Psychology of Addictive Behaviors
2018, Vol. 32, No. 2, 197–204


0893-164X/18/$12.00 http://dx.doi.org/10.1037/adb0000341

# Delay Discounting of Losses and Rewards in Alcohol Use Disorder: The Effect of Working Memory Load

Allen J. Bailey, Kyle Gerst, and Peter R. Finn
Indiana University Bloomington

Alcohol use disorder (AUD) has been consistently associated with elevated discounting rates for delayed rewards. However, there are few studies of delay discounting of losses in those with AUD even though their drinking behavior suggests that they discount future negative consequences of excessive drinking. The current study extends this literature by examining delay discounting of rewards and losses in a sample of those with AUD ($n$ = 78) and healthy controls ($n$ = 51) in 2 conditions: working memory (WM) load and no WM load. The AUD group discounted both rewards and losses at higher rates than the control group. The WM load increased discounting rates in the reward task but not in the loss task. There was also a significant Group × WM load interaction; the WM load increased discounting in control participants but not in AUD participants. These findings suggest that AUD is associated with a general propensity to discount future incentivized events regardless of nature of the incentive.

*Keywords:* delay discounting of rewards, delay discounting of losses, alcohol use disorders, working memory



Individuals with alcohol use disorder (AUD) have demonstrated a proclivity to discount larger future rewards relative to immediately available smaller rewards at higher rates compared with controls (Bobova, Finn, Rickert, & Lucas, 2009; Field, Christiansen, Cole, & Goudie, 2007; Finn, Gunn, & Gerst, 2015; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Petry, 2001). Higher delay discounting rates of rewards have also been observed across a variety of substance use disorders, including opioid use disorder, cocaine use disorder, cigarette smoking (Bickel & Marsch, 2001; Kirby, 1997), as well as obesity and pathological gambling (Bickel & Marsch, 2001; Weller, Cook, Avsar, & Cox, 2008). Common to all these disorders are difficulties in self-regulation.

Although increased discounting of delayed rewards fits in well with the symptoms and behaviors of those with an AUD, it also is evident that those with AUDs significantly discount future negative events relative to immediate negative events as well. For instance, individuals with AUDs frequently discount future negative events associated with drinking, such as job loss or severe health problems, in favor of drinking in order to immediately relieve the discomfort of craving or withdrawal symptoms. Impulsive avoidance of immediate discomfort can contribute to maladaptive decisions that ignore substantial long-term negative life outcomes. Although it appears from their behavior that those with AUD substantially discount the future negative consequences of excessive drinking, there are very few studies of delay discounting of future losses compared with discounting of future rewards. One study reported an association between higher discounting of losses and higher frequency of drinking in a nonclinical sample of undergraduates (Takahashi, Ohmura, Oono, & Radford, 2009). To our knowledge, only two studies have examined the discounting of losses in individuals with pathological drinking behaviors. A study by Myerson, Green, van den Berk-Clark, and Grucza (2015) found no significant difference between AUD participants and controls in rates of delay discounting of losses in an African American sample, but they did observe increased discounting of rewards in their AUD sample. A recent study by Gerst, Gunn, and Finn (2017) provided evidence for higher delay discounting rates of losses in individuals with AUD with or without comorbid antisocial psychopathology compared with healthy controls. There are a few studies of delay discounting of losses and tobacco use that report increased discounting of monetary and health losses in current smokers compared with never smokers (Baker, Johnson, & Bickel, 2003; Odum, Madden, & Bickel, 2002). Aside from Myerson et al. (2015), no studies have examined both discounting of future rewards and losses in an alcohol using/abusing population. The current study was conducted to test the hypotheses that (a) AUD is characterized by increased discounting of both rewards and losses, and (b) delay discounting of rewards and losses will be more strongly correlated in those with an AUD compared with controls, suggesting an underlying propensity to discount all future incentives in favor of immediate incentives in individuals with AUDs.

Research also suggests that working memory (WM) capacity is associated with delay discounting rates of rewards (Bobova et al., 2009; Finn et al., 2015). Low executive WM capacity has been associated with higher discounting rates for delayed rewards (Bobova et al., 2009; Finn et al., 2015; Shamosh et al., 2008). In addition, compromising WM capacity via a WM load has been

This article was published Online First January 22, 2018.

Allen J. Bailey, Kyle Gerst, and Peter R. Finn, Department of Psychological and Brain Sciences, Indiana University Bloomington.

This research was supported by National Institutes of Alcohol Abuse & Alcoholism Grant R01AA13650 to Peter. R. Finn and training grant fellowship to Kyle Gerst from the National Institute on Alcohol Abuse and Alcoholism, T32 AA07642.

Correspondence concerning this article should be addressed to Peter R. Finn, Department of Psychological and Brain Sciences, Indiana University Bloomington, 1101 East 10th Street, Bloomington, IN 47405. E-mail: finnp@indiana.edu

reported to substantially increase discounting rates of delayed rewards (Finn et al., 2015; Hinson, Jameson, & Whitney, 2003); however, the literature on the effects of a WM load on discounting of future losses is extremely sparse. Gerst et al. (2017) included analyses on the effects of WM load on the discounting of future losses and did not find a significant effect. Finn et al. (2015) hypothesized that the reason why low, or compromised, WM capacity is associated with increased discounting of delayed rewards is that those with reduced WM capacity lack the attentional control capacity to efficiently shift attention from the immediate (more salient) smaller reward option to the delayed and less salient larger reward, which is necessary to make the more adaptive choice for the delayed reward. In this circumstance, a WM load would increase the likelihood that a choice for the immediate (high discounting) option is made because of the greater difficulty of shifting attention to the delayed option under WM load. The context is the opposite when discounting future losses. In a delay discounting loss task, decisions are made between competing desires to avoid negative outcomes. Although the choice for the immediate reward reflects higher discounting of future larger rewards, in a discounting of future losses task, the choice of the immediate loss reflects lower discounting of the future larger loss. In a decision between two negative outcomes, such as in the current task, optimal performance only requires the individual to choose the more salient and immediate option and avoid acquiring "debt" by avoiding immediate losses. In fact, increased discounting of losses involves shifting attention from the higher salient immediate smaller loss to the larger delayed loss. Thus, we would not expect that a WM load would increase discounting of losses, because, if anything, compromising attention control would tend to decrease the discounting of future losses (i.e., decrease the capacity to shift attention to, and choose, the larger delayed loss). Another goal of this study is to test the hypothesis that a WM load will result in higher delay discounting rates in the reward task but not in the loss task in AUD participants and controls.

## Method

### Participants

**Sample characteristics.** The sample consisted of 129 young adults (*M* age = 21.27, *SD* = 1.30) divided into two groups: an AUD group with 78 participants (47 men, 31 women), and a Control group with 51 participants (28 men, 23 women). On average, participants had completed 14.34 (*SD* = 1.30) years of schooling. Diagnoses were ascertained using the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz et al., 1994) using diagnostic criteria from the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; American Psychiatric Association, 2013). AUD subjects had a current moderate or severe AUD. Controls were social drinkers (no abstainers) with no history of an AUD or other externalizing psychopathology diagnoses. Table 1 lists sample demographics. Lifetime alcohol problem counts were derived from the SSAGA interview as the total number of positive responses to interview questions in the Alcohol Use Disorder section of the SSAGA. The sample was predominantly Caucasian (78.6%), 6.3% African American/Black, 6.3% Asian, 5% Hispanic/Latino, and 5% endorsing another ethnic group not listed. This study was reviewed and approved by the Indiana University Bloomington Institutional Review Board (IRB: protocol # 0709000094).

**Recruitment.** Participants were recruited using flyers and business cards placed around the community, along with postings on the Indiana University student classifieds web page. The flyers and postings were designed utilizing the approach used by Finn and colleagues (Bobova et al., 2009; Finn et al., 2015) to prompt responses from individuals who vary in terms of levels of alcohol use, levels of impulsivity, and disinhibited traits. The postings and flyers asked for "adventurous, daring" individuals, "impulsive individuals," "heavy drinkers," "more reserved and introverted type person," "social drinkers," persons who "got in a lot of trouble as a child" or "have trouble with the law and authority," persons with "drinking problems," and those who "drink modest amounts of alcohol."

**Telephone screening interview.** Those who responded to advertisements were screened via telephone to determine whether they met study inclusion criteria. Respondents who met study inclusion criteria could read and speak English, had at least a sixth grade education, did not report any history of severe head injuries, did not report a history of psychosis, had consumed alcohol on at least one occasion in their life, and were between the ages of 18 and 30 years. Participants were informed that they must abstain from using alcohol and other drugs for at least 12 hr before study sessions. Participants in this study were involved in a larger study consisting of four sessions for a maximum of 12 hr. This study included a wide variety of personality measures, decision-making tasks, cognitive tasks, and a diagnostic interview. Participants were compensated at a rate of $10 per hour along with bonuses for showing up to

Table 1
*Group Demographic Characteristics, Alcohol Problems and Alcohol Use*

| Characteristic | Control | AUD |
|---|---|---|
| *n* (male/female) | 51 (23/28) | 78 (47/31) |
| Average age in years (±*SD*) | 21.00 (±2.28) | 21.45 (±2.18) |
| Years of education, *M* (±*SD*) | 14.22 (±1.38) | 14.42 (±1.24) |
| Lifetime alcohol problems *M* (±*SD*) | 2.88 (±3.44) | 35.71 (±12.98) |
| 2-week alcohol quantity *M* (±*SD*) | 7.75 (±7.10) | 58.95 (±37.72) |
| 2-week alcohol frequency *M* (±*SD*) | 2.92 (±2.81) | 6.97 (±2.77) |
| 3-month alcohol quantity per week *M* (±*SD*) | 6.34 (±5.25) | 31.86 (±16.99) |
| 3-month alcohol frequency per week *M* (±*SD*) | 2.10 (±1.36) | 3.99 (±1.40) |

*Note*. Lifetime alcohol problems were the summed positive responses to questions from the Alcohol Use Disorders (AUD) section of the Semi-Structured Assessment for the Genetics of Alcoholism (Bucholz et al., 1994).

sessions on time. This study utilized data collected from three of four study sessions.

**Test session exclusion criteria.** Before every testing session, participants were required to meet a set of criteria before proceeding. All participants were required to (a) have no self-reported use of drugs or alcohol within the past 12 hr prior to testing, (b) have gotten at least 6 hr of sleep the previous night, (c) have a breath alcohol level of 0.0% (tested with an AlcoSenor IV, Intoximeters Inc., St. Louis, MO), and (d) not be experiencing symptoms of withdrawal or of any illness.

## Current Drinking

Measures of current drinking levels were assessed over the previous 2-week period and the over the past 3-month period. Past 2-week drinking was assessed using the timeline follow back procedure, reviewing each day over the past 2 weeks. The 2-week drinking measures were the mean frequency of drinking occasions (per week) and mean quantity consumed per occasion over the past 2 weeks. Drinking was also assessed as the typical pattern of drinking on each day of a typical week of the last 3 months. Three-month quantity is average quantity in standard drinks consumed each week over the past 3 months, and 3-month frequency is average number of days on which alcohol was consumed per week in the last 3 months.

## Delay Discounting Tasks

The delay discounting tasks were developed in E-Prime 2.0 (Psychology Software Tools, Inc., 2012) by the second author and administered via a desktop computer. The delay discounting reward task was modified from that used in Finn et al. (2015) and Bobova et al. (2009). The delay discounting loss task was identical to that used in Gerst et al. (2017). Prior to doing the tasks, participants were informed that all of the monetary amounts for both the reward and the loss tasks were hypothetical. Participants were instructed to choose as if they would receive (or lose) their chosen value in the corresponding time delay. Both the order of discounting tasks and the order of WM conditions were completely randomized in this study.

**Delay discounting of rewards.** Participants were presented with a choice between a specific amount of money "TODAY" or $50.00 "LATER" at one of six time delays (i.e., 1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year). The immediate choice amount varied from $5.00 to $45.00 in $5.00 increments. Prior to doing the tasks, participants were informed that all money was hypothetical, but were instructed to choose as if they would receive their chosen value in the corresponding time delay. For this task, participants completed six blocks, one for each time delay (1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year). Within each block, there were ascending and descending value trials (both the order of the blocks and order of trial type was randomized). In the ascending trials, the immediate reward value began at $5.00 and then increased to a maximum of $45.00 in increments of $5.00. The ascending sequence of trials stopped when a participant switched from the delayed to the immediate reward value (or stopped at $5.00 if the immediate reward was chosen on the first trial). There were nine possible ascending trials for each of the six time-delay lengths. The point at which participants switched from the delayed value ($50.00) to the immediate option was recorded as the switch point on the ascending trials. On the descending trials, the immediate reward value began at $45.00 and decreased to a minimum of $5.00 in increments of $5.00. For the descending sequence trials, the task stopped when the participants switched from the immediate reward value to the delayed option. The point at which they switched from the immediate to the delayed option ($50.00) was recorded as their switch point for the descending sequence of trials. Again, there was a maximum of nine possible trials in the descending sequence for each of the six time-delay lengths.

**Delay discounting of losses.** Participants were presented with a choice between losing a specific amount of money "TODAY" or $50.00 "LATER" at one of six time delays (i.e., 1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year). The immediate loss amount varied from $2.50 to $47.50 in $2.50 increments. Participants completed six blocks, one for each time delay (1 week, 2 weeks, 1 month, 3 months, 6 months, and 1 year). Each block consisted of ascending and descending value trials (both order of blocks and order of trial type within blocks was randomized). In the ascending sequence trials, the immediate loss began at $2.50 and then increased to a maximum of $47.50 in increments of $2.50. The ascending sequence trials stopped when a participant switched from the immediate loss value to the delayed loss value. On the ascending sequence trials, the point at which participants switched to the delayed loss value ($50.00) from the immediate loss option was recorded as the switch point. In the descending sequence of trials, the immediate loss started at $47.50 and was decreased to a minimum of $2.50. For the descending sequence of trials, the task stopped when participants switched from the delayed loss value to the immediate loss value. The point at which participants switched from the delayed loss value ($50.00) to the immediate loss option was recorded as the switch point for the descending sequence trials. For both ascending and descending trial sequences, there was a maximum of 19 trials for each of the six time-delay lengths.

## Working Memory Load

All participants completed both a WM-load and no-load condition for each of the delay discounting tasks. The order of the tasks and conditions were counterbalanced across subjects and groups. In the WM load reward version of the task (cf. Finn et al., 2015), a decision trial started with the presentation of an immediate amount of "$ TODAY" (e.g., "$45.00 TODAY") and $50.00 in a specific time delay (e.g., $50.00 in 1 month). Then a number appeared on the screen (e.g., 999) and participants were instructed to count backward in 3s from that number (e.g., 996, 993, 990 . . .) for 10 s. Then "$ TODAY" and "$ LATER" appeared on the screen (without corresponding monetary values) and participants clicked to select their choice of the $ TODAY or $ LATER option. In the loss trials, participants were presented with a LOSE $ TODAY option (e.g., LOSE $42.50 TODAY) and a LOSE $50.00 in a specific time-delay option (e.g., LOSE $50.00 in 2 weeks). Participants then were presented with three-digit number and were instructed to count backward by 3s from that number. Then "LOSE $ TODAY" and "LOSE $ LATER" appeared on the screen (again without monetary values) and participants clicked on either option to continue to the next trial. The no-WM-load version of the tasks included a 10-s wait period to reduce possible confounds that

could arise by varying overall time of the task or the effects of choices made in more rapid succession.

## Estimation of Discounting Rate

A single-parameter hyperbolic function was used to estimate discounting rate in both reward and loss tasks (Mazur, 1987). The estimation of discounting rate was calculated using the following equation: $Vp = V/(1 + k \times dt)$, where $Vp$ was the present (discounted/subjective) value (calculated as the average of the switch points for ascending and descending trials at a particular time delay), the constant $V$ was the amount of the delayed reward ($50.00), $dt$ was the length of the time the reward or loss is delayed in days, and $k$ was the discounting rate. The estimated $k$ value of each participant was $\log_{10}$ transformed and this transformed $k$ was used in the subsequent analyses. The use of this hyperbolic model is a well-established approach to quantifying discounting rates in humans across a variety of commodities, after being found to account for significantly more variance than exponential function models (Bickel & Marsch, 2001; Kirby, 1997; Kirby & Herrnstein, 1995). A total of 105 participants never discounted on at least one task. These were retained in the sample and simply given a $k$ value of 0.00 for that task. These data are not excluded because they represent valid choices that are, in fact, optimal choices that reflect good self-control. Also, the fact that such choices require a concerted effort underlines their legitimacy. For instance, in the loss task, never discounting requires a participant to choose the immediate option on every trial in the ascending and descending trials. In the reward task, the opposite is true: The participant must choose the delayed reward in every trial of the ascending and descending trials. A total of 54 participants also met Johnson and Bickel's (2008) criteria for increased variability (Criterion 1) on at least one task and also were not excluded from the analyses because variation in choice switch points reflects normal variation in delay discounting decisions (Finn et al., 2015; Gerst et al., 2017). Also, increased variability on delay discounting task occurs under a WM load and is associated with having externalizing psychopathology (Dai, Gunn, Gerst, Busemeyer, & Finn, 2016).

## Data Analysis

The delay discounting data ($\log_{10}$ transformed $k$ value) were analyzed using a mixed effects ANOVA (SPSS Version 24) with two between-subjects factors—Group (control, AUD) and Sex (male, female)—and two within-subject factors—Task (reward, loss) and WM Load Condition (no WM load, WM load).

# Results

## Alcohol Use Disorder and Discounting of Rewards and Losses

The analysis revealed that AUD participants had higher delay discounting rates across both tasks compared with controls, $F(1, 125) = 8.589$, $p = .004$ (mean $\log_{10} k$: $M = -1.633$, $SD = .910$ for AUD participants and $M = -2.131$, $SD = .784$ for controls). Table 2 lists the mean $\log_{10}$ k values by group, task, and WM load condition. In addition, a significant main effect of discounting task, $F(1, 125) = 121.468$, $p < .001$, revealed that rewards ($M = -1.323$, $SD = .901$) were discounted at higher rates than losses ($M = -2.337$, $SD = 1.158$). There was not a significant Group × Task interaction, $F(1, 125) = 2.092$, $p = .151$, indicating that AUD participants discounted delayed rewards ($M = -1.183$, $SD = .914$) and losses ($M = -2.083$, $SD = 1.129$) at significantly higher rates than controls, (rewards: $M = -1.538$, $SD = .847$; losses: $M = -2.724$, $SD = 1.104$). Figure 1 displays these effects.

Table 2
*Discounting Rates by Task and WM Load Condition Divided by Group*

| Mean (±*SD*) $log_{10}$ *k* by task and condition | Control | AUD |
|---|---|---|
| Reward | −1.75 (±.69) | −1.25 (±.98) |
| Reward WM load | −1.33 (±1.14) | −1.11 (±1.02) |
| Loss | −2.82 (±1.21) | −2.04 (±1.19) |
| Loss WM load | −2.63 (±1.28) | −2.13 (±1.21) |

*Note*. Mean delay discounting (DD) rate ($log_{10}$ transformed $k$ values) by type of discounting task (delay discounting of rewards and delay discounting of losses) and working memory (WM) load condition divided by control and alcohol use disorder (AUD) groups.

## Effects of WM Load on Discounting Rewards and Losses

There was a significant main effect of WM load on discounting rate, $F(1, 125) = 9.575$, $p = .002$. As hypothesized, there was a significant interaction of task and WM load, $F(1, 125) = 4.534$, $p = .035$. The WM load significantly increased discounting rates in the reward task, $F(1, 125) = 13.642$, $p < .001$, but not in the loss task, $F(1, 125) = .465$, $p = .497$. This finding is illustrated in Figure 2.

There also was a significant interaction of WM load and group, $F(1, 125) = 5.956$, $p = .016$, revealing that WM load significantly increased discounting rates in controls, $F(1, 50) = 11.98$, $p = .001$, but not in the AUD group, $F(1, 77) = .130$, $p = .720$. Although there was not a significant task by WM load interaction in the control group, $F(1, 49) = 1.760$, $p = .191$, the WM load effect in controls appeared to be driven by the robust effect of the WM load in the reward tasks, $F(1, 50) = 11.288$, $p = .002$. There was not a significant effect of WM load in the loss tasks in the control group, $F(1, 50) = 2.362$, $p = .131$. Figure 3 displays these effects broken down by group, task, and WM load in effort to better display the pattern of results. Figure 4 displays the discounting curves for each task and WM load condition broken down by group. There was also a significant Sex × Task × WM load interaction, $F(1, 125) = 4.226$, $p = .042$. A breakdown of this interaction revealed that there was a significant Task × WM load interaction in males, $F(1, 68) = 8.982$, $p = .004$, but not females, $F(1, 57) = .003$, $p = .957$. In male participants, there was a significant effect of WM load in the reward task, $F(1, 68) = 15.587$, $p < .001$, with higher discounting rates in the WM-load condition ($M = -1.020$, $SD = 1.075$) compared with the no-WM-load condition ($M = -1.346$, $SD = .980$). There was not a significant effect of WM load in the loss task in males, $F(1, 68) = .085$, $p = .772$. For females, there was not a significant effect of WM load in either the reward task, $F(1, 57) = 2.243$, $p = .140$, or the loss task, $F(1, 57) = 1.274$, $p = .264$.

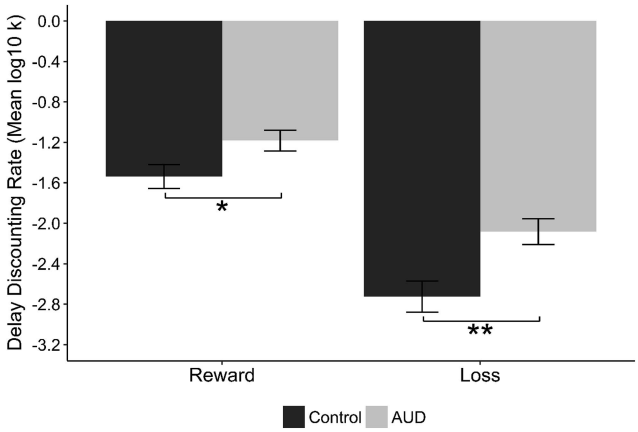


*Figure 1.* Mean delay discounting rates ($log_{10}$ transformed k) averaged across working memory load conditions in the reward and loss discounting tasks divided by control and alcohol use disorder (AUD) groups. Error bars represent ±*SEM*. * $p < .05$. ** $p < .01$.

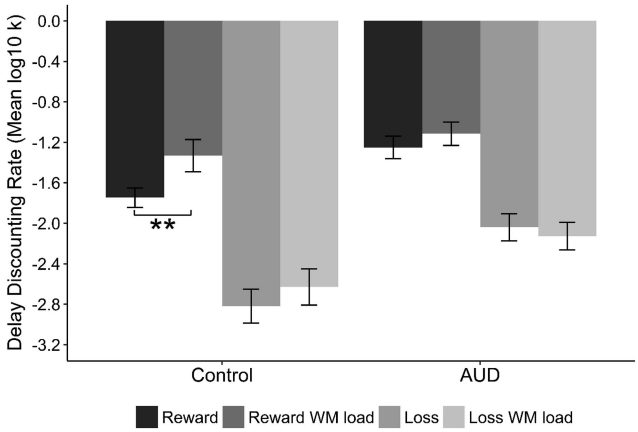


*Figure 3.* Mean discounting rates ($log_{10}$ transformed k) broken down by reward and loss discounting tasks and working memory (WM) load condition divided by control and alcohol use disorder (AUD) group. Error bars represent ±*SEM*. ** $p < .01$.

## Correlations Between Discounting Rewards and Losses

In the full sample, discounting rates of rewards (averaged across both WM conditions) were moderately correlated with discounting rates of losses (averaged across both WM conditions), $r(127) = .498$, $p < .001$, 95% confidence interval [CI] [.356, .617]. Discounting rates of rewards and losses in the no-WM-load conditions were correlated, $r(127) = .512$, $p < .001$, 95% CI [.373, .629]. There was a weaker association between discounting rates of rewards and losses in the WM-load conditions, $r(127) = .343$, $p < .001$, 95% CI [.181, .486]. However, the correlation between discounting of rewards and losses (averaged across WM-load conditions) was significantly stronger in the AUD group ($r[76] = .584$, $p < .001$, 95% CI [.416, .713]) compared with controls (control: $r[49] = .281$, $p = .046$, 95% CI [.006, .516]), $z = 2.05$, $p = .040$.

## Discussion

The main purpose of this study was to examine differences in delay discounting rates of rewards and losses in AUD and healthy controls and to determine whether those with an AUD discount future losses in a manner similar to their well-documented pattern of discounting future rewards. In addition, the study also investigated the effects of a WM load on delay discounting of both future rewards and losses. This study had three primary hypotheses: (a) the AUD group would discount future rewards and losses at a higher rate than the control group, (b) delay discounting of rewards and losses would be strongly correlated in those with an AUD, and (c) WM load would result in higher delay discounting rates in the reward task, but not in the loss task, in both the AUD and control group. As hypothesized, the AUD group discounted both future rewards and losses at higher rates than the control group. In support of the second hypothesis, delay discounting rates of rewards and losses were strongly correlated in individuals with AUD, and the association was significantly stronger in those with AUDs compared with controls. The third hypothesis was partially supported. The WM load significantly increased discounting rates in the reward task but not in the loss task. However, contrary to the third hypothesis, the

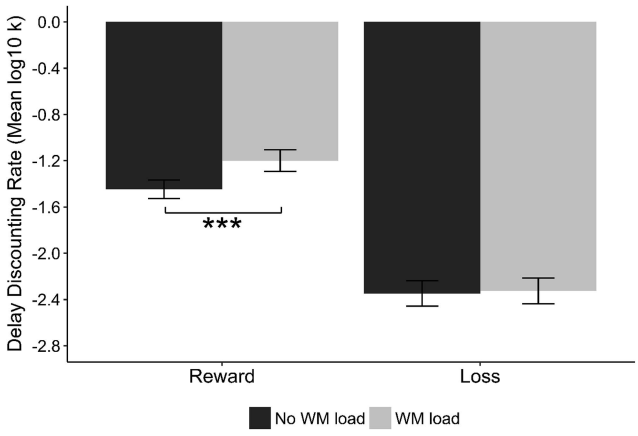


*Figure 2.* Mean delay discounting rates ($log_{10}$ transformed k) by working memory (WM) load condition in reward and loss discounting tasks. Error bars represent ±*SEM*. *** $p < .001$.

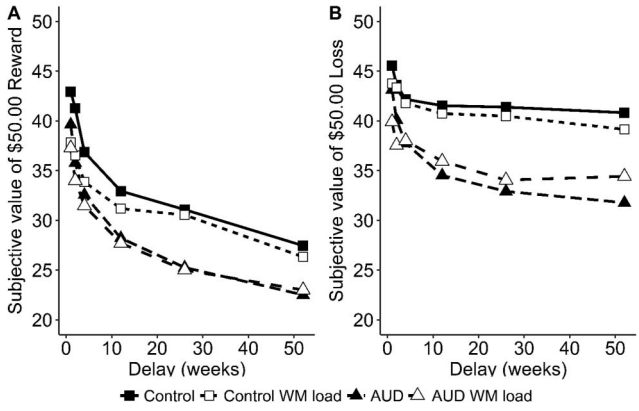


*Figure 4.* Delay discounting curves. Panel A shows delay discounting of reward curves divided by group and working memory (WM) load condition. Panel B shows delay discounting of loss curves divided by group and WM load condition. AUD = alcohol use disorder.

WM load significantly increased discounting rates in the control group only. As shown in Figure 3, this effect was driven primarily by the robust effect of WM load in controls in the reward task. Consistent with past studies, rewards were discounted at a higher rate than losses in both groups (Baker et al., 2003; Johnson & Bickel, 2008; Thaler, 1981).

Consistent with previous studies, individuals with AUD discounted future rewards at higher rates compared with controls (Bobova et al., 2009; Field et al., 2007; Finn et al., 2015; Mitchell et al., 2005; Petry, 2001). What is particularly interesting is that those with an AUD also discounted losses at significantly higher rates compared with controls as well. This is consistent with the results of a recent study (Gerst et al., 2017) showing that those with an AUD discounted future losses at higher rates compared with controls, as well as studies showing the smokers discount future losses at higher rates than never-smokers (Baker et al., 2003; Odum et al., 2002). The higher discounting rates of both delayed rewards and losses suggest that those with AUDs broadly discount future events of incentive value more than healthy controls. The finding that delay discounting rates for rewards and losses were strongly correlated in AUD participants, but not controls, also supports the idea that those with an AUD have a generalized tendency to discount the future. This might reflect a general tendency in those with an AUD to perceive future outcomes as less salient, which may lead to difficulties in the delay of gratification (failing to maximize future gains), the avoidance of immediate losses (failing to minimize future negative consequences), and planning for the future. Our results and those of Gerst et al. (2017) are not consistent with the results of Myerson and colleagues (2015), who reported that those with an AUD in their sample did not discount future losses more than controls. Differences in sample composition may account for the differences between Myerson et al. and the samples in the current study and Gerst et al. Myerson et al.'s sample was comprised of inner-city African Americans, whereas our samples were comprised of mostly White, college students at a state university. Another difference between the current study and Myerson et al. is that the current study used losses of significantly smaller magnitudes (i.e., lose $50 vs. lose $2,500) than Myerson et al. Studies have shown significant effects of reward magnitude on reward discounting rates (Green & Myerson, 2004; Green, Myerson, & McFadden, 1997; Loewenstein & Thaler, 1989) but less clear evidence on the effects of loss magnitude on loss discounting rate (Harinck, Van Dijk, Van Beest, & Mersmann, 2007; Holt, Green, Myerson, & Estle, 2008; Kahneman & Tversky, 1984). More work on possible magnitude effects of delayed losses and the correlates of increased discounting of losses and rewards is needed, including studies of potential racial differences in delay discounting in those with AUD.

In the current study, a WM load generally increased discounting of delayed rewards but did not have a significant effect on the discounting of losses. The lack of effect of a WM load on discounting losses is consistent with the results of Gerst and colleagues (2017), who found that a WM load did not increase discounting of losses in either those with an AUD or controls. Our results suggest that increased discounting of delayed rewards may reflect, in part, a difficulty shifting attention to consider long-term rewards. However, contrary to our hypothesis, the WM load significantly increased discounting rates only in the control group and not in the AUD group. This effect is contrary to the results of Finn et al. (2015), who found that a WM load increased reward discounting rates across the externalizing spectrum. A possible reason for this discrepancy is that the WM load was a between-groups manipulation in the Finn et al. study, whereas it was a within-group manipulation in the current study. It is also worth noting that a previous study by Fridberg, Gerst, and Finn (2013) found some evidence of differential effects based on sex and substance use disorder status of a WM load on decisions on the Iowa Gambling Task. In that study, male controls and females with externalizing psychopathology were most profoundly affected by a WM load during the Iowa Gambling Task.

Further complicating our results was a significant Sex × Task × WM Load interaction that indicated that only males experienced the significant increase in delayed discounting of rewards under WM load. Consistent with the above results, the WM load did not increase discounting of losses. Overall, women did not show any significant effect of the WM load on discounting of rewards or losses. This interaction is difficult to interpret given inconsistent findings about discounting rates in men compared with women, with some studies showing higher rates in females (Wallace, 1979), some showing lower rates in females (Kirby & Maraković, 1996), and many showing similar rates between sexes (Fillmore & Weafer, 2004; Reynolds, Richards, Dassinger, & de Wit, 2004; Skinner, Aubin, & Berlin, 2004). In addition, the limited literature about sex differences (with or without AUD) in effects of WM load on discounting, or general decision making, provides conflicting results (Finn et al., 2015; Fridberg et al., 2013). More studies on the reliability of WM load effects on delay discounting, and the correlates of these effects, would provide more insight into the mechanisms by which a WM load affects decision making in delay discounting contexts.

The results of the current study need to be interpreted in light of their limitations. First, the sample is mainly comprised of Caucasian undergraduates recruited from a large Midwestern university. This may affect generalizability to a different, or more heterogeneous, sample. Similarly, the sample consists of a rather narrow age range, which could limit generalizability to other time points of AUD development. Another limitation was the slight difference between increments used in the discounting reward task ($5.00) and discounting of loss task ($2.50). However, in both tasks, discounting rates are calculated by averaging the switch points of the ascending and descending trials at each time delay. Therefore, calculation of hyperbolic discounting rates ($k$ value) would be insensitive to small differences in task increments. A shortened delay discounting reward task was utilized to reduce participant burden. This shortened reward task has also produce comparable discounting rates along with comparable associations between discounting rates and criterion of interest as in previous studies using the full task ($2.50 increments; Bobova et al., 2009; Finn et al., 2015).

In conclusion, this study adds to the literature in two ways. First, the results suggest that those with an AUD discount future events associated with incentives in a general manner, regardless of whether those events are associated with rewards or losses. This result makes a lot of sense when one considers that

the drinking behavior of those with an AUD reflects a general neglect of the future, whether that neglect involves not achieving future positive outcomes or goals, or the future negative consequences of drinking. Heavy drinking, which may compromise long-term goals, reflects a decision that favors the smaller, immediate enjoyment of being intoxicated and neglects the problems in attaining long-term goals, such as good grades and successful careers. Heavy drinking in AUD syndromes appears to favor the relief of the immediate discomfort of craving or withdrawal, rather that avoiding the long-term negative health, financial, legal, and social negative consequences of continued excessive drinking.

Second, the effects of a WM load was apparent only on the reward discounting task, which suggests a specific role for attention control/shifting when deciding between a smaller immediate reward versus a delayed larger reward.

## References


American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Baker, F., Johnson, M. W., & Bickel, W. K. (2003). Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude. *Journal of Abnormal Psychology, 112,* 382–392. http://dx.doi.org/10.1037/0021-843X.112.3.382

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction, 96,* 73–86. http://dx.doi.org/10.1046/j.1360-0443.2001.961736.x

Bobova, L., Finn, P. R., Rickert, M. E., & Lucas, J. (2009). Disinhibitory psychopathology and delay discounting in alcohol dependence: Personality and cognitive correlates. *Experimental and Clinical Psychopharmacology, 17,* 51–61. http://dx.doi.org/10.1037/a0014503

Bucholz, K. K., Cadoret, R., Cloninger, C. R., Dinwiddie, S. H., Hesselbrock, V. M., Nurnberger, J. I., Jr., . . . Schuckit, M. A. (1994). A new, semi-structured psychiatric interview for use in genetic linkage studies: A report on the reliability of the SSAGA. *Journal of Studies on Alcohol, 55,* 149–158. http://dx.doi.org/10.15288/jsa.1994.55.149

Dai, J., Gunn, R. L., Gerst, K. R., Busemeyer, J. R., & Finn, P. R. (2016). A random utility model of delay discounting and its application to people with externalizing psychopathology. *Psychological Assessment, 28,* 1198–1206. http://dx.doi.org/10.1037/pas0000248

Field, M., Christiansen, P., Cole, J., & Goudie, A. (2007). Delay discounting and the alcohol Stroop in heavy drinking adolescents. *Addiction, 102,* 579–586. http://dx.doi.org/10.1111/j.1360-0443.2007.01743.x

Fillmore, M. T., & Weafer, J. (2004). Alcohol impairment of behavior in men and women. *Addiction, 99,* 1237–1246. http://dx.doi.org/10.1111/j.1360-0443.2004.00805.x

Finn, P. R., Gunn, R. L., & Gerst, K. R. (2015). The effects of a working memory load on delay discounting in those with externalizing psychopathology. *Clinical Psychological Science, 3,* 202–214. http://dx.doi.org/10.1177/2167702614542279

Fridberg, D. J., Gerst, K. R., & Finn, P. R. (2013). Effects of working memory load, a history of conduct disorder, and sex on decision making in substance dependent individuals. *Drug and Alcohol Dependence, 133,* 654–660. http://dx.doi.org/10.1016/j.drugalcdep.2013.08.014

Gerst, K. R., Gunn, R. L., & Finn, P. R. (2017). Delay discounting of losses in alcohol use disorders and antisocial psychopathology: Effects of a working memory load. *Alcoholism, Clinical and Experimental Research, 41,* 1768–1774. http://dx.doi.org/10.1111/acer.13472

Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological Bulletin, 130,* 769–792. http://dx.doi.org/10.1037/0033-2909.130.5.769

Green, L., Myerson, J., & McFadden, E. (1997). Rate of temporal discounting decreases with amount of reward. *Memory & Cognition, 25,* 715–723. http://dx.doi.org/10.3758/BF03211314

Harinck, F., Van Dijk, E., Van Beest, I., & Mersmann, P. (2007). When gains loom larger than losses: Reversed loss aversion for small amounts of money. *Psychological Science, 18,* 1099–1105. http://dx.doi.org/10.1111/j.1467-9280.2007.02031.x

Hinson, J. M., Jameson, T. L., & Whitney, P. (2003). Impulsive decision making and working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 298–306. http://dx.doi.org/10.1037/0278-7393.29.2.298

Holt, D. D., Green, L., Myerson, J., & Estle, S. J. (2008). Preference reversals with losses. *Psychonomic Bulletin & Review, 15,* 89–95. http://dx.doi.org/10.3758/PBR.15.1.89

Johnson, M. W., & Bickel, W. K. (2008). An algorithm for identifying nonsystematic delay-discounting data. *Experimental and Clinical Psychopharmacology, 16,* 264–274. http://dx.doi.org/10.1037/1064-1297.16.3.264

Kahneman, D., & Tversky, A. (1984). Choices, values, and frames. *American Psychologist, 39,* 341–350. http://dx.doi.org/10.1037/0003-066X.39.4.341

Kirby, K. N. (1997). Bidding on the future: Evidence against normative discounting of delayed rewards. *Journal of Experimental Psychology: General, 126,* 54–70. http://dx.doi.org/10.1037/0096-3445.126.1.54

Kirby, K. N., & Herrnstein, R. J. (1995). Preference reversals due to myopic discounting of delayed reward. *Psychological Science, 6,* 83–89. http://dx.doi.org/10.1111/j.1467-9280.1995.tb00311.x

Kirby, K. N., & Maraković, N. N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review, 3,* 100–104. http://dx.doi.org/10.3758/BF03210748

Loewenstein, G., & Thaler, R. H. (1989). Anomalies: Intertemporal choice. *The Journal of Economic Perspectives, 3,* 181–193. http://dx.doi.org/10.1257/jep.3.4.181

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevin, & H. Rachlin (Eds.), *The effect of delay and of intervening events on reinforcement value, quantitative analyses of behavior* (pp. 55–73). Hillsdale, NJ: Erlbaum.

Mitchell, J. M., Fields, H. L., D'Esposito, M., & Boettiger, C. A. (2005). Impulsive responding in alcoholics. *Alcoholism, Clinical and Experimental Research, 29,* 2158–2169. http://dx.doi.org/10.1097/01.alc.0000191755.63639.4a

Myerson, J., Green, L., van den Berk-Clark, C., & Grucza, R. A. (2015). Male, but not female, alcohol-dependent African Americans discount delayed gains more steeply than propensity-score matched controls. *Psychopharmacology, 232,* 4493–4503. http://dx.doi.org/10.1007/s00213-015-4076-x

Odum, A. L., Madden, G. J., & Bickel, W. K. (2002). Discounting of delayed health gains and losses by current, never- and ex-smokers of cigarettes. *Nicotine & Tobacco Research, 4,* 295–303. http://dx.doi.org/10.1080/14622200210141257

Petry, N. M. (2001). Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. *Psychopharmacology, 154,* 243–250. http://dx.doi.org/10.1007/s002130000638

Psychology Software Tools, Inc. (2012). E-Prime 2.0. Retrieved from http://www.pstnet.com

Reynolds, B., Richards, J. B., Dassinger, M., & de Wit, H. (2004). Therapeutic doses of diazepam do not alter impulsive behavior in humans. *Pharmacology, Biochemistry and Behavior, 79,* 17–24. http://dx.doi.org/10.1016/j.pbb.2004.06.011

Shamosh, N. A., DeYoung, C. G., Green, A. E., Reis, D. L., Johnson, M. R., Conway, A. R. A., . . . Gray, J. R. (2008). Individual differences in delay discounting: Relation to intelligence, working memory, and anterior prefrontal cortex. *Psychological Science, 19,* 904–911.

Skinner, M. D., Aubin, H. J., & Berlin, I. (2004). Impulsivity in smoking, nonsmoking, and ex-smoking alcoholics. *Addictive Behaviors, 29,* 973–978. http://dx.doi.org/10.1016/j.addbeh.2004.02.045

Takahashi, T., Ohmura, Y., Oono, H., & Radford, M. (2009). Alcohol use and discounting of delayed and probabilistic gain and loss. *Neuro Endocrinology Letters, 30,* 749–752.

Thaler, R. (1981). Some empirical evidence on dynamic inconsistency. *Economics Letters, 8,* 201–207. http://dx.doi.org/10.1016/0165-1765(81)90067-7

Wallace, C. J. (1979). The effects of delayed rewards, social pressure, and frustration on the responses of opiate addicts. *NIDA Monograph Series, 25,* 6–25.

Weller, R. E., Cook, E. W., III, Avsar, K. B., & Cox, J. E. (2008). Obese women show greater delay discounting than healthy-weight women. *Appetite, 51,* 563–569. http://dx.doi.org/10.1016/j.appet.2008.04.010

Received September 18, 2017
Revision received November 30, 2017
Accepted December 4, 2017 ■