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Episodic Future Thinking: Expansion of the Temporal Window in Individuals with Alcohol Dependence

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Abstract

Background—Episodic future thinking (EFT) requires an individual to vividly pre-experience a realistic future event. Inspired by previous reports of reducing delay discounting following EFT in other populations, we examined the effects of engaging alcohol-dependent individuals in EFT or episodic recent thinking (ERT; control) to examine its effects on delay discounting and alcohol purchasing.

Methods—Participants ($n = 50$) with alcohol dependence were allocated into EFT or ERT groups and asked to generate positive future or recent past events for each of 5 time points. Participants then completed a delay-discounting task, during which event cues were displayed, and a hypothetical alcohol purchase task.

Results—EFT significantly increased valuation of future monetary rewards, while decreasing initial consumption (Q_0) of alcoholic drinks indicative of lower demand intensity. Two additional findings suggest potential moderators of this effect. EFT more readily influenced individuals with lower Alcohol Use Disorders Identification Test scores, and self-reported cue valence differed between groups.

Conclusions—Together, these results suggest a widening of alcohol-dependent individuals' temporal window following engagement of EFT. While our data suggest that EFT may be moderated by certain susceptibility criteria, exercises such as EFT could be easily adaptable as a potential therapeutic tool for use in rehabilitation programs.

Keywords

Episodic Future Thinking; Delay Discounting; Alcohol Dependent; Demand; Purchase Task

Excessive discounting of delayed rewards is a recognized phenotype of individuals with substance use disorders (Bickel and Marsch, 2001; MacKillop et al., 2011). Delay discounting refers to the extent to which a reward's valuation is decreased as a function of the delay to its receipt; therefore, substance abusers value immediate small rewards more than larger delayed rewards compared to healthy individuals. In fact, a high rate of delay

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CONFLICT OF INTERESTS

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discounting can be a behavioral marker for drug addiction, severity, and sensitivity of risk for initiation (Bickel et al., 2014). Individuals with alcohol dependence have been shown to produce steeper discount rates for both money and alcoholic drinks compared to abstinent drinkers and healthy controls (Petry, 2001), and discount rates are correlated with degree of dependence (Mitchell et al., 2005; Takahashi et al., 2009). Thus, the rate at which alcohol-dependent individuals discount future rewards may serve as a measure of degree of dependence, but also a target for potential therapeutic intervention.

Deficits in future thought may also be present in these individuals because prospective memory, the skill of remembering to do something in the future (i.e., planning), has been shown to be negatively correlated with drinking severity and magnitude of dependence (Griffiths et al., 2012; Heffernan, 2008). If alcohol abusers are unable to efficiently plan for or even imagine the future, they are trapped within a narrow temporal window, which may give rise to greater valuation of immediate rewards. Research is accruing that imagining future events can improve deficits in prospective thought. Imagining future events improves prospective memory in both social drinkers (Griffiths et al., 2012) and acutely intoxicated healthy volunteers (Paraskevaides et al., 2010), perhaps providing a potential technique to expand drinkers' temporal window.

Episodic future thinking (EFT), as defined by (Atance and O'Neill, 2001), is the ability to self-project and pre-experience a future event. EFT is not ambiguous or vague. EFT is thought to be limited by the boundaries of prospective memory, decision making, and goal attainment (Atance and O'Neill, 2001) and requires the individual to vividly pre-experience a realistic event in the future. Most notably, Peters and Büchel (2010) found that reminding participants about their future thoughts during a delay-discounting task, using individually generated episodic cues, decreased discounting of delayed rewards. Expansion of this idea occurred when discount rates were significantly reduced in obese and lean participants after they generated EFT cues (Daniel et al., 2013a). Total calorie consumption was also reduced following future cues among overweight and obese when provided with unlimited access to food (Daniel et al., 2013b). Together, previous evidence suggests that EFT may expand an individual's temporal window to subsequently produce enhanced valuation of the future and more self-controlled decisions.

Given previous reports of reduced discounting following EFT in other populations, this study examined the effects of engaging alcohol-dependent individuals in either an EFT group or episodic recent thinking (ERT; control group) to examine its effects on delay discounting and purchase behavior in a hypothetical purchase task. We hypothesized that EFT would decrease discounting of delayed hypothetical monetary rewards and decrease demand for alcoholic drinks in our alcohol-dependent participants.

MATERIALS AND METHODS

Participants

A total of 55 alcohol-dependent participants enrolled in the study. Participants who reported drinking in the past 6 months and reported at least 3 of the 7 dependence criteria outlined in the DSM-IV-TR were eligible (American Psychiatric Association, 2000). Participants were

required to be 18 to 65 years of age, not pregnant or lactating, and not have any current significant medical or psychological disorders. History of stroke, seizures, or loss of consciousness was also exclusionary. Eligible participants were screened over the phone and/or in person. Informed consent was required from all participants. To determine whether the presence of alcohol, other drugs, or severe withdrawal may impair participants' ability to perform the behavioral tasks, participants provided breathalyzer and urine samples and completed a common sobriety test and withdrawal scale measure. A total of 5 participants' data were not included in the following analysis. Of those, 2 participants' baseline delay discounting did not meet consistency criteria (see data analysis below) and 3 data sets were missing due to a computer error. The remaining participants were randomly assigned to 1 group, either EFT ($n = 25$) or ERT (control; $n = 25$) for the duration of the study. Participation required completion of 1 session lasting approximately 2 hours. Demographic variables of the participants are presented in Table 1. The Virginia Tech Institutional Review Board approved all procedures.

Procedure and Assessments

Baseline Delay Discounting—All participants first completed a computerized baseline monetary delay-discounting task. All delay-discounting tasks were computerized choice programs that presented a series of trials between hypothetical immediate or delayed rewards. Specifically, participants were asked to make choices between hypothetical gains in money received now or after some delay. For example, “Would you rather have \$500 now or \$1,000 in a year?” Participants answered 6 choice trials for each of 7 delays (1 day, 1 week, 1 month, 3 months, 1 year, 5 years, and 25 years) to obtain indifference points at each delay. The delayed amount remained the same throughout the task (\$1,000), while the immediate amount was titrated based on the choices made by the participant (Du et al., 2002). The baseline-discounting task served 2 simultaneous purposes. (1) Participants were screened for systematic discounting (Johnson and Bickel, 2008). Participants who violated Criterion 1 (i.e., a measure of inconsistent jumping) more than once or Criterion 2 (i.e., lack of discounting) at any time were excluded from the future data analyses. (2) Baseline discounting served as a between group (EFT vs. control) comparison of monetary discounting prior to the generation of episodic cues.

Alcohol Use Disorders Identification Test—All participants completed the 10-question Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993) to determine their severity of alcohol misuse.

Cue Generation—Participants were prompted to generate positive cues through a researcher-administered interview-based questionnaire. Using methods adapted from Lin and Epstein (2014), participants randomized to the EFT group were asked to think about and describe the most positive event that could realistically happen at each of 5 delays in the future (1 day, 1 week, 1 month, 3 months, and 1 year). Participants randomized to the ERT control group were asked to think about and describe the most positive event that occurred at each of 5 time points from previous day (7 PM–10 PM, 4 PM–7 PM, 1 PM–4 PM, 10 AM–1 PM, and 7 AM–10 AM). Further, because episodic thought is an integration of basic systems such as, narrative, emotion, spatial imagery, senses, and motor output (Rubin 2006), we

prompted our participants with questions to encourage elaboration in all these dimensions for episodic future or control cues. The researcher methodically prompted the participant for each event and then probed for further description by systematically asking the following elaboration and sensory questions:

“What will you be doing?”

“Whom will you be with?”

“Where will you be?”

“How will you be feeling?”

“What will you be seeing?”

“What will you be hearing?”

“What will you be tasting?”

“What will you be smelling?”

Finally, for each time point, the participant was asked to integrate the event and sensory information into a concise event cue to be used in the delay-discounting task. The cues for the EFT and ERT control groups were a continuation of the sentences, “In [insert delay] from now I will be...” or “Yesterday between [insert time point] I was...,” respectively. For example, “In 1 year from now I will be at my daughter’s birthday party at home with my family eating cake.”

Cue Valence—During the interview, participants were also asked to rate each generated cue for enjoyment, importance, excitement, and vividness using a Likert scale (1 to 5).

Episodic Future Thinking Delay-Discounting Task—Similar to the baseline-discounting task, the EFT delay-discounting task was a computerized choice program that presented a series of trials between hypothetical immediate or delayed rewards. For this task, the delayed amount (\$100) remained the same while the immediate amount was titrated based on the choices made by the participant (Du et al., 2002). Specifically, participants were asked to make choices between hypothetical gains in money received now or after some delay. For example, “Would you rather have \$50 now or \$100 in a year?” Above the choices during each trial, the generated cue (EFT or control) that matched the time point was presented. Participants answered 6 choice trials for each of 5 delays (1 day, 1 week, 1 month, 3 months, and 1 year) while simultaneously being presented with the paired future or recent cue to obtain indifference points at each delay.

Alcohol Purchase Task—Only a subset of the EFT ($n = 20$) and ERT control ($n = 19$) participants completed the alcohol purchase task because this task was added after the study had started. Based on previously described and validated methodology (Jacobs and Bickel, 1999; MacKillop et al., 2010; Murphy and MacKillop, 2006), participants were asked to imagine themselves in a hypothetical scenario of being with friends at a bar from 9 PM to 2 AM to see a band during which standard alcoholic beverages (beer, wine, and/or shots of liquor) were available. Participants were then asked to indicate how many hypothetical

standard alcoholic drinks they would purchase for the night when drinks cost a specified amount of money. For example, “How many drinks would you consume if they were \$0.25 each?” Drink price increased in ascending order with each subsequent question for all participants (\$0, 0.25, 0.50, 1.00, 2.00, 2.50, 3.00, 4.00, 5.00, 6.00, 7.00, 8.00, 9.00).

Data Analysis

Delay Discounting—Participants were screened for systematic discounting during the baseline-discounting task. Violation of Criterion 1 which is an increase in an indifference point of >20% of the delayed magnitude from the preceding indifference point (i.e., jumping) more than once or Criterion 2, a difference of <10% of delayed magnitude between the first and last indifference point (i.e., lack of discounting) as described in Johnson and Bickel (2008) terminated participant eligibility to continue. Two data sets were excluded from all subsequent analyses due to violation of 1 of these criteria during baseline discounting. During the EFT delay-discounting task, no participants violated Criterion 1 more than once; however, a total of 9 (EFT $n = 6$; control $n = 3$) participants violated Criterion 2. We allowed these data to be included because EFT was hypothesized to decrease discount rate and could theoretically do so enough to incur a ceiling effect (i.e., Criterion 2 violation).

Delay-discounting data were analyzed in 2 alternate ways due to a lack of fit (R^2 values of 0.22 and -0.054 for control and EFT, respectively) of Mazur’s equation (Mazur, 1987). Lack of fit is not uncommon within the discounting literature. Instead, a 2-way analysis of variance (ANOVA) (between EFT group and within delay condition) identified differences in indifference points between groups. Second, area under the curve (AUC) was also used to measure discounting and was analyzed in a multivariate regression using group and appropriate demographic variables.

Demand for Alcohol—Purchase behavior data from our participants were subjected to the exclusion criteria described by Stein and colleagues (2015) to ensure systematic and valid data. One participant was excluded from each condition (EFT and control) due to nonconsumption and violation of the Trend Criterion (i.e., increasing purchasing over successively increasing prices), respectively. Purchase of (i.e., demand for) alcoholic drinks was analyzed by fitting group purchase data with the exponentiated behavioral economics demand model (Koffarnus et al., 2015). Initial consumption (Q_0), the measure of consumption when the commodity is free, and alpha (α), the sensitivity of commodity consumption to increasing price, were compared at the group level between EFT and control groups.

AUDIT Scores—AUDIT scores were calculated by summing the answers (0 to 4) for questions 1 to 8. Questions 9 and 10 have only 3 answers with the associated scores of 0, 2, or 4, respectively (Saunders et al., 1993). Correlation analyses were performed comparing participant AUDIT scores and their discounting AUC or Q_0 , separated by EFT group. Fisher’s z transformations were used to test for significant differences in correlations of AUDIT and AUC or Q_0 score between EFT and control groups.

Cue Valence—Cue valence scores for enjoyment, importance, excitement, and vividness were recorded for each delay or recent time period from the previous day. Ratings from each time point were compared using a 2-way ANOVA (between EFT and control groups and within subject time points).

All analyses were conducted using JMP® (Version for Mac; SAS Institute Inc., Cary, NC), IBM SPSS® Statistics (Version 23.0 for Mac; IBM Corp., Armonk, NY), and GraphPad Prism (Version 6.0 for Mac OSX; Jolla, CA).

RESULTS

Demographic variables for EFT and ERT control groups are presented in Table 1. Participants were randomly assigned to 1 of 2 groups (EFT or control). Analysis of the demographic makeup of these groups revealed that the EFT group was younger compared to the control group; however, forward model selection modeling revealed that age was not a significant contributing factor to the variance between groups in EFT discounting (see below).

Delay Discounting

Baseline Discounting (\$1,000)—Before any cues were generated, indifference points from the \$1,000 baseline delay-discounting task were not different between assigned EFT and control participants. The 2-way ANOVA revealed a main effect of delay on indifference points, $F(4, 192) = 90.11, p < 0.0001$, although no effect of EFT group on discounting, indicating similar baseline discounting *prior* to EFT cue generation and completing the EFT delay-discounting task.

Episodic Future Thinking Discounting (\$100)—Figure 1 (left) illustrates the indifference points generated by the delay-discounting task for both the EFT and control groups. A 2-way ANOVA reported significant main effects of delay, $F(4, 192) = 54.83, p < 0.0001$, and group, $F(1, 48) = 9.25, p = 0.0038$, and the interaction, $F(4, 192) = 4.06, p = 0.0035$. Moreover, the EFT group had significantly higher indifference points, compared to controls, at the 3 longest delays. To ensure control of all demographic variables, a forward model selection was performed. The model selection process reported that group condition and monthly income were significant variables in explaining variation in discounting AUC. When income was controlled for, the group condition still produced a significant effect on AUC ($p = 0.0008$), in which EFT significantly increased AUC, compared to control (Fig. 1, right).

Alcohol Demand—Group demand curves were fit for total drinks purchased by the EFT and control groups (Fig 2). The goodness-of-fit $R^2 = 0.97$ and $R^2 = 0.98$ for EFT and control group curves, respectively. Mean (\pm SEM) Q_0 values were 16.04 (\pm 0.49) and 21.55 (\pm 0.65) drinks for EFT and control groups, respectively. Mean (\pm SEM) alpha values were 0.011 (\pm 0.00077) and 0.012 (\pm 0.00086) for EFT and control groups, respectively. When comparing the curve fits, Q_0 estimates between EFT groups were significantly different $F(1, 513) = 14.93, p = 0.0001$. That is, initial purchase behavior (i.e., Q_0) for alcoholic drinks

was lower in the EFT group compared to the control group. There was no significant difference in alpha values.

Alcohol Use Disorders Identification Test—Participant AUDIT scores were negatively correlated with delay-discounting AUC measures in only the EFT group, $r(23) = -0.42$, $p = 0.036$ (Fig. 3). A Fisher's t -to- z transformation ($r_{\text{control}} = -0.166$; $r_{\text{EFT}} = -0.437$) was used to compare Pearson r correlation coefficients of AUDIT scores and AUC between EFT groups; however, there was no difference in these correlations ($p = 0.317$).

No correlations between AUDIT scores and Q_0 in either the control ($r_{\text{control}} = 0.42$; $p = 0.08$) or EFT ($r_{\text{EFT}} = 0.24$; $p = 0.33$) groups were present. Moreover, AUDIT scores and alpha values in the control ($r_{\text{control}} = -0.35$; $p = 0.15$) and EFT ($r_{\text{EFT}} = -0.08$; $p = 0.75$) groups were not significantly correlated.

Cue Valence—Ratings of enjoyment, importance, excitement, and vividness were compared between EFT and control groups at each delay using a 2-way ANOVA (Fig. 4). Ratings for enjoyment, $F(1, 48) = 26.36$, $p < 0.0001$, importance, $F(1, 48) = 23.38$, $p < 0.0001$, and excitement, $F(1, 48) = 24.13$, $p < 0.0001$, all produced significant main effects between EFT group types. Vividness ratings did not differ between groups. Post hoc analyses revealed that EFT cues were rated significantly higher than control cues at the 3 latest time points (3, 4, and 5; $p < 0.05$) for enjoyment, importance, and excitement. To determine whether cue valence scores were significantly influencing EFT or control discounting AUC, a 1-way ANOVA was performed including cue valence scores as covariates, $F(5, 49) = 3.28$, $p < 0.013$. Only condition (EFT or control) significantly ($p < 0.003$) accounted for the variance in AUC. None of the cue valence scores significantly contributed to the variance ($p > 0.05$). Interestingly, while not a significant contributor to the variance of AUC, vividness was the only valence score that approached significance ($p = 0.07$).

DISCUSSION

The results of the present study suggest a widening of the temporal window of individuals with alcohol dependence following engagement of EFT. Specifically, EFT significantly increased valuation of future monetary rewards at the longest delays to reward receipt. Also, initial consumption (Q_0) of hypothetical alcoholic drinks was significantly lower in the EFT group indicative of lower demand intensity for the reward. Two additional findings of the present study provide for a discussion of potential moderators of this effect and avenues for future study. First, correlational analyses suggested that alcohol-dependent individuals with less severe alcohol abuse (lower AUDIT scores) were readily influenced by EFT; second, self-reported cue valence differed between EFT and control groups at the longest time points. The following discussion corroborates our results with previous literature, proposes potential mechanisms for EFT's effect, and makes inferences regarding the present study's limitations and future research directions.

Our results are consistent with the previous research using EFT. Peters and Büchel (2010) found that episodic tags, presented simply as 2-word reminders of previous episodic future

thought during a delay-discounting task, decreased valuation of immediate rewards in healthy volunteers. Excessive discounting of delayed rewards is posited as a trans-disease process in which many different types of behavioral maladies, including overeating and drug addiction, exhibit excessive undervaluation of future rewards (Bickel et al., 2012b). Importantly, EFT decreased delay discounting in overweight and obese adults as well as 9- to 14-year-old obese adolescents (Daniel et al., 2013a,b, 2015), consistent with our results in alcohol-dependent individuals. Our results also revealed a decrease in initial consumption in hypothetical alcoholic drinks during a purchase task following EFT. In the present study, when alcoholic drinks were free or at very low cost, EFT participants purchased less than the control group. These data are again consistent with data from Daniel and colleagues (2013b, 2015) in which EFT decreased caloric intake in overweight adults and 9- to 14-year-old obese adolescents when given free access to highly palatable foods. These data, in combination, suggest that EFT disrupts excessive discounting of delayed rewards, overvaluation of immediate rewards, and supports the hypothesis that EFT may hold future implications for manipulating valuation of future rewards in multiple therapeutic arenas.

Generation of future events, using prospective thought, increases consideration for the value of future rewards (Daniel et al., 2013a). We assert that this increase in consideration is consistent with a widening of an individual's temporal window allowing individuals the opportunity to value future rewards more distant in time. The mechanisms at play seem to work in a manner consistent with the competing neurobehavioral decision systems (CNDS) theory (Bickel et al., 2007, 2012a). The CNDS theory posits that decisions are influenced by the relative strength of 2 competing neural systems; the impulsive system comprised predominantly limbic and paralimbic regions, and the executive system associated with frontal cortices. For example, when presented with a delay-discounting task, greater relative brain activation occurs in the impulsive decision system when the immediate choice is chosen while greater activation of the executive system occurs when the delayed choice is chosen (McClure et al., 2004, 2007; Peters and Büchel, 2009, 2010). This pattern of activation can also be manipulated by reward pathologies, such as drug abuse, obesity, or pathological gambling. Alcohol users who discount future rewards more often exhibit increased activation in the precuneus, insula, orbitofrontal cortex, and inferior frontal gyrus, all areas within the impulsive decision system and related to emotional control (Claus et al., 2011), indicative of hyperactivation of the impulsive decision system. However, future thought activates frontal poles (i.e., executive decision system areas; Okuda et al., 2003), and episodic future thought reduces delay discounting via activation of the medial rostral PFC, another prefrontal region within the executive decision system (Benoit et al., 2011). These data give rise to a potential mechanism in which EFT may strengthen the executive decision system to inhibit overvaluation of immediate rewards in individuals with alcohol dependence. However, further understanding of the individuals most benefitted by EFT and the specific conditions under which EFT cues are most effective are important next steps for application.

Analysis of participants' AUDIT scores revealed that severity of alcohol abuse was negatively correlated with delay discounting AUC after generating EFT cues; however, this correlation was not present in those who generated ERT control cues. Although the 2 correlations were not significantly different from each other, the data still suggest that lower

AUDIT scores predicted a greater AUC (i.e., decrease in discounting) following EFT. That is, participants with lower abuse severity may be more susceptible to an EFT intervention. These individual factors may interact with the effects of 3 aspects of the cue generation process of EFT and are important to discuss as potential moderators of this effect.

The first potential moderator of the interaction between self-restraint and EFT is memory. Lin and Epstein (2014) reported that participant working memory capacity moderated the EFT effect. Many reports argue that episodic thought, whether past or future, is generated and elaborated on using similar neural machinery (Addis et al., 2007; Irish et al., 2012; Race et al., 2011). Episode construction is proposed to require a combination of attention and working memory with a temporal dimension overlay (Marchetti, 2014). Thus, future autobiographical thought is related to past memories in such a way that working memory is required to generate plausible future event specificity (Hill and Emery, 2013). The hippocampus, one important brain structure for memory, is vital to the construction and elaboration of future events (Schacter et al., 2012). Memory can be challenging for individuals with alcohol dependence. For example, drinking was correlated with deficits in prospective memory (Griffiths et al., 2012). Further, when prompted, individuals with alcohol dependence produce significantly less specific autobiographical memories and their contextual details are significantly deficient when generating possible future events, compared to controls (D'Argembeau et al., 2006). These deficits are suggested to be a product of damage to frontal lobes (D'Argembeau et al., 2006) and lower hippocampal volume than healthy controls (Hoefer et al., 2014). Importantly, imagining improved prospective memory in social drinkers but alcohol-dependent individuals (Griffiths et al., 2012) perhaps providing an explanation for why the lower AUDIT scorers performed better with EFT compared to the higher AUDIT score participants in the present study. Acknowledging these characteristic differences in individuals may be a vital component when considering EFT as a therapeutic intervention for a target population. For example, Wiehler and colleagues (2015) modeled addiction in the absence of several confounding variables of substance dependence, such as neurotoxicity, using pathological gamblers. Gamblers discounted delayed rewards more steeply than matched controls; however, no significant impairments were observed in EFT capabilities between groups (Wiehler et al., 2015). These differences highlight that further investigation into substance abuse and its impact on memory may interact with the efficacy of EFT to expand the temporal view.

The second important moderator for generation of episodic thinking cues is the incorporation of personal goals. D'Argembeau and colleagues (2010) reported that imagining future events related to personal goals, paired with the belief that they would actually happen, made them subjectively closer in time, compared to plausible future events. These findings are consistent with the temporal window hypothesis and add value to considering what participants' future cues are about for EFT to work. Consistently, the reduction in discounting of future events was not date/time specific, but rather EFT reduced discounting just as well when a delayed event was clear and reward confidence was high (Peters and Büchel, 2010). Thus, the "essence" of EFT and its effects on discounting lie in constructing a hypothetical event that is personally relevant and plausible giving rise to enhanced pre-experiencing. Thinking about your personal future activates mPFC much more than your personal past or nonpersonal past or future (Abraham et al., 2008). Further,

conjunction analyses revealed that the mPFC was activated the most during personal goal processing, compared to mind wandering (D'Argembeau et al., 2010; Stawarczyk and D'Argembeau, 2015), again consistent with activation of the executive decision system during EFT. The authors suggested that these areas are relevant for "evaluating, coding, and contextualizing" future events that are personally referential and goal oriented and that personal goal processing is a major contributor to EFT's mechanism (D'Argembeau et al., 2010). Personal goals related to future thoughts were also rated as more important and vivid than nonpersonal concerns (Cole and Berntsen, 2016) perhaps shedding light on the third component that moderates the effectiveness of EFT cues, cue valence, and vividness.

The final moderator of cue generation seems to be cue valence and vividness. For example, when participants were asked to estimate what they would buy with a delayed amount of money during a delay-discounting task, participants discounted significantly less compared to when simply imagining a future thought (Benoit et al., 2011). Consistently, in the present study, EFT cues were rated as generating more enjoyment, being more important, and exciting compared to control cues. These differences were specifically apparent during the 3 longest delays; the same delays in which the differences were apparent in delay discounting between EFT groups. Interestingly, Benoit and colleagues (2011) reported that the emotionality of the future thought was especially effective in reducing discounting further corroborating our findings. Importantly, however, enjoyment, importance, and excitement ratings of the events did not drive the change in discounting when the difference in ratings was controlled for between groups in the present study. This evidence is consistent with a previous observation in which EFT decreased discounting regardless of emotional valence (Lin and Epstein, 2014). These data suggest instead that enjoyment, importance, and excitement may be moderators that enhance the experience of the future event and help bring the future closer in time while making decisions; however, thinking of the future seems to be the major mechanism.

Ratings of vividness of a future cue are most influenced by pre-experiencing, subjective closeness, and belief that a future event will happen (D'Argembeau and Van der Linden, 2012). For example, delay-discounting rates were negatively correlated with event detail scores during EFT in healthy adolescents (Bromberg et al., 2015). Consequently, this may suggest that high cue vividness ratings would predict the extent of decrease in discounting (Peters and Büchel, 2010). In the present study, vividness scores did not differ between EFT groups. This lack of difference in vividness scores seen between the EFT and control groups may have been a product of a ceiling effect of the rating scale. Both groups rated their cues at the high end of the vividness scale continuum, reducing the measure's sensitivity to detect differences. This departure from previous findings is plausible because the EFT control group generated EFT cues based on time periods from the previous day. These methods are in contrast to previous control episodic thinking methods in which participants described vivid events from travel blogs or classic fiction (Daniel et al., 2013a,b). As described above, the extent to which an event is personal influences the strength of the episodic cue; thus, cues generated from nonautobiographical information likely produced blunted vividness scores. We assert that the increase in vividness score observed in the control condition is a strength, not a limitation, of the present study. That is, although vividness scores did not differ, the EFT cues still significantly reduced discounting. Interestingly, while not

significant, the impact of vividness score on the variance of discounting AUC between groups was the only cue valence score to approach significance ($p = 0.07$). These results suggest that while vividness may be a vital predictor of EFT, thinking of *future* events is sufficient to widen participants' temporal window to increase valuation of delayed rewards.

The extent to which these procedures could be adapted into a potential clinical intervention requires future research. These data and data from previous reports are a product of a single "administration" of EFT. Examining repeated EFT and avenues in which individuals could chronically administer EFT cues independently might be a necessary next step. Additionally, the present study did not include a matched healthy control group and therefore disallowed for comparisons of EFT effect on population type. We note however that this does not hinder the relevance of the present study's contribution. Given that EFT is effective in reducing delay discounting in healthy volunteers (Peters and Büchel, 2010) and now significantly affects delay discounting in individuals with alcohol dependence, future analyses between these two, and additional, populations may elucidate how differences in population type may be differentially affected by EFT. Moreover, given the present study's AUDIT score correlations, we might hypothesize that matched healthy controls may perform better than the alcohol-dependent individuals following EFT. Determining these differences might further help identify the individuals who are more likely to be benefitted by such a potentially therapeutic intervention.

CONCLUSION

In summary, alcohol-dependent participants' discounting rate decreased significantly when reminded of self-generated positive future events. EFT cues are proposed to be most effective when they incorporate personal goals and are elaborated upon to enable emotionality, vividness, and true pre-experiencing. While our data suggest that EFT may be moderated by certain susceptibility criteria and working memory capacity, exercises such as EFT could be easily adaptable as a potential therapeutic tool for use in the clinic and outpatient rehabilitation programs.

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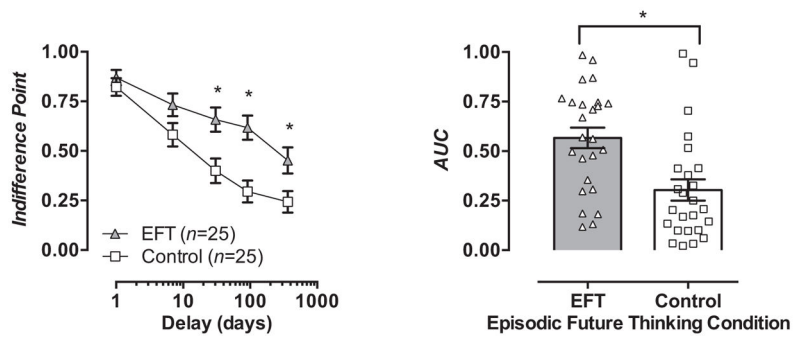


Fig. 1. (Left) Group differences in delay discounting indifference points (\pm SEM). (Right) Group average area under the curve (AUC) (\pm SEM) where points represent individual AUC values. * $p < 0.05$.

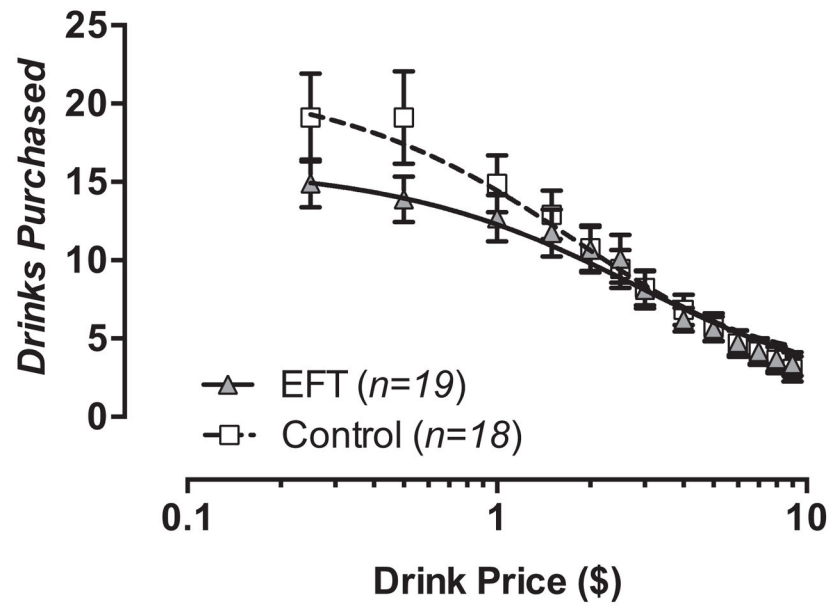


Fig. 2. Hypothetical purchasing of standard alcoholic drinks between episodic future thinking (EFT) and control groups. Points represent group average drink purchasing (SEM) including demand curve fits.

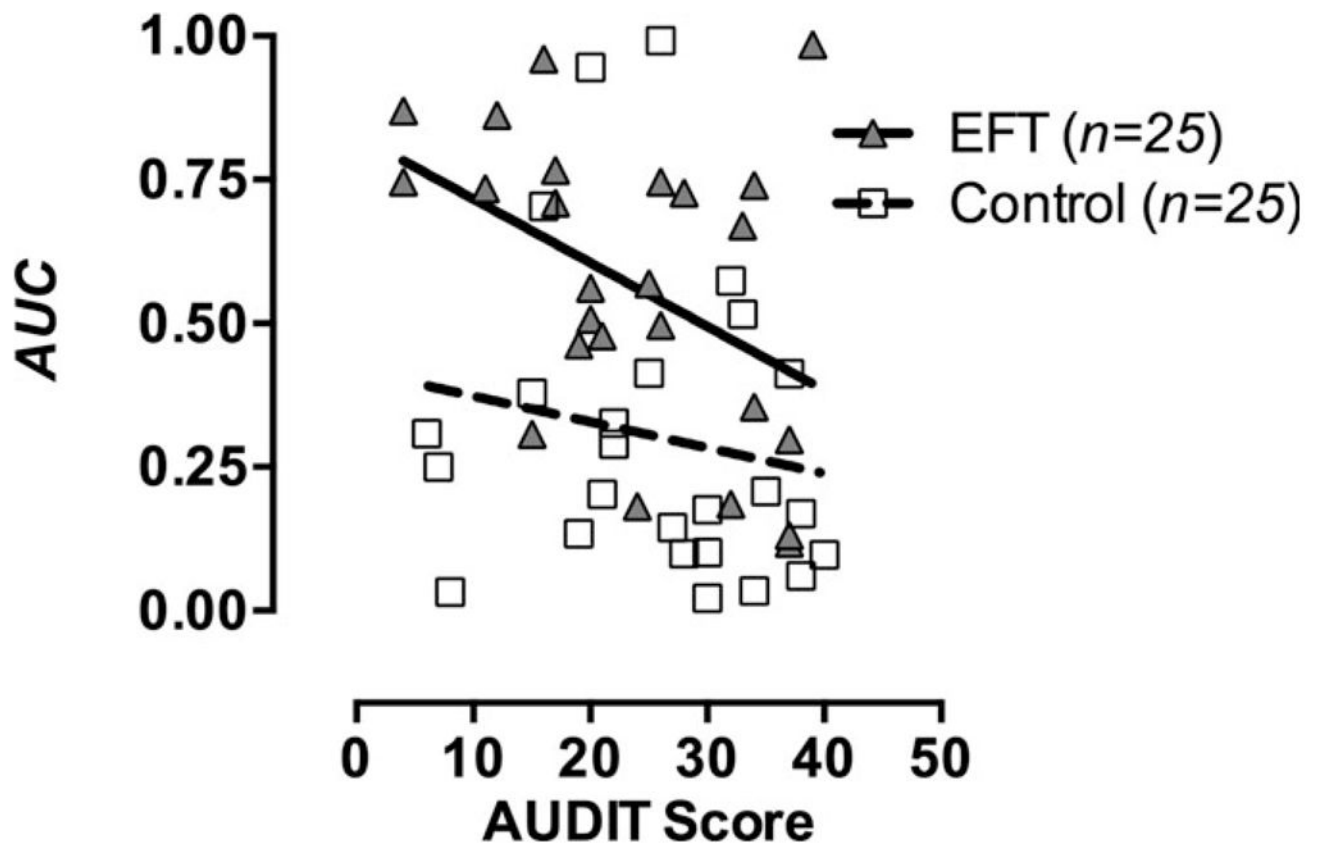


Fig. 3. Correlation between Alcohol Use Disorders Identification Test (AUDIT) score and delay-discounting area under the curve (AUC) between episodic future thinking (EFT) and control groups. Solid line indicates linear regression line for the EFT group; dashed line represents linear regression line for the control group.

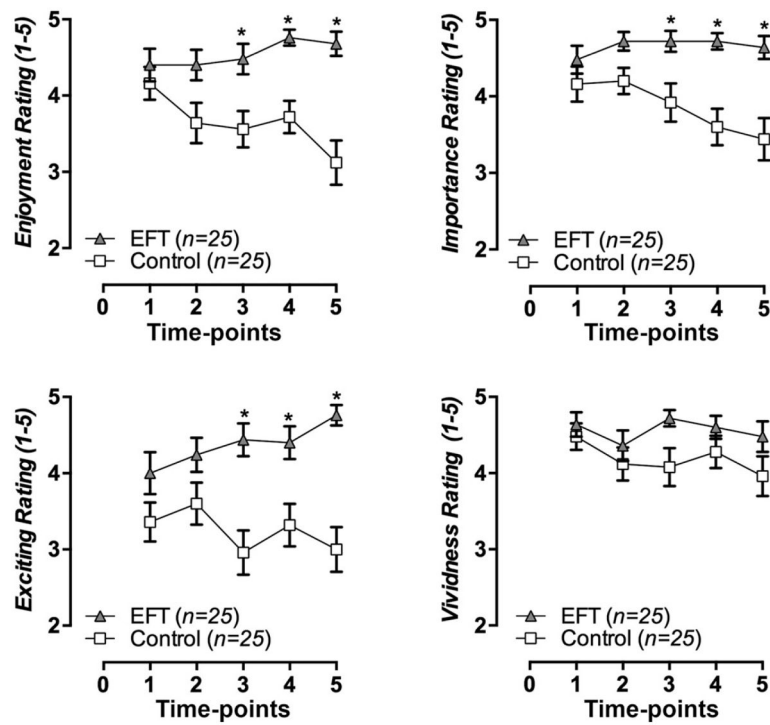


Fig. 4. Cue valence scores between groups. Enjoyment (**upper left**), importance (**upper right**), excitement (**lower left**), and vividness (**lower right**) ratings for each generated future or recent past cue. Time points (1 to 5) on the *x*-axis refer to future delays (1 day, 1 week, 1 month, 3 months, 1 year) or recent past events (7 PM–10 PM, 4 PM–7 PM, 1 PM–4 PM, 10 AM–1 PM, 7 AM–10 AM) dependent upon group assignment. All points are group means (SEM). * $p < 0.05$.

Table 1
Demographic Characteristics of Participants Randomly Assigned to Either the Episodic Future Thinking (EFT) or Episodic Recent Thinking Control Group

Group condition	Gender (% male)	Race (% Caucasian)	Age (years)	Education (years)	Monthly income (\$)	AUDIT scores
EFT	68	64	38.0 (2.3)	13.6 (0.5)	850.20 (194.0)	23.52 (\pm 2.049)
Control	84	44	44.3 (1.9)	13.1 (0.4)	652.80 (214.2)	25.56 (\pm 1.972)
<i>p</i> -values	0.19	0.28	0.036*	0.42	0.50	0.48

Gender and race variables are percentages based on the group. All other variables are group means (\pm SEM). Contrasts between demographic variables are also presented between groups.

* $p < 0.05$.