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The Phenotype of Recovery II: The Association Between Delay Discounting, Self-Reported Quality of Life, and Remission Status among Individuals in Recovery from Substance Use Disorders

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Abstract

Quality of life (QOL) and delay discounting (preference for smaller, immediate rewards) are significantly associated with substance use status, severity, and treatment outcomes. Associations between delay discounting and QOL among individuals in recovery from substance use have not been investigated. In this two-study investigation, using data collected from The International Quit & Recovery Registry, we examined the association between QOL, discounting rates, and remission status among individuals in recovery from SUD. Study 1 (N=166) investigated the relationship between delay discounting and QOL among individuals in recovery from SUD. Study 2 (N=282) aimed to validate and extend the results of Study 1 by assessing the association between the remission status, delay discounting, and QOL among individuals in recovery from alcohol use disorder (AUD). In both studies, delay discounting was a significant predictor of QOL domains of physical health, psychological, and environment even after controlling for age, gender, race, ethnicity, education, and days since last use. In Study 2, a mediation analysis using Hayes' methods revealed that the association between the remission status and QOL domains of physical health, psychological and environment were partially mediated by the discounting rates. The current study expands the generality of delay discounting and indicates that discounting rates predict QOL and remission status among individuals in recovery from substance

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use disorders. This finding corroborates the recent characterizations of delay discounting as a candidate behavioral marker of addiction and may help identify sub-groups that require special treatment or unique interventions to overcome their addiction.

Keywords

Substance Use; Delay Discounting; Quality of Life; Recovery; Remission; WHOQOL-BREF

Public Significance Statement: In this investigation, delay discounting, which assesses the extent to which an individual chooses smaller, sooner rewards over larger, delayed ones, was significantly associated with quality of life domains of physical health, psychological, and environment among individuals in recovery from substance use. In addition, delay discounting was significantly associated with the remission status among those in recovery from alcohol. That is, those in remission (had no signs or symptoms -other than craving- of active addiction in the last 3 months) had lower rates of discounting (higher valuation of larger delayed rewards) compared to those not in remission. This information may serve as a base to better identify and target subgroups at higher risk of relapse and those that need special interventions to increase their likelihood of achieving better treatment outcomes.

Substance use disorders (SUDs) are chronically relapsing conditions that entail continuous support and management to prevent relapse and support long-term recovery (NIH, 2018; Volkow, 2010). Recovery is a multidimensional process not only involving abstinence, but also improving one's wellness, health, and quality of life (Betty Ford Institute Consensus Panel, 2007; Kelly & Hoeppner, 2015; Laudet, 2007; McLellan, 2010; Rockville, 2010). Quality of life (QOL) refers generally to one's perceived well-being and comprises multiple domains such as physical health (e.g., activities of daily living, energy, pain, and work capacity), psychological functioning (e.g., appearance, feelings, self-esteem, perceived cognition), social relationships (e.g., social support, personal relationships, and sexual activity) and environment (e.g., financial resources, freedom, health and social care, and home environment). Improving the quality of life is an especially important outcome when treating chronic conditions that cannot be cured. Similar to other chronic conditions (Mendlowicz, 2000; The World Health Organization, 1995), QOL measurement in SUDs aims to capture the impact and burden of addiction on individuals and societies and assesses psychosocial functioning during substance use or recovery (Laudet, 2011). This information is important for the development and evaluation of treatments.

While in 1990, QOL was called "the missing measurement in health" (Fallowfield, 1990), today almost all areas of medicine have published studies on QOL. Research and interest in understanding the association between changes in QOL, substance use, and the recovery process has been gaining ground (Bizzarri et al., 2005; Donovan et al., 2005; Havassy & Arns, 1998; Millson et al., 2006; Morgan et al., 2003; Puigdollers et al., 2004; Rudolf & Watts, 2002; Smith & Larson, 2003; Villeneuve et al., 2006). Addiction research examining the impact of substance use treatment is gradually shifting from the traditional paradigm of assessing drug use as the main outcome of treatment to a new paradigm that is complemented by QOL outcomes (Donovan et al., 2005; Institute of Medicine et al.,

2006; Laudet, 2011; McLellan et al., 2000; White et al., 2003). Previous studies among individuals with alcohol and drug-dependencies have indicated a negative impact of SUD on domains of QOL such as physical functioning (Morgan et al., 2003; Stein et al., 1998), mental functioning (Préau et al., 2007; Smith & Larson, 2003; Volk et al., 1997), social relationships, employment and others (Hubbard et al., 2003; Smith & Larson, 2003). QOL is significantly associated with substance use status and severity. For example, current users and SUD treatment seekers have poorer QOL compared to non-users (Donovan et al., 2005; Gonzales et al., 2009; Rudolf & Watts, 2002; Smith & Larson, 2003). Moreover, the severity and number of alcohol or drug problems are negatively associated with functioning in almost all QOL domains (McKenna et al., 1996; Volk et al., 1997). Previous studies reported positive treatment-related changes in most QOL domains of functioning, including overall life satisfaction, psychosocial functioning, social relationships, environment, and employment (Donovan et al., 2005; Fassino et al., 2004; Foster et al., 2000; Hubbard et al., 2003; Kraemer et al., 2002; Morgan et al., 2003; Villeneuve et al., 2006). In addition, a study by Laudet and Stanick (2010) has indicated that the level of QOL satisfaction measured at the end of outpatient treatment is predictive of commitment to abstinence, which in turn is a strong predictor of actual abstinence.

Understanding the processes underlying decision-making in substance use (e.g., choosing short-term reinforcement from substance use or long-term reinforcement from abstinence) are important to the success of treatment. Behavioral economics, which integrates psychology and economics, has been widely utilized to understand the effects of psychological, cognitive, social, and emotional factors on decision-making (Bickel et al., 2014; Heather & Vuchinich, 2003). Delay discounting, the subjective decline in the value of a reward with the delay to its receipt (Madden & Bickel, 2010), is a candidate behavioral marker of addiction (Bickel et al., 2019; Bickel et al., 2014). Individuals with SUD have greater rates of discounting compared to healthy controls (Amlung et al., 2016; Bickel et al., 2014; MacKillop et al., 2011). This finding is consistent among most substances of abuse, including alcohol (Mitchell et al., 2005; Petry, 2001). Delay discounting is associated positively with the risk of substance use, substance consumption and dependence (Fernie et al., 2013; Khurana et al., 2013; MacKillop et al., 2011), and negatively with the likelihood of successful abstinence (Krishnan-Sarin et al., 2007; MacKillop & Kahler, 2009; Sheffer et al., 2012; Sheffer et al., 2014; Washio et al., 2011; Yoon et al., 2007). Moreover, previous studies comparing the ability of different neurocognitive measures to differentiate users from control or to predict treatment outcomes indicated that delay discounting is the best neurocognitive measure to predict substance dependence (Bickel et al., 2017) and treatment outcomes (correctly predicted treatment outcomes of 80% of the sample post-treatment and 81% at follow-up; Coughlin et al., 2018).

Based on a study conducted by Rubenis et al. (2018), discount rates may predict QOL improvement during early treatment for people with methamphetamine dependence. However, to our knowledge, the relationship between delay discounting and QOL among individuals in recovery from SUDs in general and from alcohol use disorders (AUDs) specifically has not been previously examined. The current investigation, in two separate cross-sectional studies, assessed the relationship between delay discounting and QOL among individuals in recovery from SUDs. Additionally, as an integral part of the recovery process,

remission from SUDs and its association with delay discounting and QOL were examined. Remission is defined as freedom from substance use disorder criteria (except craving) for at least 3 months (Hasin et al., 2013). Study 1 investigated the relationship between delay discounting and QOL among 166 (104 females) individuals in recovery from SUDs. Study 2 sought to validate and extend the results of Study 1 by assessing the association between the remission status, delay discounting, and QOL among 282 (172 females) individuals in recovery from AUD. We hypothesized that higher rates of discounting would be associated with lower QOL among individuals in recovery from SUDs (studies 1 and 2). In addition, we hypothesized that individuals in remission from AUD would show lower discounting rates and greater QOL compared to those still meeting the AUD criteria (Study 2). Establishing the association between delay discounting, QOL, and remission status might help identify individuals in recovery who are at greater risk of relapse.

General Methodology

Participation in both studies was voluntary. Consent was implied through the completion and submission of the survey. This investigation was approved by the Institutional Review Board at Virginia Polytechnic and State University.

Participants

Both studies were conducted using data collected online through the International Quit and Recovery Registry (IQRR), an online community and registry launched in 2011 geared toward individuals in self-reported recovery from various substances. The aims of the IQRR include learning more about the different factors that allow people to overcome addiction, the association between addictions and decision-making, and identifying phenotypes of recovery (see also Athamneh et al., 2017, 2019). Individuals can register on the website (https://quitandrecovery.org), and may create profiles that enable them to complete monthly assessments aimed at advancing the aforementioned goals of the IQRR with no minimum commitment to stay in the registry. For each assessment completed, participants earn a badge (available on their profile) and a set number of points (400 to 1000 points), which can be exchanged at a rate of 100 points for $1.00. In addition, resources aimed at promoting recovery are available on the IQRR website for participants to access at any time and they are encouraged to utilize them.

Study 1

Methodology

A total of 172 participants completed the assessment. Inclusion criteria for Study 1 required that participants be 18 years or older and self-report recovery from one or more SUDs. Given the distinctive set of risks associated with SUDs compared to non-substance addictions such as the impact of substances on physical and mental health, participants were excluded if they reported a non-substance-related addiction (e.g. gambling, binge eating, excessive shopping, etc.; n = 6); thus, the final sample consisted of 166 participants.

Study Measures—Various demographic data including age, race, ethnicity, annual income, gender, marital status, and education level were collected using a standardized questionnaire. All participants self-reported being in recovery from at least one substance addiction. The primary addiction was determined using the question "What was your primary addiction?" for which the options were nicotine, alcohol, cannabis products, opioids, cocaine, stimulants, prescription pain relievers, hallucinogens, dissociative anesthetics, tranquilizers/depressants, inhalants, caffeine, gambling, overeating, binge eating or other eating disorders, excessive shopping, excessive sexual activity, excessive video gaming, excessive viewing of pornography, and excessive preoccupation with activities on the internet. Moreover, participants were asked "When was the last time you engaged in your primary addiction?" and days since last use was calculated by subtracting the response to that question from the date of completing the assessment.

Delay Discounting.: Delay discounting was measured using an adjusting-delay task (Koffarnus & Bickel, 2014). The adjusting-delay tasks determine the delay at which the larger reward loses about 50% of its value compared to the immediate reward. In this task, participants were asked to choose between $1000 in 3 weeks or $500 now. Depending on the response, the next question lengthens or shortens the delay of the $1000 reward (i.e. if the delayed $1000 is chosen, the next question lengthens the delay to 2 years; if the immediate $500 is chosen, the next question shortens the delay for the $1000 reward to 1 day). The delays continue to adjust for a total of five choice trials (Koffarnus & Bickel, 2014). The adjusting-delay task assumes that the value of the delayed reward is discounted hyperbolically based on Mazur's equation (Mazur, 1987).

The indifference points (expressed in days) provided by the adjusting-delay task were used to calculate ED_{50} (i.e., the delay expected to reduce the value of the larger reward by 50%). Then, the inverse of this ED_{50} ($1/ED_{50}$) was calculated to provide an estimate of the discounting rate (k) based on Mazur's hyperbolic discounting equation (Koffarnus & Bickel, 2014; Yoon & Higgins, 2008). As the observed *k* values were positively skewed, the natural log transformation of *k* was used in analyses. The 5-trial adjusting-delay task was used in this study due to its flexibility and ability to quickly but accurately assess the discounting rate (Koffarnus and Bickel 2014). However, given that the task is relatively new and only assesses a single indifference point, an increased measurement error is possible.

World Health Organization Quality of Life Assessment (Brief).: The original World Health Organization Quality of Life Assessment (WHOQOL-100) was created as a 100-item assessment that would allow for cross-cultural indication of perceptions of quality of life (Group & The WHOQOL Group, 1994; Kim, 2014). The brief version (WHOQOL-BREF) is a 26-item assessment shortened from the original WHOQOL-100 ("Development of the World Health Organization WHOQOL-BREF quality of life assessment. The WHOQOL Group," 1998). The assessments attempt to measure four main domains of QOL (multiple facets per domain): (1) physical health (e.g., activities of daily living, energy and fatigue, pain and discomfort); (2) psychological (e.g., negative and positive feelings, thinking, learning, and concentration); (3) social relationships (e.g., personal relationships, social support, sexual activity); and (4) environment (e.g., financial resources, freedom, physical

safety, and physical environment). Each item in the WHOQOL-BREF is associated with one facet of one of the four larger domains, and two questions are meant to represent a more general perception of the quality of life and health. Each item in the WHOQOL-BREF was scored with a 5-point Likert scale (three items are reverse scored), and these scores were used to generate raw scores for each domain, which were then scaled 0–100 (the World Health Organization, 1998).

Statistical Analysis—Descriptive statistics were used to determine the means and distribution of sample characteristics. Bivariate linear regression analyses of delay discounting were carried out with each of the QOL domains, and results were presented as unadjusted coefficients with 95% confidence intervals (CI). In addition, to assess the ability of discounting rates to predict QOL, multivariate linear regression analysis was run with each of the QOL domains as dependent variables and discounting rates, demographics and substance use (i.e., age, gender, race, ethnicity, education level, and days since last use) as independent variables. All analyses were conducted in SPSS 26 (IBM Analytics, Armonk, NY) at a significance level of 0.05.

Results

A total of 166 participants completed the questionnaire and were included in the analysis. The distribution of the socio-demographic characteristics, substance use, discounting rates, and QOL domains for participants in Study 1 is shown in Table 1. The multivariate linear regression results indicated that all QOL domains (i.e., physical health, psychological, social relationships, and environment) were associated *negatively* with delay discounting rates even after controlling for age, gender, race, ethnicity, recent substance use, time since last use, and education level indicating that participants with lower degrees of delay discounting reported higher QOL (Table 2). Although the main findings are in agreement with our predictions, Study 1 did not assess the association and predictive utility of QOL or discounting rates of one's remission status. In addition, given the possible distinctive effect associated with different SUDs on discounting rates and QOL, replicating the findings among each of the substances separately could enhance generalizability. Thus, before discussing the findings in Study 1, we aimed to replicate them in Study 2 among individuals in recovery from AUD while adding the Diagnostic and Statistical Manual (DSM-5) criteria for AUD dependence and remission.

Study 2

Methodology

A total of 282 participants completed the assessment. Inclusion criteria for Study 2 required that participants be 18 years or older and meet the DSM-5 criteria for lifetime abuse and dependence of alcohol (report at least 2 DSM-5 criteria of AUD during lifetime).

Study Measures—We collected demographic data including age, income, gender, race, marital status, ethnicity, years of education, and days since last use. Similar to Study 1, the adjusting-delay discounting tasks and QOL measures were collected. All study measures were collected in the same assessment.

DSM-5 for abuse, dependence, and remission from AUD.: DSM-5 alcohol use disorders were assessed using the criteria of the DSM for alcohol abuse and dependence- 5th edition (American Psychiatric Association, 2013; Hasin et al., 2013). Alcohol-specific diagnoses were made for the life-time, last year, and last 3 months timeframes. The survey included 11 symptom questions from the DSM-5 criteria for a diagnosis of alcohol abuse and dependence (American Psychiatric Association, 2013; Hasin et al., 2013; Kuerbis et al., 2013; Sullivan et al., 2020). DSM-5 AUD lifetime diagnosis was established if participants indicated at least two of the 11 criteria in their life-time. Remission status included 2 groups: (1) early remission, defined as ≥3 to <12 months without meeting alcohol use disorders criteria (except craving); and (2) sustained remission as ≥12 months without meeting alcohol use disorders criteria (except craving). The test-retest reliability and validity of DSM-5 SUD diagnosis have been examined in psychometric studies, with fair to good test-retest reliability ($\kappa = 0.4 – 0.6$) and fair to excellent dimensional criteria scales (intraclass correlation coefficient [ICC] = 0.5 – 0.9, respectively; (Grant, Goldstein, Saha, et al., 2015; Grant, Goldstein, Smith, et al., 2015; Hasin et al., 2015)

Statistical Analysis—Descriptive statistics were used to determine the means and distribution of sample characteristics. Bivariate linear regression analyses of delay discounting were carried out with each of the QOL domains, and results were presented as unadjusted coefficients with 95% confidence intervals (CI). In addition, to assess the ability of discounting rates to predict QOL, multivariate linear regression analysis was run with each of the QOL domains as dependent variables and discounting rates and demographics (i.e., age, gender, race, ethnicity, marital status, education level, and days since last use) as independent variables.

One-way ANOVA analyses and chi-square analyses were used to compare the means and distribution of sample characteristics within groups (not in remission, in early remission, in sustained remission). As no significant difference in any of the demographics or outcome measures were found between those who were identified as in early remission (n=184) or sustained remission (n=22) based on DSM-5 remission criteria (data not shown), and given the small sample size for those in sustained remission, the two remission groups were reclassified into one group (i.e., in remission) to ease the analysis and interpretation of the results.

T-test and chi-square analyses were used to compare the means and distribution of sample characteristics between the “in remission” and “not in remission” groups. A separate multivariate binary logistic regression was performed to assess the relationship between the remission status (outcome variable) and each of the four QOL domains and delay discounting while controlling for the demographic variables (i.e., age, gender, years of education, marital status, race, and ethnicity).

Next, mediation analysis was conducted using Hayes’ (2017) methods to explore whether rates of discounting partially accounts for the association between QOL domains and the remission status. A bootstrapping technique (with 10,000 bootstrap samples) to estimate 95% confidence intervals (CI) was used. A 95% CI for the product of indirect path coefficient that does not include zero provides evidence of a significant indirect effect

(Preacher et al., 2007). All analyses were conducted using IBM SPSS Statistics Version 26 (IBM Analytics, Armonk, NY; George & Mallery, 2019) and macro-program PROCESS 3.4 (Hayes 2009; Hayes 2017) at a significance level of 0.05.

Results

A total of 282 participants completed Study 2 and were included in the analysis. Means and distribution of the socio-demographic characteristics, discount rates, and QOL domains for participants in Study 2 are shown in Table 3. The multivariate linear regression results indicated that discounting is a significant predictor of three of the four QOL domains (i.e., physical health, psychological, and environment) even after controlling for age, gender, race, ethnicity, marital status, and education level (Table 4). Interestingly, the QOL domain of social relationships was not significantly associated with rates of discounting.

The t-test and pearson chi square analysis of the continuous and categorical demographic variables, respectively, indicated a significant difference in age; t(280) =−5.365, p <0.001], race; X2 (5, N=282) = 14.976, p =0.010, and marital status; X2 (5, N= 282) = 21.005, p =0.001 between the two groups (Table 5). We controlled for demographics (age, gender, race, ethnicity, marital status and education level) in our final multivariate logistic regression analysis (Table 6).

The multivariate binary logistic regression analysis indicated that discounting is a significant predictor of remission status with lower rates of discounting found among those in remission (M =−5.81, SD = 2.23, M_{ED5}= 3.81 years) compared to those not in remission (M =−4.18, SD = 2.96, M_{ED50}= 1.19 years, p= .006; Figure 1). In addition, those in remission had greater physical health (M =69.43, SD = 19.37) compared to those not in remission (M =59.43, SD = 19.24, p= .003), greater psychological status (M =64.86, SD = 18.87) compared to those not in remission (M =53.00, SD = 23.4, p= .004), and better environment (M =76.72, SD = 17.89) compared to those not in remission (M =66.80, SD = 21.04, p= .019; Figure 2). Interestingly, no significant difference in social relations was observed between those in remission (M =59.50, SD = 22.69) and those not in remission (M =52.54, SD = 28.95, p= .061; Figure 2). Therefore, this variable was not included in the subsequent mediation effect analysis.

We next used the associated QOL domains (i.e., physical health, psychological, or environment) in mediation analysis. Results suggested significant indirect association between the scores of these domains and the remission status, through delay discounting (Figure 3). Overall, the discounting rates (lnk) represented 24% of the total effect between physical health score and the remission status, 19% of the total effect between psychological score and the remission status, and 35% of the total effect between environment score and the remission status.

Discussion

The present study examined the association between discounting of delayed monetary rewards, assessments of QOL, and remission status in a sample of individuals in recovery from SUDs from the International Quit and Recovery Registry. The results indicate

significant associations between physical health, psychological, and environment domains of QOL and discounting (both studies). Greater QOL was observed among those with lower discount rates. In addition, the current findings indicated lower discounting rates and greater physical health, psychological, and environment QOL scores (indicating higher satisfaction) among those in remission from AUDs compared to those not in remission (Study 2). Overall, the discounting rates accounted for 24%, 19%, and 35% of the total effect between the remission status and physical health, psychological, and the environment scores, respectively. These results extend the findings of previous research by reporting a significant association between QOL, rates of discounting and remission status among individuals in recovery from substance dependence. These findings further support delay discounting as a behavioral marker of addiction (Bickel et al., 2014) and support the evolving definition of recovery from substance use disorders as a multifaceted phenomenon (Betty Ford Institute Consensus Panel 2007; Kelly and Hoeppner 2015; Laudet 2007; McLellan 2010). Below, we discuss those findings in more detail.

The WHO-QOL BREF Physical Health domain assesses someone's body condition to perform daily living activities, including questions on the dependence on medicinal substances and medical aids, level of energy and fatigue, mobility, pain, and discomfort, sleep and rest and work capacity. Previous studies have reported associations between different facets of physical functioning and lower future valuation, such as chronic pain (Tompkins et al., 2016; Wakaizumi et al., 2019), sleep deprivation (Curtis et al., 2018); or greater future valuation, such as physical activity (Tate et al., 2015) in different populations. Overall, the significant relationship between delay discounting and physical health with delay discounting rate accounting for 24% of the total effect between psychological score and remission status is consistent with those findings, suggesting that the capacity to perform daily tasks plays an important role in the subjective valuation of the future among individuals in recovery from substance use disorders.

Even though no previous study has examined the relationship between delay discounting and physical health in individuals in recovery from substance use disorders, the association between physical health-related indicators and treatment effectiveness has been established. Physical activity, for example, is often used as an adjunctive approach to substance use treatment to improve physical health amid other outcomes (see Wang et al., 2014 for a review). Interestingly, one study showed that differences in global functioning between adults submitted to a treatment program and population norms were initially verified but vanished three months after treatment commenced (Morgan et al., 2003). Similarly, detected differences in delay discounting and physical health between participants in remission (lower discount rates and higher physical health scores) and not in remission (higher discount rates and lower physical health scores) enhance the importance of the first months of recovery to leverage outcomes, improve physical health and increase the temporal window.

The WHO-QOL BREF psychological domain investigates several characteristics relating to mental health and cognitive functioning including enjoyment and meaningfulness of life, ability to concentrate, acceptance of bodily appearance, self-satisfaction, and negative feelings such as anxiety and depression. Psychiatric comorbidities, including anxiety and

mood disorders, are common in individuals suffering from AUD specifically and in SUD generally (Walker & Druss, 2018). A bi-directional relationship between SUD and psychiatric disorders has been documented, such that the presence of one increases the risk for the other (Hunt et al., 2020). As previously noted, delay discounting has been well established as a determinant of substance use disorder severity (MacKillop et al., 2011), and recent meta-analysis identified discounting as a trans-diagnostic process undergirding several psychiatric conditions including depression (Amlung et al., 2019). Additionally, delay discounting has been shown to have a negative relationship with cognitive functions including working memory (Hinson et al., 2003; Wesley & Bickel, 2014) and educational attainment (Mischel et al., 1989; Kirby et al., 2005), and similar associations have been noted in SUD (Jaroni et al., 2004; Khurana et al., 2013). The relationship between remission status and psychological quality of life have been well documented. Reductions in alcohol use are associated with increased mental health and function status in early and longer-term remission (Donovan et al., 2005). Interestingly, some aspects related to psychological quality of life, including self-esteem and coping ability, have been shown to decrease in early recovery and are a risk factor for relapse (Dennis et al., 2007). The extant research coupled with the finding of this study provides further support for the importance of future valuation in the treatment of SUD. Further understanding of the relationships between psychological quality of life, SUD, and delay discounting seems likely to refine the therapeutic efficacy of current substance use treatment and improve the quality of life of individuals suffering from SUD.

The environment domain of the WHO-QOL BREF assesses a number of behaviors known to be associated with delay discounting and/or alcohol use, including financial resources (Snider et al., 2019; Hamilton & Potenza, 2012; Moos et al., 2010; Mishra & Lalumière, 2017; Ersner-Hershfield et al., 2009), freedom (Petry 2003), physical safety (Hayashi et al., 2015), health and social care (Mishra & Lalumière, 2017; Sheffer et al., 2018; Snider et al., 2019), home environment (Wang et al., 2016), participation in and opportunities for recreation/leisure activities (Snider et al., 2019; Moos & Moos, 2007), and physical environment (Grana et al., 2010; Snider et al., 2019; Gelino & Reed, 2020). The behaviors assessed in the environment domain have been shown to both influence delay discounting and be influenced by delay discounting. For example, demographic characteristics, like education or socioeconomic status, have been shown to influence delay discounting (Wilson et al. 2015; Stanger et al. 2012), and delay discounting rates have been shown to predict relapse rates in smokers (González-Roz et al. 2019; Sheffer et al. 2014). Although neither delay discounting nor the environment domain of quality of life were manipulated in this study, it is worth noting that these measures could influence one another. The current findings of significant association between discounting, the environment domain of QOL, and remission status further support previous literature as mentioned above.

Contrary to our initial hypothesis, social relations did not significantly differ between individuals in remission versus those not in remission. Previous work has shown that engagement in social relationships is imperative in the recovery process and predicts future abstinence (Brereton et al., 2014; Lookatch et al., 2019). Additionally, the larger the social network and the greater the percentage of abstinent individuals in this network, the greater the likelihood that the patient will remain abstinent (Zywiak et al., 2002). Some studies

have even used relationship enhancement programs as interventions, showing that this treatment (compared to brief broad-spectrum or extended cognitive-behavioral treatments) is the most effective for individuals who have unsupportive social networks or low levels of investment in their previous social networks (Longabaugh et al., 1995). Collectively, this work shows that abstinence is most successful when individuals in recovery are able to embed themselves in supportive social networks, with the most beneficial being those that are homophilic (i.e., composed of individuals in similar recovery situations). Indeed, social relationships are considered an important part of the environmental enrichment that is now considered necessary for addiction treatment (Galaj et al., 2020).

The majority of the research to date examining the relationship between recovery and social networks has focused on recovery houses, such as Oxford House (OH), or 12-step recovery programs, such as Alcoholics or Narcotics Anonymous (AA/NA), whereby the social networks consist primarily of individuals in recovery (Doogan et al., 2019). Our research here focuses on a potentially more diverse population of individuals in recovery. One interpretation of our negative results is that social relationships may be the most resistant to change or most difficult to repair after the experience of addiction. Additionally, unlike the other QOL subscales, social relationships require the interaction of two people, which might make this area of life particularly challenging to repair. Individuals early in recovery may have social networks that consist largely of drug users, and as recovery progresses, shifting the social network to include others in recovery, and heal familial, romantic, and friend relationships may prove especially challenging. As the positive relationship between social functioning and quality of life in other psychiatric populations has been established (Trompenaars et al., 2007), future studies should investigate factors that promote the recovery of social relations in individuals in addiction recovery.

Finally, a small literature has investigated the phenomenon of social temporal discounting where individuals are required to make a choice between a smaller reward to be shared amongst a group of unknown individuals now or a larger reward to be shared amongst that same group sometime in the future (Charlton et al. 2013; Jones and Rachlin 2006). Interestingly, reports show that individuals are more willing to wait for shared rewards than for individual rewards (Charlton et al. 2013). That is, making monetary decisions in a social context makes individuals more future oriented. Additionally, social discounting rates increase as the perceived social distance between self and other increases (Jones and Rachlin 2006). Consistent with the delay discounting literature, we have shown that individuals with substance use disorders and obesity show steeper social discounting rates than healthy controls (Bickel et al. 2012; Bickel et al. 2014). To our knowledge, no studies to date have explicitly examined social discounting in individuals in addiction recovery. This is clearly an open area of inquiry, and we hypothesize that as recovery progresses, akin to delay discounting, social discounting rates would decrease. Other work has investigated the relationship between delay discounting and social relationships. For example, one prospective longitudinal study found that lower quality parent-adolescent relationships predict later risky sexual behavior, and this relationship is mediated through DD (Kahn et al., 2015). Future research is needed to establish how social relationship quality prior to recovery, engagement in social networks during recovery, and their relationship to DD predict success in addiction recovery and how these measures relate to social discounting.

A significant quality of the current study was the opportunity to use data from the IQRR, a unique online resource that permits the scientific study of recovery processes, depicts different groups of individuals in recovery, and provides an insight into the association between quality of life, delay discounting rates, and remission status in this specific population. The current study suggests several areas for future research. Further research examining the predictive utility of delay discounting of QOL for individuals in recovery from other types of substance and behavioral problems (e.g., cocaine, nicotine, gambling, overeating) may be beneficial. Moreover, additional research is needed to characterize the longer-term trajectory of the recovery process by understanding the relationships between changes in delay discounting over time and their related changes in substance use or remission status.

Despite the findings of the present study, several limitations are worth considering. First, although the IQRR is a valuable research tool to better understand the phenotype of recovery, the online-based assessments consist of self-report measures and limit our sample to include only those individuals in recovery who use technology, have an email address, and register in the IQRR. However, the use of online data collection has been validated by many studies reporting results similar to laboratory-based data collection (Birnbaum 2000; Buhrmester et al., 2011; Paolacci et al., 2010; Suri & Watts, 2011). Most relevant to the present study, online studies have replicated many discounting-related phenomena observed in laboratory studies, including cross-sectional differences in delay discounting related to cigarette smoking and alcohol use disorder (Jarmolowicz et al., 2012; Johnson et al., 2015; VanderBroek et al., 2016).

Second, although the present study assessed the relationship between delay discounting and QOL, several variables were not assessed and they may have affected the results. For example, the study did not collect data about other psychiatric comorbidities, living conditions, or stress levels. As those variables may alter rates of discounting and/or QOL, future research that includes assessments of these factors might be needed to better understand the relationship between QOL and delay discounting. Moreover, in Study 1 we asked participants to self-report being in recovery but did not provide a specific definition to this term. Hence, participants might have interpreted the meaning of recovery differently. In addition, in Study 1 participants were excluded if they reported a non-substance-related addiction. As previous studies have demonstrated that individuals with more than one impulsive disorder (e.g., alcohol use disorder and problem gambling) might exhibit greater discounting, investigating the effect of having multiple addictions on the association between discounting and quality of life would be beneficial to improve our understanding of the current findings. Furthermore, using the cross-sectional design in this study limited our ability to predict the temporal precedence and association between delay discounting and the multiple domains of quality of life. For example, while changes in delay discounting may alter one’s QOL, changes in the QOL and SUD status could feasibly alter self-reported delay discounting as well (e.g., relative improvements in those domains could reduce delay discounting). In addition, as we mentioned in the methods section, while the 5-trial adjusting-delay task is brief, flexible and can accurately assess the discounting rate (Koffarnus and Bickel 2014), the task is relatively new and only assesses a single indifference point increasing the possibility of measurement error. Finally, although all

individuals in recovery from substance use are encouraged to join the IQRR, self-selection bias for those who volunteered to join might be present.

Conclusion

The current study expands previous research investigating the association between rates of discounting and substance use and indicates that discounting rates predict the remission status and physical health, psychological, and environment domains of quality of life among individuals in recovery from substance use disorders. This finding corroborates the recent characterizations of delay discounting as a candidate behavioral marker of addiction and may help identify sub-groups that require special treatment or unique interventions to overcome their addiction. Future research characterizing the longer-term trajectory of the recovery process by understanding the relationships between changes in delay discounting over time and their related changes in the substance use or remission status is needed. Moreover, examining the predictive utility of delay discounting of QOL for individuals in recovery from other types of substance and behavioral problems (e.g., cocaine, nicotine, gambling, overeating) may be beneficial.

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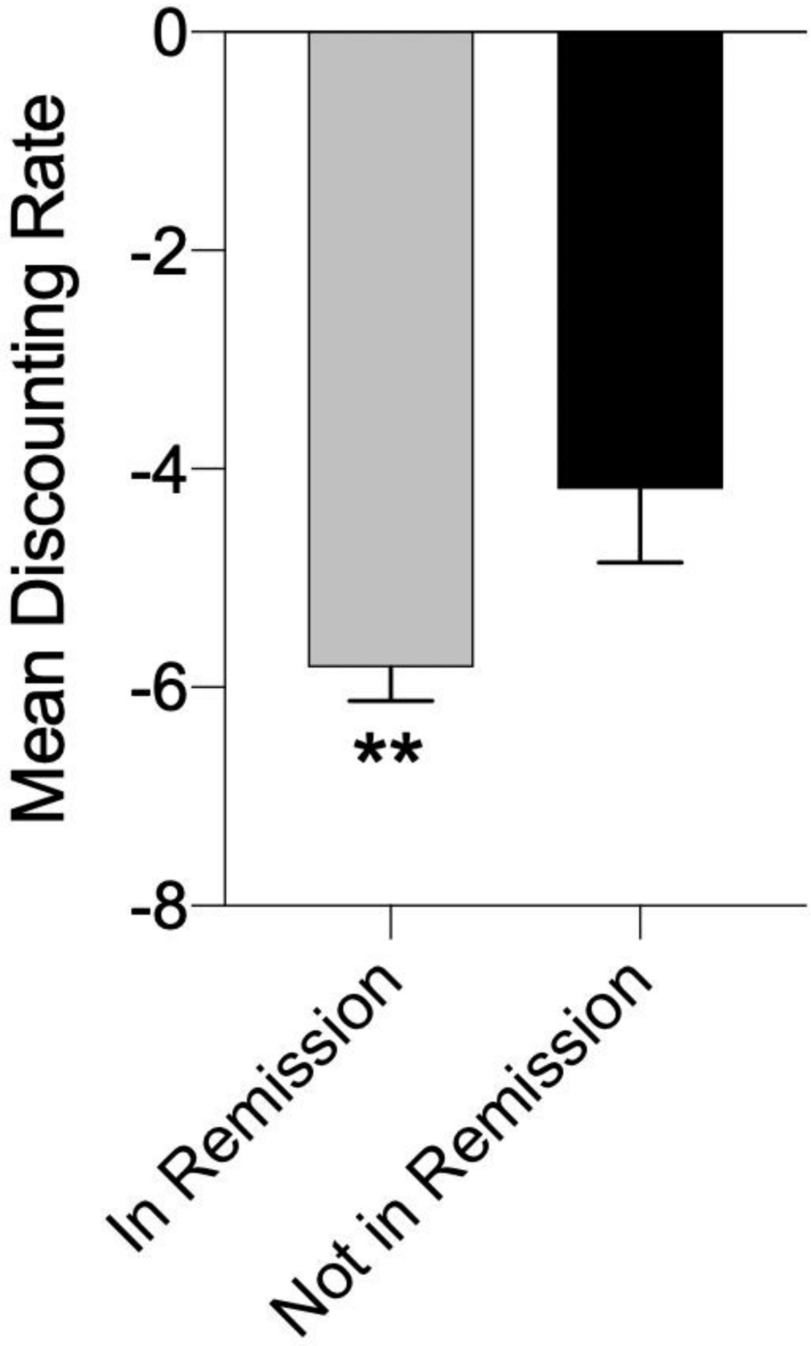

Figure 1.

A Comparison from Study 2 of Discounting Rates (ln[k]) between Individuals in Remission and Not in Remission from AUDs.

Note. Error bars represent 95% confidence intervals.

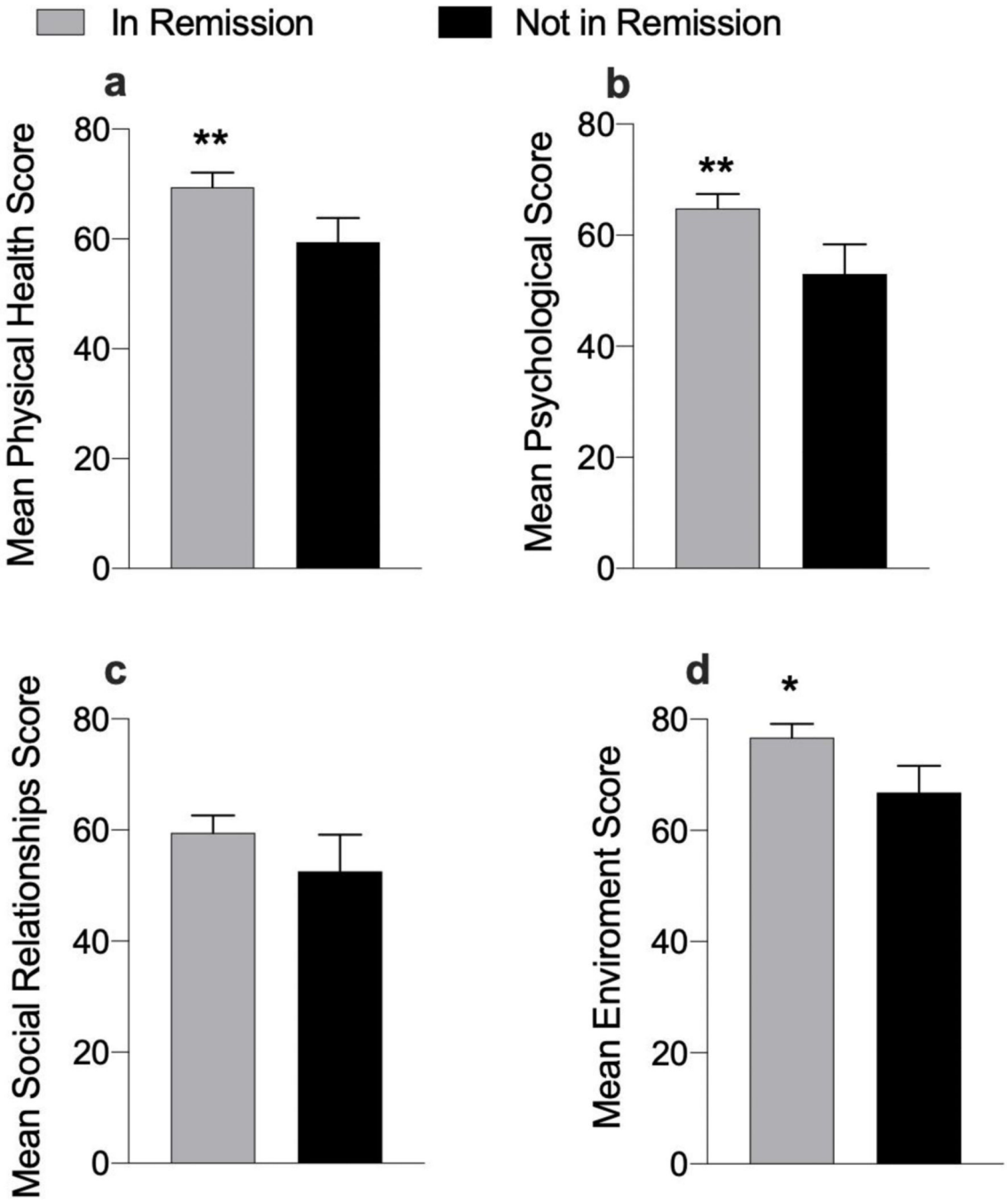

Figure 2.

A Comparison from Study 2 of QOL Domains: (a) Physical Health, (b) Psychological, (c) Social Relationships, and (d) Environment between Individuals in Remission and Not in Remission from AUDs.

Note. Error bars represent 95% confidence intervals.

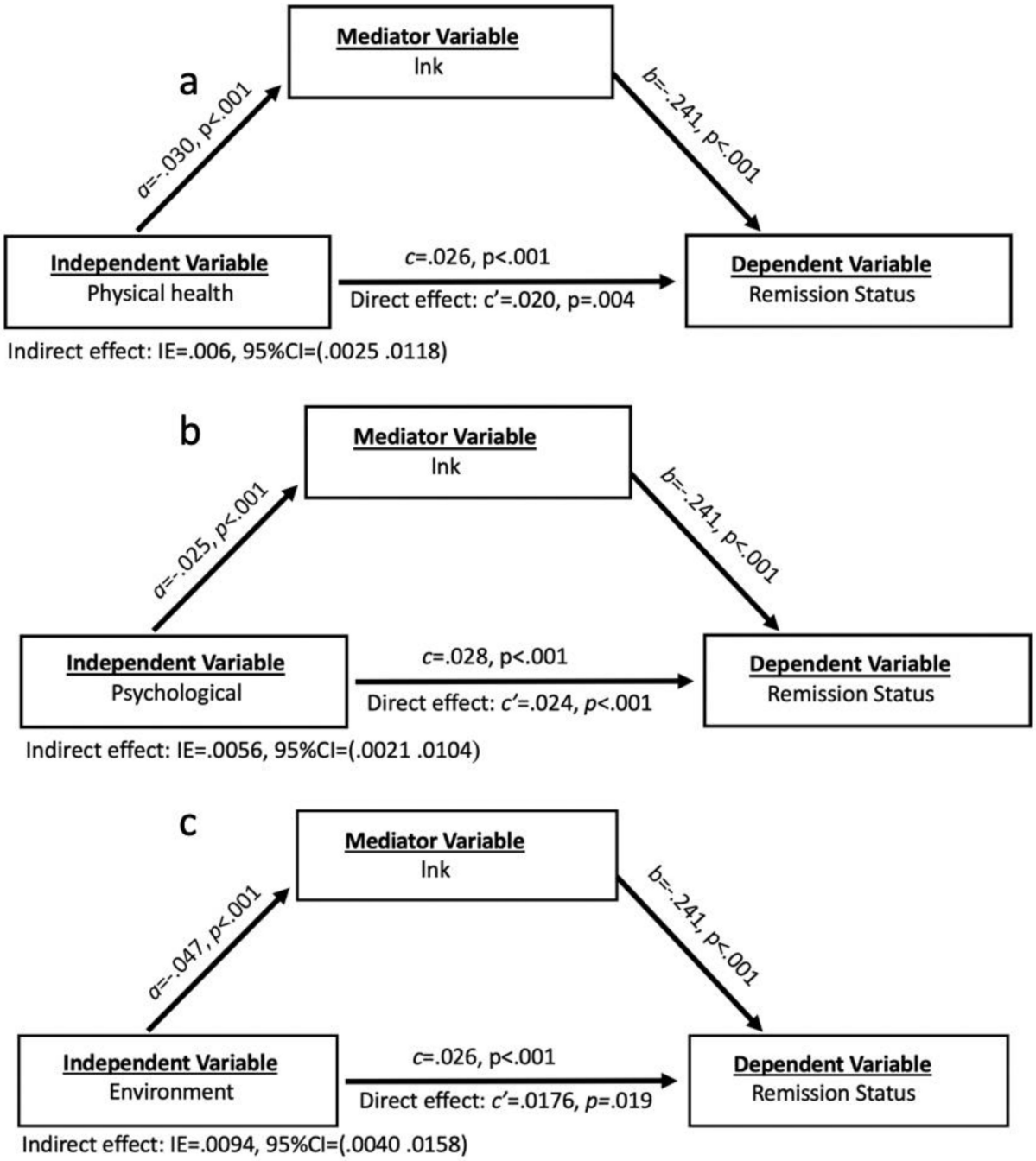

Figure 3.

Mediation Analyses Using QOL Domains: (a) Physical Health, (b) Psychological, and (c) Environment

Note. Given that in all cases the indirect effect is statistically significant, they support partial mediation.

Table 1

Sample Characteristics for Study 1 (N = 166)

Characteristics	Frequency (%) / Mean (*SD*)
Female	104 (62.7)
Marital Status *	
Single	76 (46.1)
Married	46 (27.9)
Other	45 (27.3)
Education level *	39 (23.6)
High school diploma/GED or less	60 (36.4)
Some college or vocational training	
Completed a 4-year college degree or higher	66 (40.0)
Income*****	
Less than $9,999	46 (28.6)
$10,000–$29,999	41 (25.5)
$30,000–$49,999	40 (24.8)
$50,000–$69,999	13 (8.1)
$70,000+	21 (13.0)
Race**	
Asian	12 (7.3)
Black or African American	8 (4.9)
White	134 (81.7)
Other	10 (6.1)
Non-Hispanic***	158 (96.9)
Primary addiction	
Alcohol	98 (59.0)
Opioids	22 (13.3)
Other	46 (27.7)
Age	46.77 (14.02)
Time since last use (days)	3375.68 (3921.22)
Delay discounting rates (ln[k])	−4.89 (2.56)
ED50 (years)	2.21 (4.33)
WHOQOL-BREF Domain Scores	
Physical Health	64.24 (23.06)
Psychological	60.32 (20.83)
Social Relationships	55.16 (26.06)
Environment	68.45 (21.00)

Note.

* denotes one refusal to respond

Table 2

Linear Regression Results for QOL and Delay Discounting Rates for Study 1

Variable	Unadjusted coef. (95% CI)	P-value	Adjusted coef. (95% CI) [a]	*P-Value* [b]
Physical Health	−2.901 (−4.211 −1.590)	<.001	−2.052 (−3.465 −.639)	.005
Psychological	−2.887 (−4.056 −1.717)	<.001	−1.439 (−2.698 −.180)	.025
Social Relationships	−3.751 (−5.205 −2.296)	<.001	−2.621 (−4.276 −.966)	.002
Environment	−3.551 (−4.687 −2.415)	<.001	−1.975 (−3.132 −.818)	.001

Note. Cl= confidence interval

[a]Adjusted to age, gender, years of education, race, ethnicity, and days since last use.

[b]For the adjusted values

Table 3

Sample Characteristics for Study 2 (N = 282)

Characteristics	Total Frequency (%) / Mean (*SD*)
Female	172 (61)
Marital Status	
Single	75 (26.6)
Married	106 (37.6)
Divorced	50 (17.7)
Other	51 (18.1)
Income	
Less than $9,999	63 (22.3)
$10,000–$29,999	87 (30.9)
$30,000–$49,999	51 (18.1)
$50,000–$69,999	30 (10.6)
$70,000+	51 (18.1)
Race	
White	252 (89.4)
Black or African American	18 (6.4)
Other	12 (4.2)
Non-Hispanic	266 (94.3)
Age	49.81 (14.06)
Years of education	14.39 (4.57)
Time since last use (days)	3962.60 (4310.59)
Delay discounting rates (ln[k])	−5.37 (2.55)
ED50 (years)	3.12 (5.22)
WHOQOL-BREF Domain Scores	
Physical Health	66.74 (19.81)
Psychological	61.66 (20.82)
Social Relationships	57.62 (24.68)
Environment	74.05 (19.26)

Table 4

Linear Regression Results for QOL and Delay Discounting Rates for Study 2

Variable	Unadjusted coef. (95% CI)	*P* value	Adjusted coef. (95% CI) [a]	*P* Value [b]
Physical Health	−1.824 (−2.712 −.936)	<.001	−1.569 (−2.500 −.637)	.001
Psychological	−1.719 (−2.657 −.780)	<.001	−1.071 (−2.014 −.129)	.026
Social Relationships	−.701 (−1.836 .434)	.225	−.579 (−1.784 .626)	.345
Environment	−2.696 (−3.526 −1.867)	<.001	−2.361 (−3.243 −1.480)	<.001

Note. Cl= confidence interval

[a]Adjusted to age, gender, years of education, race, ethnicity, and days since last use.

[b]For the adjusted values

Table 5

Chi- square and T-test Results for the Demographics Variables by Remission Status in Study 2 (N = 282)

	Total Frequency (within group %) / Mean (*SD*)		
Characteristics	**In remission n=206**	**Not in remission n=76**	**P value**
Female	128 (74.4)	44 (57.9)	.517
Marital Status			
Single	43 (20.9)	32 (42.1)	.001
Married	86 (41.7)	20 (26.6)	
Other	77 (37.3)	24 (31.6)	
Income*****			.160
Less than $9,999	37 (18.0)	26 (34.2)	
$10,000–$29,999	64 (31.1)	23 (30.3)	
$30,000–$49,999	38 (18.4)	13 (17.1)	
$50,000–$69,999	24 (11.7)	6 (7.9)	
$70,000+	43 (20.9)	8 (10.5)	
Race			.010
White	189 (91.7)	63 (82.9)	
Black or African American	8 (3.9)	10 (13.2)	
Other	9 (4.3)	3 (3.9)	
Non-Hispanic	196 (95.1)	70 (92.1)	.327
Age	52.41 (13.59)	42.75 (12.93)	<.001
Years of education	14.19 (4.386)	14.93 (5.05)	.236

Table 6

Summary of Multivariate Binary Logistic Regression Analysis of Discounting and QOL Predicting Remission Status in Study 2 (N = 282)

Characteristics	*B*	S.E	Wald	P value[a]	Exp (B)	95% CI for Exp (B)	
Delay discounting rates	−.162	.059	7.574	.006	.850	.758	.954
WHOQOL-BREF							
Physical Health	.023	.008	8.629	.003	1.023	1.008	1039
Psychological	.021	.008	8.098	.004	1.022	1.007	1.037
Social Relationships	.011	.006	3.497	.061	1.011	.999	1.023
Environment	.018	.008	5.520	.019	1.019	1.003	1.034

Note. Abbreviations: CI, confidence interval; OR, odds ratio; SE, standard error.

[a]Variables entered in all models are age, gender, years of education, race, ethnicity, and marital status.