Studies like Gottfredson & Sokol (2019) explored hypotheses around addiction transfer and behavioral addiction propensities, finding that addiction propensity predicted higher caloric and sugar intake, along with increased appetite. These findings underscore the complex interplay of impulsivity, craving, and decision-making in shaping recovery outcomes and maladaptive eating behaviors in SUD populations. These findings also align with the Reinforcer Pathology framework, which posits that, due to high levels of demand and high rates of delay discounting when choosing for reinforcers, individuals may develop vulnerabilities to alternative reinforcers or maladaptive behaviors, including calorie-dense foods, as they recover from substance use (Bickel et al., 2017).

Moreover, BMI changes and negative emotional states during recovery have been consistently documented in the literature. Cabral et al. (2024) identified significant associations between BMI and stress, anxiety, and depression, suggesting that weight gain during recovery may be linked to underlying emotional challenges. Similarly, Koball et al. (2018) observed that individuals in residential SUD treatment exhibited significant increases

in BMI, though no concurrent changes in food addiction symptoms were noted. These findings highlight the multifaceted relationship between emotional states, recovery, and weight changes in SUD contexts.

Alongside emotional factors, the influence of substitute behaviors during recovery has been highlighted. Sinclair et al. (2021) reported that 36.5% of participants engaged in substitute behaviors post-treatment, with recovery capital and employment status being key predictors. This suggests that environmental and social factors significantly contribute to the development of maladaptive behaviors, including unhealthy eating habits. Additionally, Koball et al. (2019) reported that while cravings for substances significantly decreased among individuals in residential treatment for SUD, food addiction and food cravings remained stable. This persistence underscores the unique challenges in managing FA during recovery.

Some studies focus on identifying behavioral profiles and environmental factors that may influence eating behavior and substance use across different populations. For example, Buscemi et al. (2021) identify distinct profiles of alcohol consumption and obesity, while Mallorquí et al. (2023) explore decision-making in clinical groups such as individuals with any SUD, obesity, and gambling disorders. Mahboub et al. (2023) examined weight gain patterns among drug users undergoing rehabilitation in Lebanon. These studies provide valuable insights into the different behavioral patterns that influence eating behaviors and substance use, highlighting the need for targeted interventions to address these complex issues. By exploring these behavioral profiles, researchers can better understand how substance use, eating behaviors, and external factors intersect, leading to more nuanced and effective treatment strategies.

Studies have also investigated the influence of sociodemographic factors on the relationship between SUD, eating disorders, and recovery (Buscemi et al., 2021; Basso et al.,

2022; Cabral et al., 2024; Mahboub et al., 2023). While many of these studies employed robust methodologies, such as longitudinal analysis and mediator testing, some, like Gottfredson & Sokol (2019), faced limitations due to cross-sectional designs and reliance on self-report data. Despite these methodological differences, these studies collectively underscored the importance of considering individual and environmental factors when examining the complex dynamics of SUD recovery and its impact on eating behaviors. Given the complexity of these factors, understanding how they persist during recovery, particularly in relation to food choices, is crucial.

In contrast, Nolan (2019; 2024) observed that individuals in SUD recovery chose foods with significantly higher energy content than those in active treatment, suggesting a lingering influence of reward-seeking behaviors even after initial substance recovery. Psychological factors such as emotional dysregulation and trauma further contribute to the interplay between SUD recovery and FA. Hardy et al. (2017) found overlapping psychological profiles between women with FA and those recovering from SUD, highlighting shared risk factors except for trauma history, which was more prominent in FA. Significant weight changes are frequently observed during SUD recovery, with trends varying by treatment type and individual characteristics. Mahboub et al. (2023) reported that individuals in opioid rehabilitation programs gained an average of 10.6 kg, compared to 2 kg in those undergoing opioid substitution treatments. Weight gain was particularly pronounced in individuals who were underweight or of normal weight before treatment.

Behavioral and cognitive challenges, including impulsivity and distress tolerance, also affect weight management. Tavares et al. (2021) noted slower reaction times on inhibitory control tasks among overweight and obese individuals with SUD, suggesting difficulties in regulating eating behaviors. Food cravings, particularly for energy-dense foods, further complicate weight management and increase the risk of relapse. Abrantes et al. (2021) linked

cravings for sweets to alcohol cravings in individuals recovering from Alcohol Use Disorder (AUD), finding that these cravings heightened the likelihood of relapse.

The psychological interplay between SUD recovery and FA underscores the need for integrated treatment approaches. Studies by Gottfredson and Sokol (2019) and Basso et al. (2022) highlighted the importance of addressing FA in recovery programs. Gottfredson and Sokol (2019) found moderate support for the "Propensity for Behavioral Addiction Hypothesis," suggesting that recovering from substance addiction may increase susceptibility to behavioral addictions like FA. In contrast, Basso et al. (2022) observed improved cognitive function and reduced FA symptoms in individuals recovering from SUD, suggesting that cognitive improvements during recovery may mitigate food-related risks.

Discussion

This review highlights the intricate interplay between substance use disorder (SUD) recovery and food addiction (FA), with significant implications for maladaptive eating patterns, weight fluctuations, and long-term recovery outcomes. By synthesizing evidence, this discussion seeks to elucidate potential mechanisms and inform future research and treatment approaches.

The findings emphasize delay discounting (DD) as a central mechanism linking SUD recovery and maladaptive eating behaviors. Individuals with SUD exhibit a heightened preference for immediate rewards, which may persist during recovery and extend to food-related choices. This aligns with the Reinforcer Pathology framework, which posits that recovery from substance use increases susceptibility to alternative reinforcers and overvaluation of certain commodities contributes to maladaptive behaviors, including substance abuse and overeating, such as highly palatable foods (Bickel et al., 2011; 2017) and may exacerbate vulnerability to food addiction (FA) (Basso et al., 2022; Kekic et al., 2020). These results suggest that interventions targeting impulsivity and decision-making deficits

could mitigate or reduce the risk of FA and associated maladaptive eating behaviors (Mallorquí-Bagué et al., 2016). Importantly, some evidence suggests that individuals in recovery from SUD may show reductions in delay discounting over time, indicating improved valuation of long-term rewards. Rather than contradicting the Reinforcer Pathology framework, this could reflect neurobehavioral changes fostered by abstinence or treatment, highlighting the potential of targeted interventions to reverse reward-based vulnerabilities. To address this, future interventions could incorporate DD assessments into SUD treatment plans and integrate therapies that improve self-regulation and food-related decision-making, such as behavioral therapy approaches or training to change decision-making (e.g., Episodic Future Thinking, EFT [Ruhi-Williams et al., 2022]).

A notable finding is the persistence of FA even as substance cravings diminish (Kekic et al., 2020). Reward responsiveness to food remains heightened, complicating recovery trajectories. This suggests that while traditional SUD treatments effectively reduce substance cravings, they may inadequately address overlapping psychological risk factors shared by FA, such as emotional dysregulation and trauma. Integrating trauma-informed care and emotion regulation strategies into SUD treatment may address these vulnerabilities and improve outcomes for both conditions (Basso et al., 2022; Cabral et al., 2024). To overcome this limitation, future research and treatment approaches should consider the development of dual-diagnosis programs that target both SUD and FA concurrently. These programs should include trauma-informed care, emotion regulation strategies, and nutrition education tailored to individual needs as recommended by Cabral et al (2024).

Significant weight changes, particularly weight gain, are prevalent during SUD recovery, further complicating the process (Cabral et al., 2024; Tavares et al., 2021). Evidence indicates that weight gain is most pronounced in individuals who were underweight or of normal weight before treatment. Psychological factors such as impulsivity and distress

tolerance exacerbate these fluctuations, underscoring the importance of weight management strategies within SUD recovery programs (Nolan, 2024; Cabral et al., 2022). To counteract this issue, future studies and clinical interventions should incorporate personalized weight management strategies, including behavioral interventions that target cognitive and emotional factors influencing eating and weight control. Regular dietary assessments, behavioral coaching, and peer support groups could provide continuous support for effective weight management.

The bidirectional relationship between SUD recovery and FA underscores the need for integrated treatment approaches to prevent the substitution of one addictive behavior for another (Gottfredson & Sokol, 2019; Kim et al., 2021). Nutrition counseling, therapy addressing maladaptive eating, and interdisciplinary interventions could form a comprehensive framework for managing FA and supporting SUD recovery (Wiss et al., 2021; Chavez & Rigg, 2020;). Tailored interventions should also account for individual weight status and vulnerabilities to maladaptive eating behaviors. Group-based therapies fostering peer support and addressing shared challenges, such as cravings and emotional regulation, may further enhance recovery outcomes (Bunio et al., 2020). In response to this challenge, clinical programs should focus on integrated approaches that address both SUD and FA concurrently, ensuring that food-related issues are not overlooked. Programs should also include group therapies to support social and emotional regulation, which can reinforce individual behavioral changes.

Despite the insights provided by this review, several limitations in the reviewed studies warrant attention. The reliance on self-report measures introduces potential biases, and the cross-sectional designs limit causal inferences. Heterogeneity in sample characteristics and measurement tools further complicates comparisons across studies (Basso et al., 2022; Koball et al., 2019; Mallorquí-Bagué et al., 2016). Future research should

prioritize longitudinal designs to explore the temporal relationship between SUD recovery, FA, and weight changes over time (Basso et al., 2022). Standardizing assessment tools for FA and SUD, such as validated delay discounting tasks and diagnostic measures, is critical for enhancing comparability across studies (Basso et al., 2022; Kekic et al., 2020; Mallorquí-Bagué et al., 2023). Exploring the biological mechanisms underlying FA during SUD recovery, including neural reward pathways, hormonal influences, and genetic predispositions, could provide deeper insights into the shared vulnerabilities between these conditions. Additionally, targeted research on integrated interventions—such as multi-modal treatment models combining nutritional counseling, behavioral therapy, and pharmacological approaches—can inform best practices for managing FA and SUD concurrently. Finally, population-specific investigations are needed to address the unique challenges faced by subgroups such as women, adolescents, and individuals with comorbid psychiatric conditions, offering tailored strategies for effective recovery support.

Building on the insights gained from the systematic review, which underscored the interplay between food addiction and recovery from substance use disorders (SUDs), the experiment, described below, empirically investigated key behavioral mechanisms identified in the literature. Specifically, the study examined the relationship between weight gain, temporal discounting, demand, and remission status in individuals recovering from SUDs. By transitioning from a broad synthesis of existing evidence to targeted experimental research, this investigation aimed to deepen our understanding of the behavioral processes underlying recovery and provide actionable insights to inform the development of effective interventions.

Experiment

During various stages of recovery from substance addictions, weight changes have been observed among individuals, highlighting the complex relationship between substance

use, food, and eating behaviors (Gottfredson & Sokol, 2019). Cowan and Devine (2007) indicated that individuals often change their weight as part of a compensatory mechanism following activity addiction.

To better understand the relationship between weight gain and treatment for SUDs, several studies have employed different strategies to assess body changes (e.g., collecting BMI data, ingredients, and amount of food eaten, food craving, weight, and treatment period, comparing theories such as addiction transfer and propensity for addiction) (Hodkings et al., 2007; Gottfredson & Sokol, 2019). Hodkings et al. (2007) conducted a study to investigate the association between supervised drug abstinence and increased weight gain among adolescents receiving treatment at a residential substance abuse treatment center. The researchers examined weight and BMI over time, focusing on the interaction between smoking and weight change. The results indicated that weight and BMI exhibited statistically significant changes during treatment, with notable gains observed primarily within the first 60 days. This finding suggested that individuals in early recovery experienced significant weight gain.

Cowan and Devine (2007) conducted a study involving 25 men in recovery, categorizing them into three distinct stages: Early (1-6 months), Mid (7-13 months), and Later recovery (14-36 months). The findings revealed that during early recovery, almost all participants experienced weight gain over short periods, while over time, they desired to lose the excess weight gained during recovery. These results demonstrated the interconnectedness of food, substance abuse, and weight changes, presenting opportunities for weight interventions during recovery.

Gottfredson and Sokol (2019) further investigated the factors contributing to weight gain during recovery. They tested two explanations: (a) "The Addiction Transfer Hypothesis", which suggests that individuals recovering from substance use disorder may

substitute one addiction (e.g., cigarette) for another (e.g., compulsive eating), leading to weight gain; and (b) "Propensity for Behavioral Addiction Hypothesis, which posits that some individuals may have an underlying tendency toward multiple addictive behaviors due to common risk factors, such as immediate reward preferences." Their study involved 111 participants recruited from recovery clinics. The participants provided information on nutritional outcomes, cravings, substance use, impulsivity, food addiction symptoms, weight changes, and changes in appetite during recovery. The results did not support the Addiction Transfer hypothesis; however, individuals with a family history of addiction reported more food addiction symptoms and tended to consume more calories and sugar. According to the authors, these findings suggested that genetic factors and predisposition to addictive behaviors may affect weight changes during recovery. It is important to note that while the authors attribute these findings to genetic factors, they do not explicitly control for the influence of learned behaviors within the family environment. Thus, the observed relationship between family history of addiction and food addiction symptoms could also be explained by environmental factors, such as shared eating habits and coping strategies within families. Further research is needed to disentangle genetic influences from familial and social learning mechanisms in weight changes during recovery.

By considering the components of RP Theory and its implications in temporal decision-making, along with the association between temporal discounting, Food Addiction (FA) symptoms, and overweight/obese outcomes during recovery, an experiment was conducted that aimed to investigate the relationship between weight gain, temporal discounting, and substance use status remission. The hypothesis proposes that weight gain would be linked with a higher delay discounting and a reduced probability of remission. This study compared individuals' substance use disorder (SUD) remission status at different time points and analyzed the relationship between changes in their body weight and temporal

discounting. By examining these factors, the experiment seeks to better understand the intricate dynamics among weight changes, intertemporal choices, and recovery outcomes in individuals who have undergone substance use recovery.

The Reinforcer Pathology Theory (RP) integrates behavioral economics and addiction neuroscience to explain how excessive valuation of immediate rewards at the expense of future benefits contributes to maladaptive behaviors. RP suggests that a shorter temporal integration window, measured by delay discounting (i.e., the depreciation of a reward's value as its receipt is delayed), is associated with a heightened valuation of immediate reinforcers, such as substances or high-calorie foods, and a diminished valuation of long-term reinforcers, such as prosocial and healthy activities (Bickel et al., 2019). In addition to delay discounting, RP employs behavioral demand measures to assess the intensity and persistence of desire for specific reinforcers. These measures include: (a) elasticity of demand (i.e., the change in substance consumption as cost increases); (b) Intensity (i.e., consumption of a substance when freely available); (c) Omax (i.e., maximum expenditure an individual is willing to make to obtain the substance or commodities); (d) Breakpoint (i.e., maximum price an individual would pay for a single unit of the substance); and (e) Pmax (i.e., the point at which consumption moves from being inelastic to elastic). Demand provides a different perspective on an individual's preferences for specific reinforcement, characterizing distinct aspects of the demand curve (Athamneh et al., 2018).

The RP has been widely applied to substance use disorders and obesity, making it a suitable framework for investigating weight gain during recovery. This study extends RP by hypothesizing that weight gain in individuals recovering from SUDs is associated with higher temporal discounting (i.e., preference for immediate gratification over long-term benefits) and a reduced probability of remission.

Given that prior literature has identified temporal discounting as a key factor in both substance use and overeating behaviors, this study seeks to examine whether individuals with greater discounting tendencies are more likely to gain weight and experience difficulties in sustaining remission from SUDs. This will be accomplished by comparing individuals' SUD remission status at different time points and analyzing the relationship between changes in their body weight and temporal discounting, grounding itself in RP. By examining these factors, the experiment seeks to better understand the intricate dynamics among weight changes, intertemporal choices, and recovery outcomes in individuals who have undergone substance use recovery.

Method

Participants

Individuals were recruited through the International Quit and Recovery Registry (IQRR)[2], an online community for individuals around the world in self-reported recovery from substance use or behavioral addictions. At the first moment, participants completed a screening with an initial assessment to collect demographic information, history of substance use, and recovery. Participants earned a predefined number of points for each assessment completed, depending on the length of the assessment, and every 100 points could be exchanged for $1.00.

Inclusion and Exclusion Criteria. Participants were selected according to the following criteria: (a) age above 18 years old; (b) reside in the United States; and (c) at least three months in recovery. Individuals should meet all inclusion criteria to be eligible to participate. The exclusion criteria were: (a) experiencing psychiatric conditions and (b) participants who had difficulty comprehending the instructions of the questions. These

[2] For more information visit https://www.quitandrecovery.org/

criteria were defined considering previous studies (e.g., Basso et al., 2022) and to ensure that the results obtained could be attributed to experimental manipulation rather than other variables.

A total of 723 participants were in the original sample. After data preprocessing and cleaning the final analytical sample included 404 participants. Those participants had a mean age of 42.73 years (*SD* = 11.36), which represents a predominantly middle-aged population, and a mean of 14.08 years of education (*SD* = 3.94), which indicates that the majority of participants had at least a college education. Our sample was also predominantly female (64.1%), followed by males (35.6%), and a small fraction which identified as other (.2%); largely White/Caucasian (81.9%), followed by Blacks or African Americans (7.7%), Multiracial (4.5%), American Indians or Alaska Native (3.0%), Asians (2.2%), and other races (.7%); and, predominantly lower to middle-income population, with 51.0% earning between $0-30k per year, 19.6% between $30k-50k per year, 20.3% between $50k-100k per year, and 9.2% earned more than $100k per year. Finally, 75.0% (303 individuals) reported experiencing three or more Substance Use Disorders (SUDs), indicating a significant presence of individuals with complex health profiles, 12.6% (51 individuals) reported two SUDs, while 12.4% (50 individuals) reported one SUD.

Materials

Demographics. Demographic data were collected in IQRR's initial assessment, such as age, gender, race, ethnicity, education, and income. Usually, age is calculated in the IQRR by subtracting the participant's year of birth from the year the assessment is completed.

Stunkard Figure Rating Scale. This scale shows ten different silhouettes and asks participants which one is more similar to their body at three points: (a) six months before the beginning of recovery, (b) six months ago, and (c) right now (see Appendix C). The weight

information (i.e., choose silhouettes) was asked of participants at the beginning of the survey; thus, weight change can be noted from the quit date and at present (Stunkard et al., 1983).

DSM-V Criteria. DSM-V criteria was used to observe if participants adhere to the criteria for substance use disorders (APA, 2013). They were questioned about which substances they are in recovery from, followed by the time-related questions, for example: "When you used each of the following substances, did you end up using more OR for a longer time than you planned? Has this been true in the past 90 days (3 months) for any of the following? Please answer Yes or No for each listed substance(s)" and were presented with all the categories of substance use described in the DSM V, such as Nicotine, Cannabis products, Cocaine, Opioids, Stimulants, etc (see Appendix D).

Quit date. Participants were asked about their quit date by stating when they last consumed or used any substance.

Snack Choice and Portion. This questionnaire assesses the preference and the portion showing some snack options to participants (Freitas-Lemos, Unpublished). They were presented with the question: “Please choose your favorite snack item”, and were presented with eight options of snacks (e.g., Doritos, Oreo, Ritz, Reese’s, Lay’s, Chips Ahoy, Cheetos or M&M’s). Subsequently, they were asked to choose one of the options with approximately 20g (It will show pictures of the amount of their favorite snack on a plate compared to the equivalent of the total of the pack). These preferences were used in the delay discounting task (cross-commodity) (see Appendix E).

Brief Assessment of Snack Demand. This 3-item scale measured three of the most widely used indices of snack demand: intensity, Omax, and breakpoint (e.g., Owens et al., 2015). These indices all provide a different way of understanding an individual’s demand for snacks by characterizing other aspects of an individual’s demand curve. Adapting the task developed by Owens et al. (2015), the (a) intensity was measured using the question “If your

favorite snack was free, how many servings would you have?"; (b) Omax was measured using the question "What is the maximum total amount of money that you would spend on your favorite snack (approximately)?" and (c) breakpoint was measured using the question "What is the maximum amount of money you would pay for a single serving of your favorite snack?". Participants were oriented to answer the questions considering that the number of snacks must be consumed in 24 hours, without saving them for later (see Appendix F).

6-trial - Delay Discounting (cross-commodity). These tasks required participants to indicate a preference between an immediately available amount of one commodity (snack) and a delayed amount of a different commodity (money) (Freitas-Lemos, Unpublished). This task assessed snacks now (at the time of answer) vs. money later. The snack was presented with repeated choices between a fixed amount of snack now *versus* a worth $1000 in adjusted delays (see Appendix G).

5-trial - $1000 minute Task. This delay discounting task examined the devaluation of monetary rewards as a function of delay to their receipt. These computerized assessments present hypothetical choices between smaller, sooner and larger, later rewards available at a range of delays (i.e., Which would you rather have? $500 now or $1000 in 3 weeks). The amount of the larger reward is adjusted until the participant reports that they are indifferent between the two options, meaning that they view the immediate and delayed rewards as equally valuable (Koffarnus & Bickel, 2014). The IQRR updates the participant's data every three months. Respondents were to address these queries only if they had not provided answers within the IQRR library/repository within the last three months (see Appendix H).

Yale Food Addiction Scale. This scale was valuable for assessing addictive-like eating behaviors towards specific foods. Developed based on the DSM-IV diagnostic criteria for substance dependence in the DSM-IV (APA, 2000; Gearhardt et al., 2009), this scale provides a validated measure to explore the presence of potential food addiction. Comprising

25 items, the YFAS evaluates criteria such as persistent desire, clinically significant impairment, and unsuccessful attempts to quit, aligning with the diagnostic criteria for substance dependence (see Appendix I).

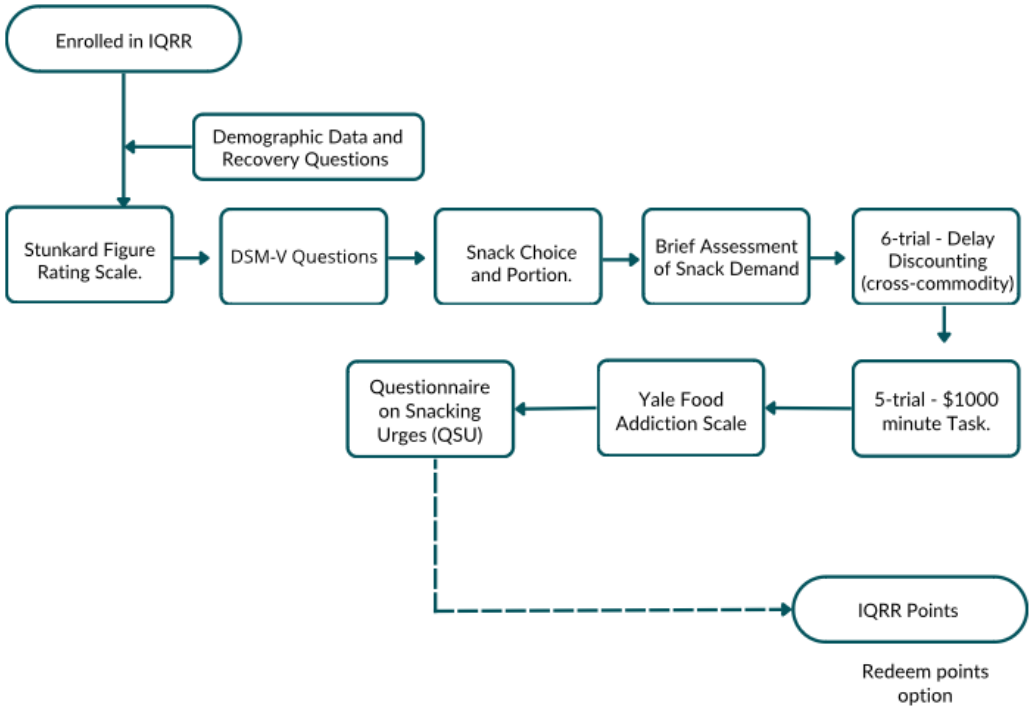
The Yale Food Addiction Scale uses two scoring options: food addiction and diagnosis. Participants were assigned a symptom score from 0 to 7, corresponding to the number of confirmed DSM-IV diagnostic criteria. Three or more symptoms are consistent with DSM-IV diagnoses of substance dependence. The YFAS is considered a trustworthy tool to confirm or refute the existence of food addiction and may help design appropriate treatments (Pursey et al., 2014).

Procedure

Initially, participants were presented to the Consent Form. After agreeing with the terms, they needed to complete a demographic and the recovery history question (i.e., quit date, last time that used, etc). Next, they were presented with the Stunkard Figure Rating Scale, DSM-V criteria for the last three months (to be explained in the Materials section). Following these questionnaires, participants completed the Snack Choice and Portion (e.g., choosing their favorite snack), Brief Assessment of Snack Demand, 6-trial Delay-Discounting (cross-commodity), and a $1000 minute Task. In conclusion, participants answered the Yale Food Addiction Scale. The entire study, including the initial questionnaire and task completion, took approximately 25-30 minutes to complete (an effective rate of 200 points) (see Figure 1).

Figure 1

Flow of Tasks Completed by Participants.



Data Quality Assurance. Two Captchas were applied before the screening (i.e., a security measure known as response authentication). Two quality control questions immediately followed by the delay discounting task (screening to select individuals who met the inclusion criteria, and the primary survey with the complete questionnaire, i.e., "Do you prefer $100 in one day or $0 now?" and "Do you prefer $0 in one day or $50 now").

Data Analysis

This study comprehensively analyzed demographic factors and their impact on various health outcomes, including weight change, remission status, substance use, and delay discounting. Demographic variables, such as race, income, and sex, were summarized using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Data were compared between groups using Fisher's exact test (for dichotomous data) and a t-test (for continuous data) to assess differences in demographic factors across participants.

Linear regression analysis was employed to evaluate the intragroup association between weight changes (independent variable) and delay discounting (dependent variable). This statistical technique investigates the linear relationship between continuous independent and dependent variables, and in this case, it assessed how weight changes are related to variations in delay discounting (Johnson & Bickel, 2008). Additionally, logistic regression was used to examine the relationship between weight changes (independent variable) and SUD remission status (dependent variable). Logistic regression is particularly suitable for analyzing relationships with binary outcomes, such as remission status (e.g., remission vs. non-remission). This analysis helped determine whether weight changes are associated with the likelihood of remission from substance misuse.

Demand was analyzed by considering intensity, Omax, and breakpoint to characterize the demand curve. The Yale Food Addiction Scale (YFAS) was used to categorize the presence or absence of food addiction (FA), with one or no symptoms indicating no FA and two or more symptoms indicating food addiction, ranging from mild to severe.

Furthermore, the demographic, socio-economic, and health-related characteristics of the sample provided a robust foundation for analyzing the study's outcomes. The diversity in income levels, educational attainment, and SUD prevalence offers valuable insights into how different factors might influence health behaviors, quality of life, and treatment responses. However, the limited racial and ethnic diversity within the sample should be taken into account when interpreting the findings, as it may limit the applicability of the results to broader, more diverse populations, particularly in understanding how cultural factors influence treatment efficacy (Adler & Ostrove, 2006; Patrick et al., 2012).

Results and Discussion

Body Shape Perception and Body Mass Index (BMI) Change

The relationship between body shape perception (BSP) and substance use disorders (SUDs) has been a growing area of interest (Nieri et al., 2005; Ralph-Nearman & Filik, 2020). BSP refers to individuals' self-assessment of their body shape, typically measured by silhouette selection tasks. Individuals in recovery from substance use often experience changes in body image that can influence their psychological and physical health. This analysis aimed to examine whether there were significant changes in BSP across different time points in recovery and whether these changes were based on the number of SUD participants recovering from and their remission status.

Specifically, we assessed BSP at three-time points: one month before recovery, six months before recovery, and at the moment of the questionnaire (now). We also examined differences based on remission status (currently in remission vs. relapse) and the number of SUDs (one, two, or three or more). Figure 2 illustrates these relationships, showing how BSP varied across these factors. The x-axis represents the three-time points, while the y-axis represents BSP scores. Different line colors and markers distinguish between participants based on the number of SUDs and remission status. Contrary to the findings n the literature, BSP scores remained relatively stable across time, which it difficult to determine whether perceived body changes reflect real weight variation (Stunkard et al.,1983). However, these results align with Gardner et al.'s (1989) findings, which affirm that people are uncertain about how their bodies look.

To investigate the relationship between the number of SUD and BSP, a multivariate analysis of variance (MANOVA) was conducted, considering the three perception variables. The overall model was significant, indicating that at least one of these variables differed between groups. To further explore this effect, a separate univariate analysis of variance

(ANOVA) was performed for each variable. Given the presence of significant differences, post-hoc comparisons were conducted using Scheffé's test, which controls for type I error when making multiple comparisons (see Table 2). The results showed that individuals with three or more SUDs had significantly different scores on body shape perception six months before recovery compared with only one (p=.011) or two (p=.017). However, no significant differences were found between groups for body perception one month (p>.75) or at the moment of the questionnaire (p>.73). These findings suggest that the BSP six months prior to recovery may be particularly sensitive to differences in the number of SUDs, while perceptions closer to the time of recovery do not show a statistically significant pattern of variation across groups.

Table 2.

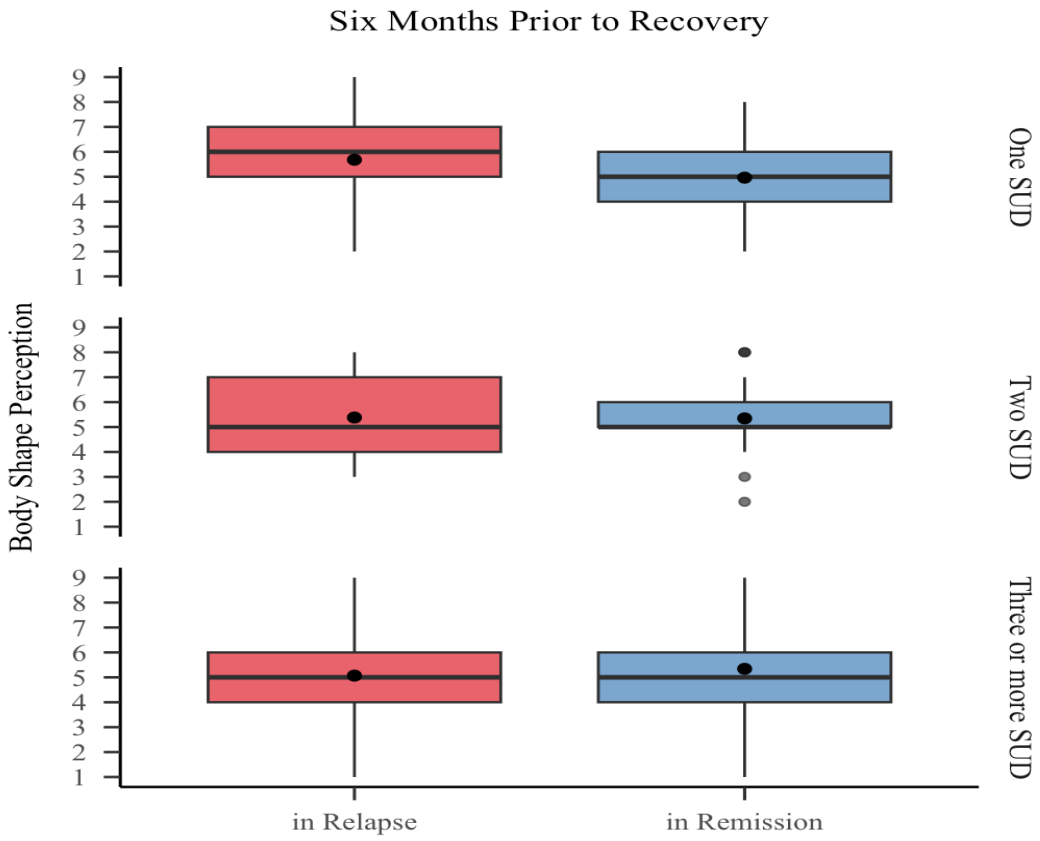
P Values Conducted Using Scheffé's Test, which Controls for Type I Error When Making Multiple Comparisons at three points of Body Shape Perception: One Month Before Recovery, Six Months Before Recovery, and at The Present

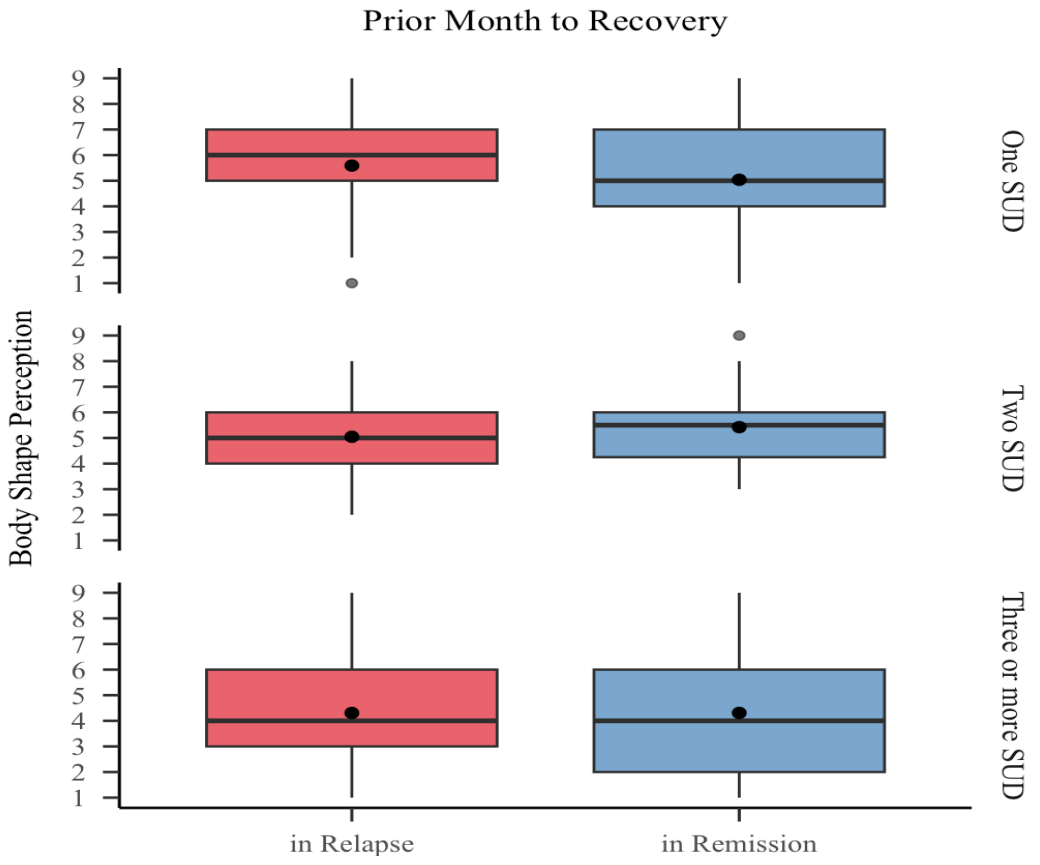
Comparison	*P* value		
	Six months before recovery	One month before recovery	Now
One SUD – Two SUD	.99	.97	.86
One SUD – Three or more SUD	.011	.89	.99
Two SUD – Three or more SUD	.016	.75	.73

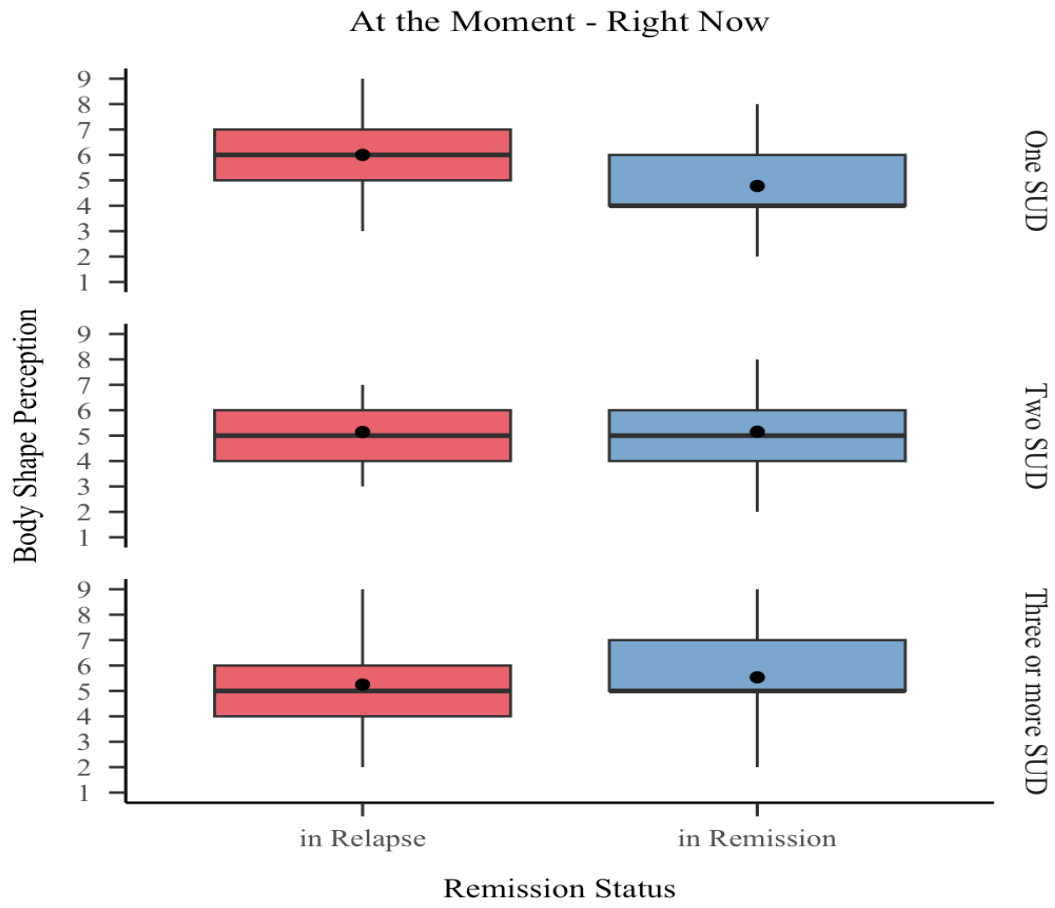
Visual inspection of the data suggests some potential trends in body size perception over time, although these were not statistically significant. For participants recovering from a single SUD and in relapse, a slight increase in perceived body size was observed between one month before recovery (mean BSP: 5.55) and the present (mean BSP: 5.90). Similarly, participants recovering from two SUDs and in relapse showed a slight decrease in BSP (from 5.21 to 5.11) over the same period. For participants in remission, the patterns were somewhat different. Those recovering from a single SUD showed a slight decrease in BSP from 5.08 to 4.85, while those recovering from two SUDs showed a slight decrease from 5.46 to 5.33. Participants in remission recovering from three or more SUDs showed a slight increase from 4.22 to 5.52. These results, while not statistically significant, highlight the complex interplay of psychological, sociocultural, and physiological factors that can influence body perception during substance use recovery, which may vary depending on remission status and number of SUD recovery (Nieri et al., 2005). Further research with a larger sample size may be needed to elucidate these findings.

Figure 2

Body Shape Perception Compared with the Number of Substance Use Disorders at Three Time Points: Six Months Prior To Recovery, One Month Prior To Recovery And At The Time Of Data Collection


Six Months Prior to Recovery
Body Shape Perception
One SUD
Two SUD
Three or more SUD
in Relapse
in Remission


Prior Month to Recovery
Body Shape Perception
One SUD
Two SUD
Three or more SUD
in Relapse
in Remission



Note. This figure displays the distribution of perceived Body Shape Perception among groups, stratified by the number of substance use disorders (SUD). Higher values indicate a perception of having a larger body size, based on the Stunkard et al. (1983) figure rating scale.

Previous research has underscored the risks associated with eating disorders and negative body image in SUD populations, highlighting that those with a distorted body image are more prone to turn to substances as a coping mechanism (Nieri et al., 2005). Substances such as stimulants and alcohol, known to act as appetite suppressants, may attract individuals as a weight-control measure (Lilenfeld & Kaye, 1996). Furthermore, certain SUD behaviors, such as substituting meals with alcohol or cigarettes, can worsen the individual's relationship with food and body image (Nieri et al., 2005; Nolan, 2013). In line with these findings, our analysis revealed that individuals recovering from three or more SUDs displayed

significantly different body shape perception six months before recovery compared to those recovering from one or two SUDs (p = .011 and p = .017, respectively). However, no significant differences were found in body shape perception one month before recovery or at the time of the questionnaire. These findings suggest that body shape perception may be particularly sensitive to the number of SUDs during the earlier stages of recovery, emphasizing the importance of integrating treatment strategies that address both eating disorders and substance use from the outset to improve recovery outcomes. This co-occurrence of SUDs and body image issues underlines the importance of integrated treatments that address both eating disorders and substance use, as these conditions often exacerbate each other (Nolan, 2013). Addressing body image issues in this early phase of recovery may be especially crucial for those with multiple SUDs, as the overlap between substance use and body image distortions can significantly impact long-term recovery outcomes. Targeted, multidisciplinary interventions that address both the psychological underpinnings of body image and the physiological factors tied to substance use are crucial for fostering sustainable recovery.

To investigate the relationship between body shape perception (BSP) and BMI, Pearson correlation analyses were conducted separately for individuals in relapse and remission. The results showed a strong positive correlation between the current BMI (as calculated based on participants' weight and height measurements). The value of BSP for those in relapse (r = .76) and a moderate correlation to individuals in remission (r = .55) suggest that as current BMI increases, there is a corresponding increase in current BSP in both groups. This finding aligns with previous studies (Ralph-Nearman & Filik, 2020; Parzer et al., 2021), highlighting an association between higher BMI and BSP measured by the Stunkard Figure Rating Scale. These studies reinforce the scale's applicability in estimating BMI and understanding how individuals perceive their body weight in association with their

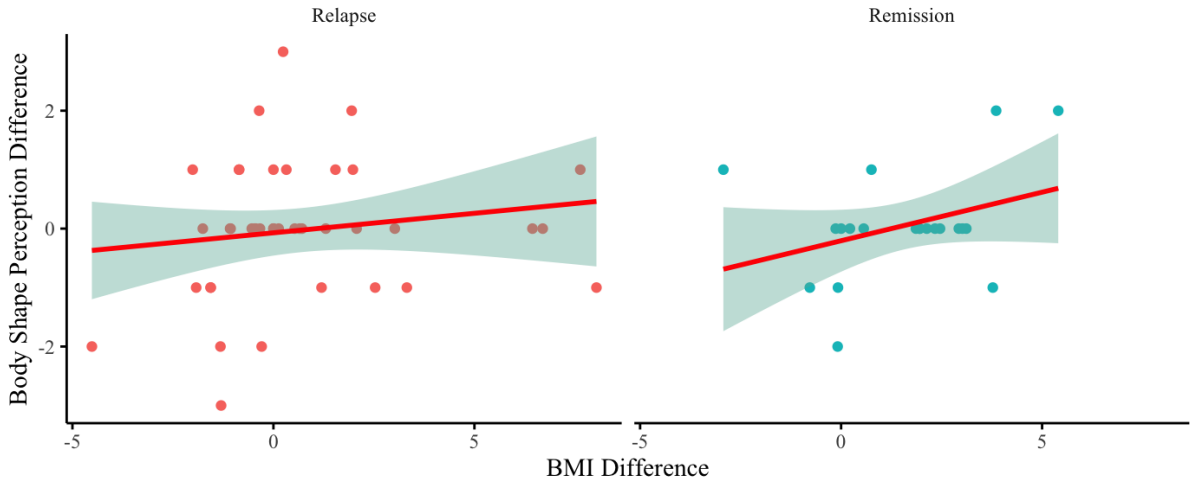
actual BMI. However, considering the potential influence of additional variables, we further examined the relationship between BSP, BMI, Food Addiction, and delay discounting rate (ln(*k*)).

The results indicated a significant positive correlation between BSP and Food Addiction Score in both groups (remission: r = .27, *p* = .0008; and relapse: r = .27, *p* = .0001), as well as between BMI and Food Addiction (remission: r = .20, *p* = .0009; and relapse: r = .27, *p* = .0001). This finding suggests that individuals with higher BMI and greater body shape perception reported more food addiction symptoms, reinforcing the link between disordered eating patterns and body image perception in recovery (Gearhardt et al., 2011). In contrast, no significant correlation emerged between BMI and ln(*k*) (remission: r = .01, *p* = .34; relapse: r =.10, *p* = *.12*), nor between BSP and ln(*k*) in relapse (r = 0.1, *p* = 0.18), suggesting that among individuals who have relapsed, a different body shape perception may be linked to differences in delay discounting patterns.

Additionally, the difference between BSP (specifically, the subtraction of BSP now and BSP six months before recovery) and BMI (subtraction of BMI now and BMI six months before recovery) over the recovery period was calculated by comparing current values to those six months before recovery. The finding provides insights into how changes in BMI and BSP are interconnected during the recovery process. Individuals in the Relapse (*r* = .15) and the Remission (*r* = .37) showed a moderate positive relationship, where an increase in BMI difference is linked with an increase in body perception over time (see Figure 3). This correlation, although modest, aligns with previous research suggesting that weight changes during recovery are accompanied by shifts in body image perception (Nieri et al., 2005; Parzer et al., 2021).

Figure 3

Correlation Between Changes in Body Shape Perception and BMI During Recovery

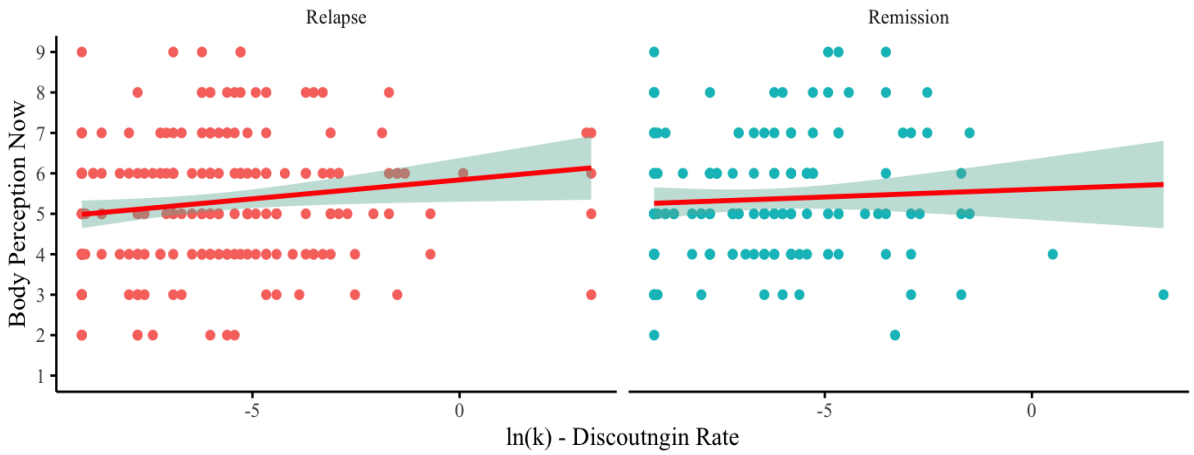


Note. The figure displays the relationship between Body Mass Index difference (BMI now – BMI six months before recovery) and Body Shape Perception difference (BSP now – BSP six months before recovery for individuals in relapse and remission. The red line represents a linear regression line; the shaded area indicates the 95% confidence interval. Each data point represents an individual participant's BMI Difference and BSP difference. The difference between the groups was statistically significant ($p < 0.05$).

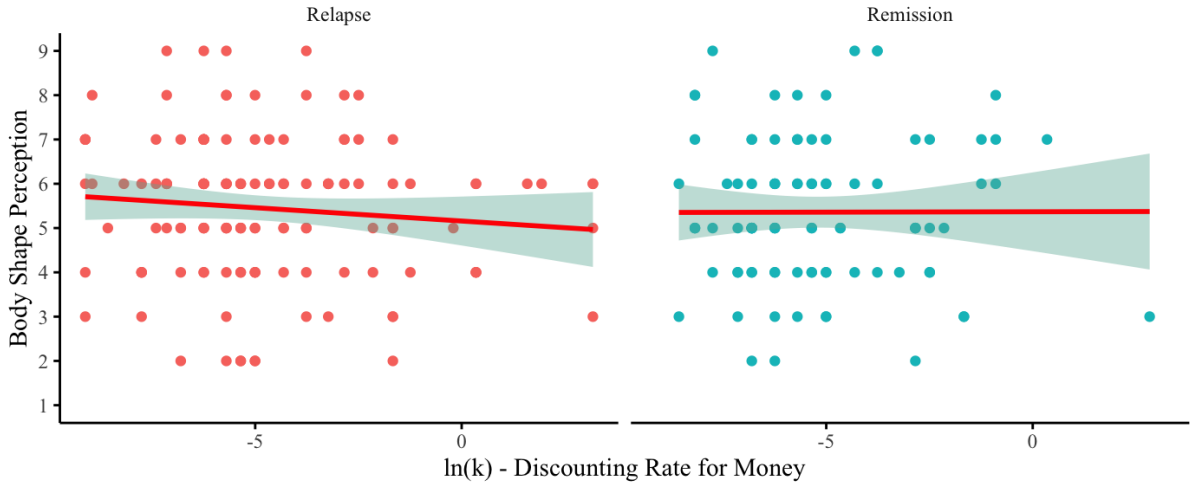
A regression analysis was conducted to investigate the association between BSP at the moment of the assessment and the log-transformed delay discounting variable (which considers the adjusted choice task, and the parameters used to characterize discounting, which includes k). Given the potential impact of remission status on this relationship, the analysis was performed separately for individuals in relapse and remission (see Figure 4). For the relapse group, the model explained approximately 1.47% of the variance in BSP (F [1, 380] = 5.684, p = .018), indicating a statistically significant but modest relationship. This suggests that individuals in relapse who have higher delay discounting rates (i.e., greater preference for immediate rewards) tend to have slightly altered BSP. These results emphasize the relevance of delay discounting in shaping body perception during the recovery process, as changes in ln(k) were linked with subtle shifts in BSP (Hendershot et al., 2011).

Figure 4

Relationship between Body Shape Perception Now and ln(k).



Relationship between ln(k) for Money and Body Shape Perception (Q709)



Furthering our understanding of the participant's body perceptions, delay discounting, and BMI over time, we conducted multiple regression analyses. The first model examined whether the discounting rate (ln(*k*)) predicted changes in BSP relative to BMI one month before recovery indicated no significant association (β = -.034, p = .401), suggesting that the variation in the discount of delay did not impact individuals' body perception during this time frame. A second regression model explored the relationship between the discounting rate and changes in BSP relative to weight six months before recovery. Although the association did not reach statistical significance (β = .041, p = .083), the positive trend suggests that individuals with higher delay discounting may experience greater perceived changes in body

shape over a longer period. This finding warrants further investigation, as behavioral adjustments (e.g., increased workout, healthy eating behavior, etc.) before the onset of recovery may have already altered BSP, influencing the obtained results and preventing relapse (Hendershot et al., 2011).

To complement these analyses, we conducted separate one-way ANOVAs to investigate the relationship between participants' weight change status and behavioral economic measures of demand (specifically, on the variables Intensity of Demand, Omax, and BreakPoint). These measures were derived from the Brief Assessment of Snack Demand task, which assessed participants' willingness to expend effort to obtain snack foods. Weight change status was categorized into three groups: weight gain, weight maintenance, or weight loss, based on participants' self-reported weight changes since the beginning of recovery.

For Intensity of Demand (i.e., consumption when food is free), no statistically significant differences were found between the weight change groups (F [2, 349] = .832, p = .436), indicating that the mean intensity does not vary significantly among individuals who gained, lost, or maintained weight. Similarly, for Breakpoint (i.e., the maximum price a participant is willing to pay for a food item), no significant differences were observed between the weight change groups (F [2, 349] = .824, p = .439). In contrast, for Omax (i.e., the maximum expenditure allocated for food), the results indicated statistically significant differences between weight change groups (F [2, 349] = 3.253, p = .040), suggesting that weight change status influences Omax scores. Post-hoc Dunn's test with Bonferroni correction identified a significant difference between the individuals who gained weight and lost weight (Z = 2.54, p = .033), with who gained weight exhibiting a significantly higher Omax than those who lost weight. These findings suggest that individuals who gained weight during recovery may be more willing to allocate financial resources toward acquisition compared to those who lost weight. One possible explanation is that weight gain in recovery

could be associated with a higher reinforcing value of food, reflecting increased hedonic drive to consume energy-dense foods, supporting previous research (Basso et al., 2022). Future research should explore whether these patterns persist over time and how they interact with factors such as dietary habits, satiety signaling, and emotional eating tendencies.

Snack Choice, Portion, and Interaction between Demand for Preferred Snacks and Delay Discounting

The snack choice and portion were collected based on the Freitas-Lemos (unpublished) model. Individuals were asked to choose their favorite snack between the nine options provided. The most chosen snack was the Reese's with 29,8% of the total, followed by Doritos with 15% of the preferences. Demand for their preferred snack was calculated and analyzed through measures of Intensity, Omax, and Breakpoint - measured in terms of consumption regardless of price, the maximum expenditure individuals are willing to allocate, and at which price the consumption becomes zero (Owens et al., 2015).

To investigate whether individuals' sensitivity to delayed rewards influences their economic demand for their preferred snack. According to the Reinforcer Pathology Theory (RPT), individuals with heightened delay discounting (DD) (i.e., a stronger preference for immediate over delayed rewards) are more likely to exhibit greater demand for reinforcing stimuli, such as palatable foods (Bickel et al., 2011). Based on this framework, we examined whether individuals with higher discount rates exhibit different demand patterns specifically for their self-selected favorite snack.

To quantify delay discounting (DD), we used the natural log-transformed k-value (ln(k)), a widely used metric in discounting research. Participants were divided into discount groups based on a threshold of -6.219, comparing the mean of the delay discounting metric *ln(k)*, resulting in classifications of "High ln(k)" (i.e., displayed a stronger demand for immediate rewards and exhibited higher mean values for Intensity, Omax, and Breakpoint)

and "Low ln(*k*) (greater willingness to wait for delayed rewards across all metrics). This categorization aimed to assess whether individuals with a preference for immediate demonstrate heightened demand for their preferred snack.

The analysis of demand and delay discounting reveals significant differences between groups of individuals classified by their ln(*k*) values, which indicate their sensitivity to delay in reward, suggesting that DD plays a role in shaping the decision-making to obtain a highly reinforcing snack (see Table 3). Independent-sample t-tests were conducted to compare demand-related variables (Intensity, Omax, and Breakpoint) between High and Low ln(*k*) groups.

The results indicate that individuals with High ln(*k*) displayed significantly higher mean values for Intensity ($t(350) = 13.51$, $p < .001$) and Omax ($t(350) = 13.06$, $p < .001$) compared to those with Low ln(*k*), suggesting a stronger motivation to expend effort or resources to obtain their preferred snack. The Breakpoint value was also significantly higher for the High ln(*k*) group ($t(350) = 7.21$, $p < .001$), but the effect size was smaller compared to Intensity and Omax. These findings support the idea that the preference for immediate is linked to an increased reinforcement value of personally preferred food, rather than food in general, and consumption (Rollins et al., 2011). Moreover, this finding aligns with evidence suggesting the heightened sensitivity to immediate rewards, as seen in individuals with greater delay discounting, is associated with an overvaluation of palatable foods, potentially contributing to maladaptive behaviors (Carr et al., 2011). Future research should further investigate whether these effects persist when examining less preferred food or a variety of snack options, as well as explore how demand interacts with weight change trajectories to shape long-term eating behaviors.

Table 3

Comparison between Demand and Delay Discounting by groups of individuals with High or Low ln(k) based on the mean with T-test.

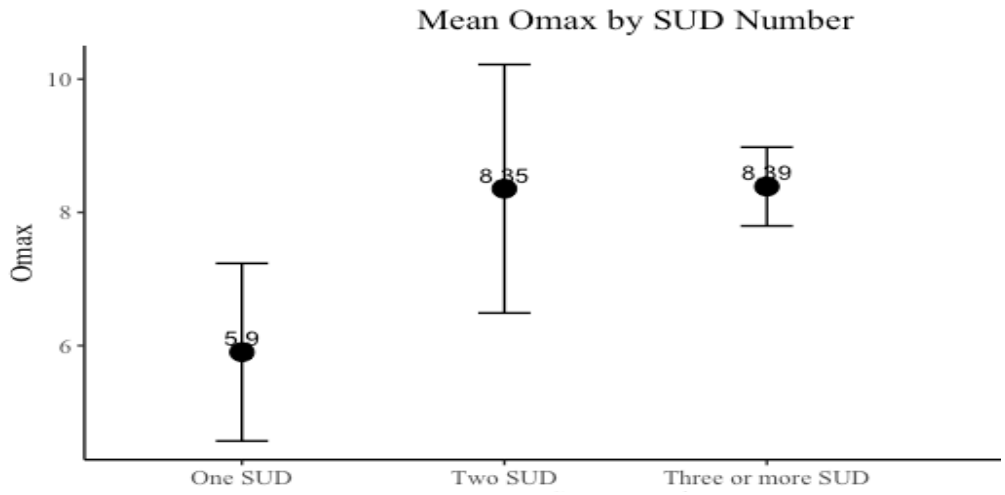
Demand	Discount	Coefficient [95% CI]	t(350)	*p*	Std. Coef.	Std. Coef. 95% CI
Intensity	High ln*(k)*	8.52 [7.28, 9.76]	13.51	< .001	0.18	[0.03, 0.33]
	Low ln*(k)*	-2.92 [-4.64, -1.20]	-3.34	< .001	-0.35	[-0.56, -0.14]
Omax	High ln*(k)*	9.81 [8.33, 11.28]	13.06	< .001	0.18	[0.03, 0.33]
	Low ln*(k)*	-3.36 [-5.41, -1.32]	-3.23	< .001	-0.34	[-0.55, -0.13]
BreakPoint	High ln*(k)*	3.34 [2.43, 4.25]	7.21	< .001	0.08	[0.07, 0.23]
	Low ln*(k)*	-0.89 [-2.15, -0.37]	-1.39	.166	-0.15	[-0.36, -0.06]

A series of regression analyses were conducted to explore further whether demand-related measures varied as a function of Food Addiction, remission status or SUD number. Specifically, measures of demand, including Intensity, Omax, and Breakpoint were examined to determine whether these behavioral economic indicators were differentially associated with these factors. The results revealed no significant associations between Intensity or Breakpoint and ln(*k*), remission status, number of SUDs, or Food Addiction, suggesting that these behavioral economic indicators may not vary meaningfully across these groups. However, Omax exhibited a marginally significant relationship with remission status (F = 5.383, p = .024), indicating that individuals in remission may allocate different levels of resources to food reinforcers, the other variables did not exhibit similar trends (see Figure 5). This pattern suggests that while general demand for food reinforcers does not systematically

vary by addiction-related factors, the maximum expenditure individuals are willing to make for food may be influenced by their remission status.

Figure 5

Demand Omax compared with SUD Number.



Note. The figure displays the mean Omax values for individuals with one SUD, two SUDs, and three or more SUDs.

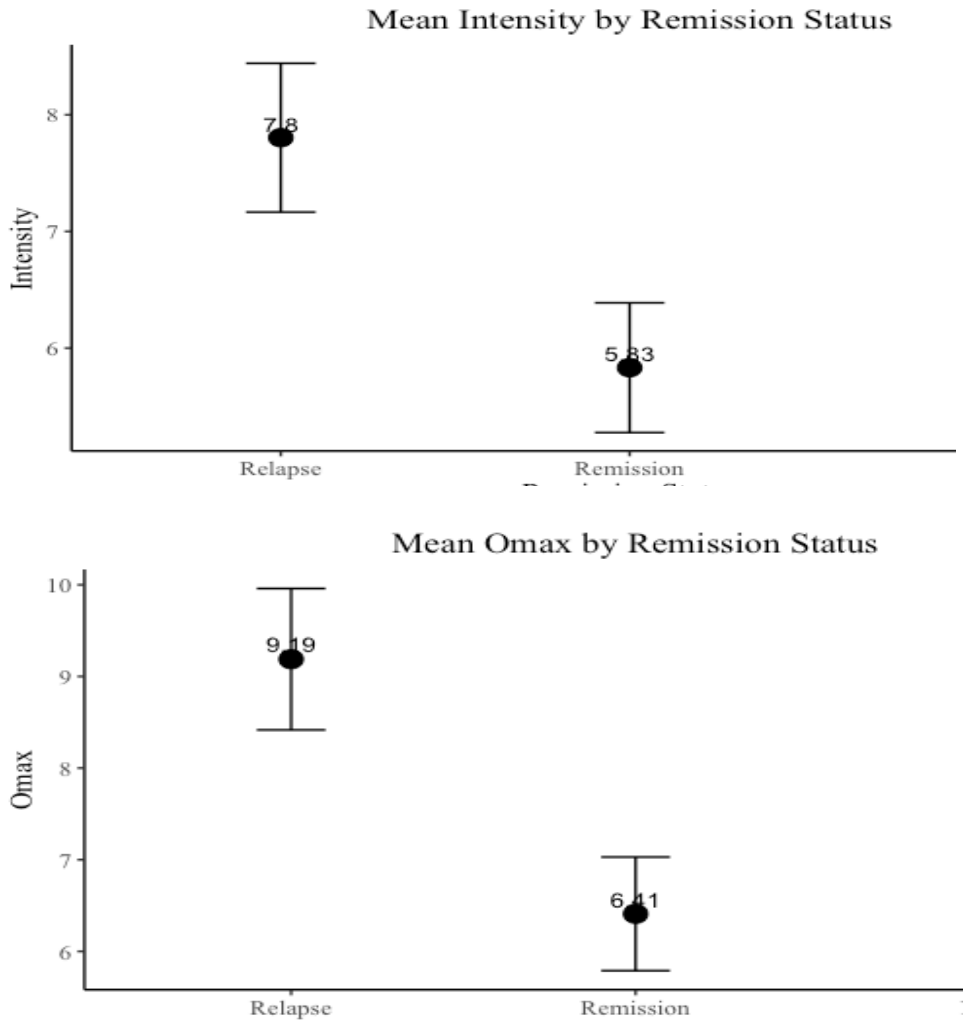
These findings suggest that the transference of addiction behaviors from substances to food may not be uniform across individuals and might depend on additional factors not captured in the present study, such as psychological, environmental, or metabolic influences. Supporting this notion, Gottfredson and Sokol (2019) found no evidence for the Addiction Transfer Hypothesis but highlighted a modest association between addiction propensity and increased caloric consumption, added sugar intake, and weight gain during early recovery from SUD. Instead, their findings provided higher addiction propensity was associated with increased calorie consumption and greater odds of weight gain. These results highlight the complexity of food addiction (FA) in the context of SUD recovery and underscore the need for further research to refine the theoretical framework of FA. Further research should incorporate larger samples, comprehensive measures of addiction and eating behavior, and

longitudinal designs to capture dynamic changes in substance use and eating patterns (Gottfredson & Sokol, 2019).

To examine how remission status might influence demand-related measures, an analysis of variance (ANOVA) was conducted to compare differences between remission groups Intensity and Omax. The results revealed significant differences in both variables, Intensity ($F = 4.823$, $p = .029$) and Omax ($F = 6.812$, $p = .009$), individuals in relapse showed significantly higher scores on both Intensity and Omax compared to those in remission. These findings suggest that remission status (specifically, relapse) significantly influences individuals' consumption patterns of favorite snacks. The observed variations highlight the potential impact of behavioral factors on dietary choices, which could have implications for recovery (see Figure 6). This aligns with Wiss et al. (2021), who found that targeted interventions in substance use disorder (SUD) treatment settings can effectively reduce barriers to nutrition-related care, such as facility-wide collaboration and menu adjustments. Their results emphasize the importance of integrating nutrition into recovery frameworks to support healthier dietary behaviors. Future researchers should explore how demographic variables, and individual behavioral traits interact with these measures, as well as implement multiple comparison analyses to pinpoint the specific subgroups contributing to these differences, thereby enhancing the understanding of eating behaviors in the context of remission and relapse.

Figure 6

Demand for Intensity and Omax compared with Remission Status.



Note. This figure illustrates the mean Intensity and Omax values for individuals in different remission statuses (relapse and remission). The graph shows that both Intensity and Omax are significantly higher for individuals in relapse compared to those in remission.

Food Addiction

Building upon these findings, the next set of analyses examined Food Addiction using a structured classification system based on responses to the Modified Yale Food Addiction Scale Version 2.0. Food Addiction was calculated based on the scores provided by the questionnaire applied, along with the assessment of clinical significance, which considers the real impact of those symptoms on daily life. Participants were classified as follows: those with one or fewer symptoms, without significant impact on their daily functioning, were classified as having No Food Addiction (n = 150); those with two or three symptoms, along

with noticeable impairments in their routines, were categorized as having Mild Food Addiction (n = 28); participants with four or five symptoms and clinically significant impact were classified as having Moderate Food Addiction (n = 21); and finally, those with six or more symptoms and evident impairments in daily life were classified as having Severe Food Addiction (n = 205).

To assess how decision-making relates to body weight in the context of food addiction, a linear regression was conducted examining the relationship between Body Mass Index (BMI) at the moment and the logarithm of the discount rate (ln(k)), with food addiction status as a moderating variable. The results revealed a statistically significant effect of ln(k) on BMI for individuals with Mild Food Addiction ($p = 0.005$) and Severe Food Addiction ($p < 0.001$). However, this effect was not significant for those with Moderate Food Addiction ($p = 0.079$). Despite non-significant results for the moderate group, all food addiction categories demonstrated higher mean BMI values compared to individuals without food addiction. Additionally, ln(k) independently showed a significant positive association with BMI across the sample ($p = 0.021$). These findings suggest that the delay discount rate, as measured by ln(k), may influence BMI, particularly in individuals with specific levels of food addiction, further highlighting the role of impulsivity and decision-making in eating behavior regulation. This aligns with Pape et al. (2021), who reported that individuals with Food Addiction exhibit higher BMI, psychological distress, weight bias internalization, and emotional eating behaviors. Such findings emphasize the need for a multidimensional approach when examining the mechanisms linking decision-making tendencies to BMI and Food Addiction.

This study's findings are consistent with prior literature highlighting the connection between food addiction and increased BMI. Research has consistently shown that individuals with addiction tendencies exhibit changes in eating behavior that strongly correlate with

higher BMI (Gearhardt et al., 2012; Romero-Blanco et al., 2021; Pape et al., 2021). In particular, the observation that individuals without food addiction demonstrate greater self-regulation aligns with studies emphasizing the critical role of self-control in maintaining a healthy weight (Carbone et al., 2023). This nuanced observation, suggesting that individuals without food addiction may engage distinct regulatory mechanisms in response to variations in ln(k), underscores the complexity of eating behaviors and their implications for weight management. Given these results, future investigations should focus on identifying the specific behavioral strategies that differentiate individuals with and without food addiction and SUD in their delayed rewards, as these insights may contribute to a better understanding of eating behaviors and their implications for weight management.

Furthermore, these findings corroborate previous studies linking disordered eating behaviors to the development of obesity (Gearhardt et al., 2012; Hauck et al., 2020). Sengor & Gezer (2020) further support this connection, demonstrating that food addiction correlates positively with higher energy, carbohydrate, and fat intake, while disordered eating behaviors negatively correlate with energy and carbohydrate consumption. These results highlight the multifaceted interactions between food addiction, eating behaviors, and nutritional intake. However, the lack of a significant relationship in changes in BMI over time in the current study could be explained by limitations such as the cross-sectional design, sample heterogeneity, and uncontrolled covariates. Future studies should consider including detailed dietary intake analyses, such as macronutrient composition, and incorporating assessments of body composition beyond BMI to better capture the impact of food addiction and disordered eating on physical health.

The results of this research, although preliminary, contribute to the growing body of evidence pointing to the complexity of the relationship between FA and obesity. However, it is important to highlight the limitations of the study, such as the absence of a randomized

control group and the observational nature of the data, which prevent the establishment of causal relationships. Future studies with longitudinal designs and specific interventions for the treatment of food addiction are needed to elucidate the underlying mechanisms of this relationship and to evaluate the effectiveness of different treatment strategies. Additionally, incorporating sociocultural, financial, and psychological factors could provide a more comprehensive view of how food addiction interacts with individual lifestyles and broader health outcomes.

In light of these results, it is clear that there is a need for further research in this area to refine the current theoretical framework and intervention approaches. Future research directions may include exploring interventions that improve self-regulation in individuals with food addiction, aiming to reduce BMI and enhance eating control. Additionally, longitudinal studies investigating how changes in eating behavior over time impact BMI across different food addiction groups could provide valuable insights. Research could also examine the role of specific dietary patterns and their interactions with psychosocial factors, such as stress and social support, in the relationship between food addiction and obesity. Finally, implementing educational programs focusing on eating control skills and awareness of food addiction risks may support individuals at risk of developing obesity.

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Appendix A - Consent IQRR

Please read this carefully as our compensation system has changed: For every 3 IQRR assessments, you will receive an escalating compensation based on the number of assessments completed (a minimum of $5 per assessment). Specifically, you will receive $5 for the 1st assessment you complete, $6 for the second, and $7 for the third. In addition, you will receive a bonus of $5 for every 3 assessments completed. After getting the bonus, compensation will be back to $5 for the 1st, $6 for the second, and $7 for the third, with a second bonus ($5) for the second group of 3 assessments completed.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Consent to Take Part in a Research Study

Title of research study: International Quit & Recovery Registry, IRB # 11-716

Principal Investigator: Warren K. Bickel (540-526-2015, wkbickel@vtc.vt.edu)

Other study contacts: The study team at 540-315-0205 or iqrr@vtc.vt.edu

Key Information: The following is a summary of this study to help you decide whether or not to be a part of this study. More detailed information is listed later on in this form. This is a research assessment administered by the International Quit & Recovery Registry at the Fralin Biomedical Research Institute at VTC. The primary purpose of this assessment is to learn about how you feel about certain events and how you've felt recently. This assessment will take about 10-15 minutes to complete. This is a monthly assessment as a part of our 2023 Around the World Series. Please answer all questions honestly. Your answers will be kept strictly confidential. There are not any direct benefits of participation in this research. However, your responses will enhance our knowledge about addiction and recovery, with the hope of benefiting those who are still working to overcome their addiction. Participation is voluntary, and you can stop completing the assessment without submitting it at any time.

Detailed Information: The following is more detailed information about this study in addition to the information listed above.

Who can I talk to? If you have questions, concerns, or complaints, or think the research has hurt you, speak to the research team at 540-315- 0205 or iqrr@vtc.vt.edu

This research has been reviewed and approved by the Virginia Tech Institutional Review Board (IRB). You may communicate with them at 540-231-3732 or irb@vt.edu if: You have questions about your rights as a research subject. Your questions, concerns, or complaints are not being answered by the research team. You cannot reach the research team. You want to talk to someone besides the research team to provide feedback about this research.

How many people will be studied? We plan to include about 1000 people in this research study.

What happens if I say yes, I want to be in this research? You will complete a one-session online survey. The study will take 10-15 minutes to complete. The study will ask questions about how you feel about your recovery and decision-making.

What happens if I say yes, but I change my mind later? You can leave the research at any time, for any reason, and it will not be held against you. If you decide to leave the research, there will be no adverse consequences. If you decide to leave the research, just stop completing the assessment without submitting it. Data from incomplete assessments will not be used in the analysis and, therefore, you will not be compensated for it.

Is there any way being in this study could be bad for me? (Detailed Risks) There may be risks such as embarrassment or discomfort associated with completing the online survey as it covers sensitive information including drug use, familial and social relationships, etc. It is possible that some of the survey questions may make you feel uncomfortable or upset. You may choose not to answer any question or take a break at any point during the survey. If you become upset, please tell a member of the study team (see page 1 for contact information).

There is also a risk of loss of confidentiality. We will make every effort to protect your privacy and the confidentiality of your information if you decide to take part in the study. Always know that this study is voluntary, and you may leave the study at any time without penalty.

What happens to the information collected for the research? We will make every effort to limit the use and disclosure of your personal information, including research study and medical records, only to people who have a need to review this information. We cannot promise complete confidentiality. Organizations that may inspect and copy your information include the IRB, Human Research Protection Program, and other authorized representatives of Virginia Tech. If identifiers are removed from your private information or samples that are collected during this research, that information or those samples could be used for future research studies or distributed to another investigator for future research studies without your additional informed consent.

The results of this research study may be presented in summary form at conferences, in presentations, reports to the sponsor, academic papers, and as part of a thesis/dissertation.

Can I be removed from the research without my OK? The person in charge of the research study or the sponsor can remove you from the research study without your approval. Possible reasons for removal include if it is determined to be in your best interest, you do not follow the study instructions, the study is stopped or ended, or for other administrative reasons. We will tell you about any new information that might affect your health, welfare, or choice to stay in the research.

What else do I need to know? This research is being funded by Fralin Biomedical Research Institute at Virginia Tech Carilion. Any expenses accrued for seeking or receiving medical or mental health treatment will be your responsibility and not that of the research project, research team, or Virginia Tech.

Please read this carefully as our compensation system has changed:

In 2023, for every 3 IQRR assessments, you will receive an escalating compensation based on the number of assessments completed (a minimum of $5 per assessment). Specifically, you will receive $5 for the 1st assessment you complete, $6 for the second, and $7 for the third. In addition, you will receive a bonus of $5 for every 3 assessments completed. After getting the bonus, compensation will be back to $5 for the 1st, $6 for the second, and $7 for the third with a second bonus ($5) for the second group of 3 assessments completed.

We will not offer to share your individual results with you. Your consent to participate in this research is implied when you choose to continue with the assessment.

Thank you!

Would you like to continue?

Appendix B - Recovery History Questions

Have you tried to recover/initiated recovery from any of the following substances?

By initiating recovery we mean that you started actively changing your substance use behavior* and doing things to cut down or stop using (not just thinking about changing your substance use) whether or not you were successful.

*The substance use behavior could be a change in your substance use but could also be another change you made that started you toward recovery (e.g., limiting your social relationships with other users, starting therapy, focusing on improving your psychosocial wellbeing, etc.)

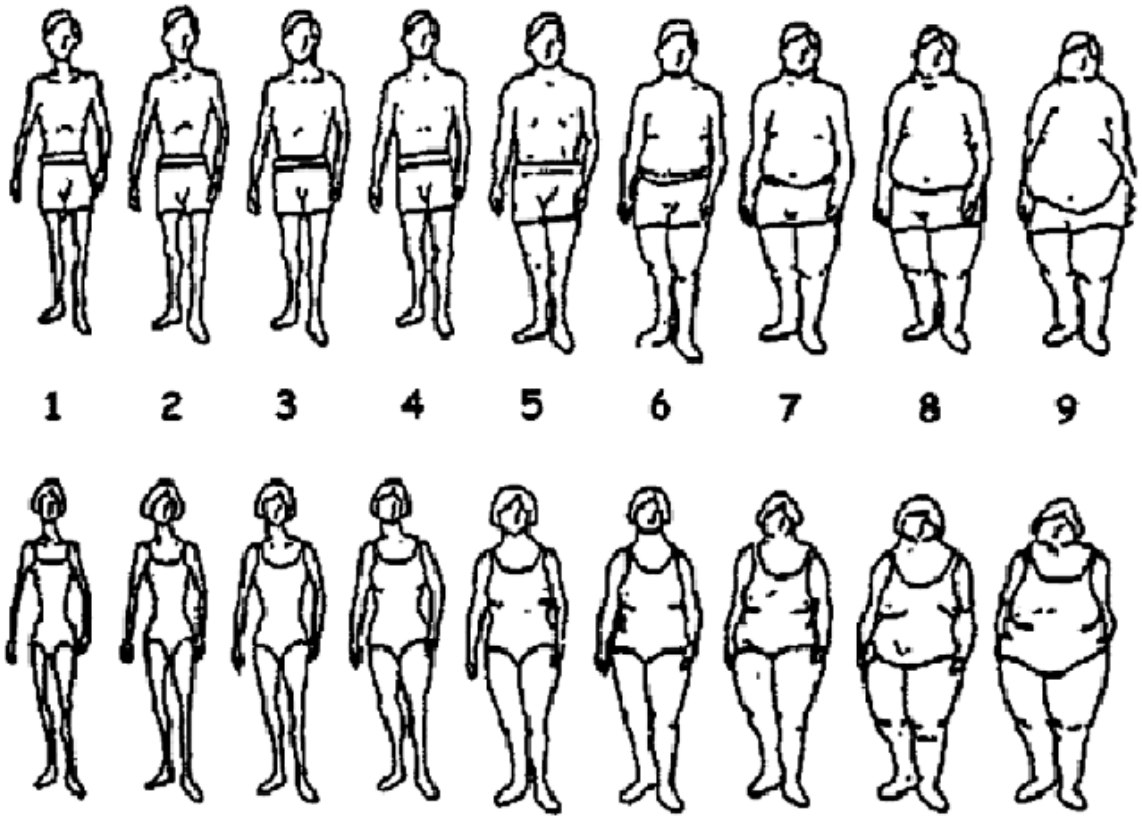
	Yes	No
Nicotine (cigarettes, cigars, smokeless tobacco, pipe tobacco)	○	○
Alcohol (liquor, beer, wine)	○	○
Cannabis products (marijuana, hashish, hash, THC, pot, grass, weed, reefer, spice, K2)	○	○
Opioids (heroin, opium, morphine, methadone)	○	○
Cocaine (snorting, IV, freebase, crack)	○	○
Stimulants (amphetamines, methamphetamine, speed, crystal meth, crank, Dexedrine, methylphenidate, Ritalin, diet pills, bath salts, Adderall)	○	○
Prescription pain relievers (codeine, OxyContin, Tylox, Percodan, Percocet, Demerol, Vicodin, Actiq, Duragesic, Sublimaze, Darvon, Darvocet, Lorcet, Lortab, Dilaudid)	○	○
Hallucinogens (MDMA, MDA, ecstasy, LSD, acid, mescaline, peyote, psilocybin, STP, magic mushrooms, salvia)	○	○
Dissociative anesthetics (PCP, angel dust, PeaCe Pill, Tranq, Hog, ketamine, Ketalar SV, Special K)	○	○
Tranquilizers/Depressants (barbiturates, benzodiazapines, Ativan, Halcion, Valium, Xanax, Librium, Dalmane, Rohypnol, roofies, Roofinol, GHB, Quaalude, Seconal, reds, Miltown)	○	○
Inhalants (glue sniffing, ethyl chloride, poppers, snappers, nitrous oxide, laughing gas, amyl nitrate, butyl nitrate, rush)	○	○

What is your current smoking status? (This refers to smoking cigarettes)

- ○ Current Cigarette Smoker
- ○ Former Cigarette Smoker
- ○ Never Smoked Cigarettes

Appendix C - Stunkard Scale Adaptation and BMI Questions

Please pay attention to this image, as the following questions will refer to it.



This scale was adapted from Stunkard Scale to ask the participants about their assemble shape at three different time points (before recovery, six months ago, and right now - during the assessment).

1. Which image most resembled your body before recovery?
2. Which image most resembled your body six months ago?
3. Which image most resembled your right now?
4. How tall are you in inches?
5. How much do you weight in pounds?

This Scale will be shown in the beginning and end of the survey.

Appendix D - DSM-V Questions Three Months

All the questions in Appendix D shows only the options selected by the individual as in substance use recovery-based Appendix A. The questions were selected by DSM criteria about the last three months and the options will be presented consistent with the model of Question 1.

Question 1:

Have you ever found that you needed to use much more of the following substances to get the same effect that you did when you first started taking it? OR have you ever found that you got less of an effect when you did the same amount?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

	Yes	No
Nicotine (cigarettes, cigars, smokeless tobacco, pipe tobacco)	○	○
Alcohol (liquor, beer, wine)	○	○
Cannabis products (marijuana, hashish, hash, THC, pot, grass, weed, reefer, spice, K2)	○	○
Opioids (heroin, opium, morphine, methadone)	○	○
Cocaine (snorting, IV, freebase, crack)	○	○
Stimulants (amphetamines, methamphetamine, speed, crystal meth, crank, Dexedrine, methylphenidate, Ritalin, diet pills, bath salts, Adderall)	○	○
Prescription pain relievers (codeine, OxyContin, Tylox, Percodan, Percocet, Demerol, Vicodin, Actiq, Duragesic, Sublimaze, Darvon, Darvocet, Lorcet, Lortab, Dilaudid)	○	○
Hallucinogens (MDMA, MDA, ecstasy, LSD, acid, mescaline, peyote, psilocybin, STP, magic mushrooms, salvia)	○	○
Dissociative anesthetics (PCP, angel dust, PeaCe Pill, Tranq, Hog, ketamine, Ketalar SV, Special K)	○	○

Tranquilizers/Depressants (barbiturates, benzodiazapines, Ativan, Halcion, Valium, Xanax, Librium, Dalmane, Rohypnol, roofies, Roofinol, GHB, Quaalude, Seconal, reds, Miltown)	○	○
Inhalants (glue sniffing, ethyl chloride, poppers, snappers, nitrous oxide, laughing gas, amyl nitrate, butyl nitrate, rush)	○	○

Questions 2:

When you reduced or stopped using the following substances, did you have withdrawal symptoms (aches, shaking, fever, weakness, diarrhea, nausea, sweating, heart pounding, difficulty sleeping, or feeling agitated, anxious, irritable, or depressed)? (AND/OR) Did you continue with it to keep yourself from getting sick (withdrawal symptoms) or so that you would feel better?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 3:

Have you often found that when you used the following substances you ended up taking more or for a longer amount of time than you thought you would?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 4:

Have you ever tried or had a persistent desire to reduce or stop taking the following substance(s) but failed?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 5:

On the days you used the drug, did you ever spend substantial time (more than 2 hours) obtaining, using, engaging, or in recovery from the following substance(s), or thinking about the drug?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 6:

Did you ever spend less time working, enjoying hobbies, or being with family or friends or give up these activities because of your use of the following substance(s)?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 7:

If using the following substance(s) caused you persistent or reoccurring health or mental problems or made these problems worse, did you ever still keep on using it?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 8:

Did you ever experience cravings, or a strong desire or urge to use the following substance(s)?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 9:

Did your use of the following substance(s) cause you to give up on other responsibilities, such as work, school, or at home?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 10:

Did you continue to use the following substance(s) even though your use or behavior caused problems with your family or other people?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Question 11:

Did you use or were intoxicated by the following substance(s) repeatedly in situations where you were physically at risk (for example, driving a car, riding a motorcycle, using machinery, boating, etc.)?

Has this been true in your **past 90 days (3 months)** for any of the following?

Please answer Yes or No for each of the listed substance(s)

Appendix E - Snack Choice and Portion

The following questions ask how many individual snacks you would purchase **RIGHT NOW** (that is, at the present moment) to use over the next 24 hours if they cost various amounts of money.

During each question, you will imagine a specific event that you created. You will imagine your event in as much detail as possible.

Please assume that:
-The available snacks are your usual brand.
-You have no access to any snacks or food products other than those offered at these prices.
-You would eat these snacks over the next 24 hours -- not save or stockpile them for a later date.
-You may not give away any of the snacks that you purchase.

Please choose your favorite snack item:

This is your favorite snack item. On the left-hand side is one serving of your favorite snack. The right-hand side refers to the number of servings in a pack. **Please pay attention to this serving size, as the following questions will refer to it.**

Appendix F - Brief Assessment of Snack Demand Task

In the following questions, your **preferred snack** will be available to purchase. At each price, please use the keyboard to enter the number of servings that you would like to purchase. Please consider the serving in the picture.

You may purchase as many servings of your favorite snack as you would like. However, the amount that you purchase **can only be consumed during a single, 24-hour period.** Assume that you cannot save these snacks for a later time or give them away and that you have no access to other food items.

These are hypothetical questions, but please answer as if all purchases are real and that you are spending your own money with the same income/savings as you have now. There are no right or wrong answers in this task. Please take your time and answer thoughtfully.

Please continue when you are ready to begin.

If your favorite snack was free, how many servings would you have?

What is the maximum total amount of money that you would spend on your favorite snack (approximately)?

What is the maximum amount of money you would pay for a single serving of your favorite snack?

Appendix G - 6-trial - Delay Discounting (cross-commodity)

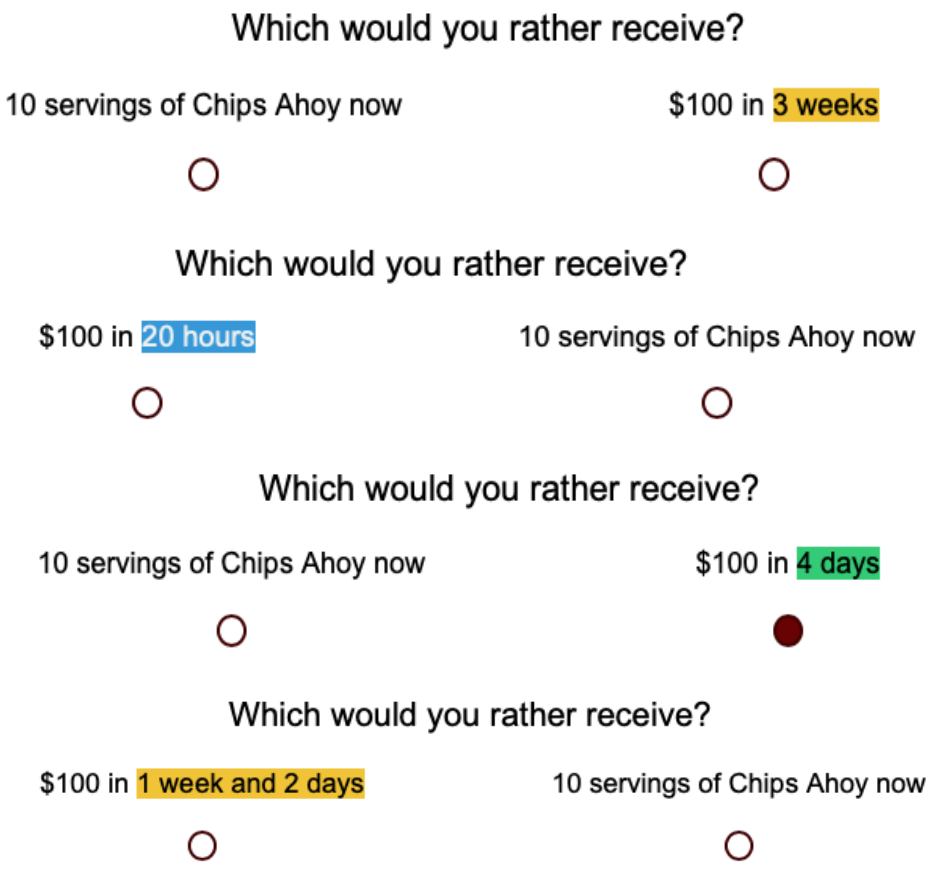
Imagine that you had a choice between servings of your favorite snack item or receiving money. How many servings of is equal in value to $50?

(As an example, entering 15 means you'd view 15 servings of as equal to receiving $50.)

You will now be presented with a series of choices relating to your favorite snack item and money.

These questions are hypothetical, but please choose your answer as if you will receive the reward in the time frame selected.

Please pay close attention to the amount and time frame of each option, and choose accordingly. There are no right or wrong answers in this task. Please take your time.



Which would you rather receive?

10 servings of Chips Ahoy now

$100 in 6 days

Which would you rather receive?

10 servings of Chips Ahoy now

$100 in 1 week

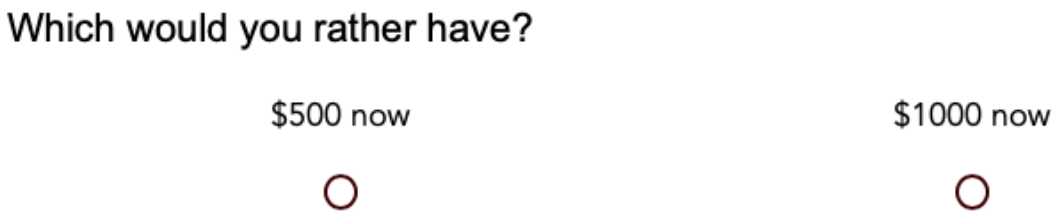
Which would you rather receive?

10 servings of Chips Ahoy now

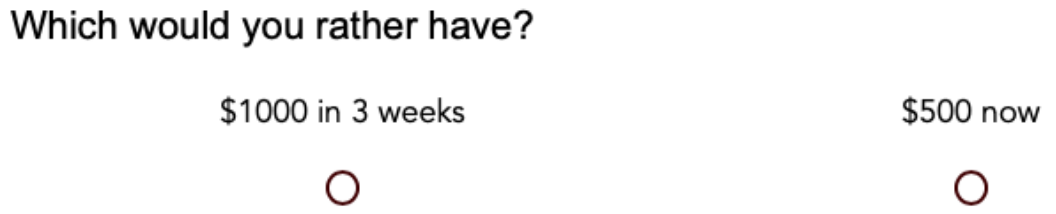
$100 now

Appendix H - 5-trial - $1000 minute Task

You will now be presented with a series of decision situations relating to money. These are hypothetical, but please choose your answer as if you will receive the money in the time frame selected. Please pay close attention to the amount and time frame of each option, and choose accordingly. There are no right or wrong answers in this task. Please take your time.



Only six questions will be shown to the participants based in their choices. Every time they choose between immediate or delayed option the next option will change increasing or decreasing the delay. An attention check will be shown in the task following the example:



Appendix I - Yale Food Addiction Scale

This survey asks about your eating habits in the past year. People sometimes have difficulty controlling how much they eat of certain foods such as:

- Sweets like ice cream, chocolate, doughnuts, cookies, cake, candy
- Starches like white bread, rolls, pasta, and rice
- Salty snacks like chips, pretzels, and crackers
- Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza, and French fries
- Sugary drinks like soda pop, lemonade, sports drinks, and energy drinks

When the following questions ask about "CERTAIN FOODS" please think of ANY foods or beverages similar to those listed in the food or beverage groups above or ANY OTHER foods you have had difficulty with in the past year.

	Never	Less than monthly	Once a month	2-3 times a month	Once a week	2-3 times a week	4-6 times a week	Every day
I ate to the point where I felt physically ill.	○	○	○	○	○	○	○	○
I spent a lot of time feeling sluggish or tired from overeating.	○	○	○	○	○	○	○	○
I avoided work, school or social activities because I was afraid I would overeat there.	○	○	○	○	○	○	○	○
If I had emotional problems because I hadn't eaten certain foods, I would eat those foods to feel better.	○	○	○	○	○	○	○	○
My eating behavior caused me a lot of distress.	○	○	○	○	○	○	○	○
I had significant problems in my life because of food and eating. These may have been problems with my daily routine, work, school, friend, family, or health.	○	○	○	○	○	○	○	○
My overeating got in the way of me taking care of my family or doing household chores.	○	○	○	○	○	○	○	○
I kept eating in the same way even though my eating caused emotional problems.	○	○	○	○	○	○	○	○
Eating the same amount of food did not give me as much enjoyment as it used to.	○	○	○	○	○	○	○	○
I had such strong urges to eat certain foods that I couldn't think of anything else.	○	○	○	○	○	○	○	○
I tried and failed to cut down on or stop eating certain foods.	○	○	○	○	○	○	○	○
I was so distracted by eating that I could have been hurt (e.g., when driving a car, crossing the street, operating machinery).	○	○	○	○	○	○	○	○
My friends or family were worried about how much I overate.	○	○	○	○	○	○	○	○