HHS Public Access

Author manuscript

Addiction. Author manuscript; available in PMC 2017 November 01.

Published in final edited form as:

Addiction. 2016 November ; 111(11): 1956–1965. doi:10.1111/add.13492.

Behavioral Economic Indicators of Drinking Problem Severity and Initial Outcomes Among Problem Drinkers Attempting Natural Recovery: A Cross-sectional Naturalistic Study

Jalie A. Tucker,
University of Florida—Gainesville

JeeWon Cheong,
University of Florida—Gainesville

Susan D. Chandler,
University of Florida—Gainesville

Brice H. Lambert,
University of Alabama at Birmingham

Heather Kwok, and
University of Alabama at Birmingham

Brittney Pietrzak
University of Alabama at Birmingham

Abstract

Background and aims—Research using different behavioral economic (BE) and time perspective (TP) measures suggests that substance misusers show greater sensitivity to shorter term contingencies than normal controls, but multiple measures have seldom been investigated together. This study evaluated the extent to which multiple BE and TP measures were associated with drinking problem severity, distinguished initial outcomes of natural recovery attempts, and shared common variance. Hypotheses were (1) greater problem severity would be associated with greater impulsivity and demand for alcohol and shorter TPs; and (2) low-risk drinking would be associated with greater sensitivity to longer term contingencies compared with abstinence.

Design—Cross-sectional naturalistic field study.

Setting—Southern United States.

Participants—Problem drinkers, recently resolved without treatment (N = 191 [76.4% male], M age = 50.1 years) recruited using media advertisements.

Measurements—Drinking practices, dependence levels, and alcohol-related problems prior to stopping problem drinking were assessed during structured field interviews. Measures included the

Correspondence to: Jalie A. Tucker, Department of Health Education and Behavior, College of Health and Human Performance, University of Florida, P.O. Box 118210, Gainesville, FL 32611-8210. jaliet@ufl.edu.

Declarations of interest: None.

Portions of the research were presented at the annual meeting of the Research Society on Alcoholism, San Antonio, TX, June 2015.

Zimbardo Time Perspective Inventory; BE analogue choice tasks (Delay Discounting [DD], Melioration-Maximization [MM], Alcohol Purchase Task [APT]); and the Alcohol-Savings Discretionary Expenditure (ASDE) index, derived from real spending on alcohol and voluntary savings during the year before problem cessation.

Findings—Measures of demand based on real (ASDE) and hypothetical (APT) spending on alcohol were associated with problem severity (ps < .05), but DD, MM, and TP measures were not. More balanced pre-resolution spending on alcohol versus saving for the future distinguished low-risk drinking from abstinent resolutions (ASDE OR = 5.59; p < .001). BE measures did not share common variance.

Conclusions—Two behavioural assessment tools that measure spending on alcohol, the Alcohol Purchase Task and the Alcohol-Savings Discretionary Expenditure index, appear to be reliable in assessing the severity of drinking problems. The ASDE index also may aid choices between low-risk and abstinent drinking goals.

Keywords

Drinking problem severity; natural recovery; behavioral economics; alcohol demand; delay discounting; behavioral allocation

INTRODUCTION

Behavioral economics (BE) [1,2] integrates operant psychology approaches to understanding choice behavior, particularly impulsive choice, with microeconomic models of consumer demand. BE is concerned with how individuals allocate limited resources (e.g., money, time, behavior) to obtain commodities available at different costs and delays, and strength of preference (i.e., demand) for a given commodity is inferred from relative resource allocation to obtain it. The framework has been widely applied to explain substance misuse and other maladaptive behaviors (e.g., risky sex, overeating, gambling [2–5]) using various measurement approaches. The evidence supports models of substance misuse as a "reinforcement pathology" [6,7] involving excessive demand for substances and chronic insensitivity to control of current behavior by more valuable, delayed outcomes in favor of less valuable short-term outcomes with delayed harmful effects. Social psychological studies of time perspective, reflecting life orientations toward the past, present, or future, have found similar relationships. Substance misusers and those engaged in other risky behaviors tend to have more present-oriented and less future-oriented time perspectives (TP) compared to controls [8–11].

BE measures associated with addiction status and outcomes include intertemporal choice tasks that assess how delayed rewards lose value as a function of time to availability [12,13], distributed choice tasks in which local and molar reinforcement contingencies are opposed [14,15], and measures of demand for substances based on hypothetical [16,17] and real [18–22] monetary spending to obtain them. Relatively stronger preference for immediate but less valuable rewards over delayed larger rewards, and higher spending on substances under different conditions of contextual constraint, were associated with greater problem severity

in cross-sectional studies [13,15] and with poorer outcomes of treatment-assisted and natural recovery attempts [16, 18–26].

These findings suggest that shifting control of behavior from shorter to longer term contingencies should promote recovery [7] and that active substance misusers with greater sensitivity to longer term contingencies, even when actively using, should have a better prognosis, as found in BE studies of natural recovery from alcohol problems [18–22]. The latter relationship was particularly strong for recoveries that involved low-risk drinking compared to abstinence [21,22], suggesting that problem drinkers with relatively greater behavioral self-control even when drinking abusively were more likely to achieve stable non-abstinent recoveries [27]. Understanding who can safely resume low-risk drinking has gained importance as interventions have expanded beyond abstinence-oriented treatments for alcohol dependent persons to include brief, less intensive interventions for the larger, often untreated majority with less severe problems for whom low-risk drinking is a preferred and potentially attainable goal [28,29].

Despite these positive findings and the conceptual similarities across the BE and TP literatures on substance misuse, studies examining multiple BE and TP measures simultaneously are quite limited with mixed results. Some studies found significant, but small, correlations (rs ≤ 0.2) of these measures with outcomes in the predicted direction [30–32], whereas others found discordance among measures [33–37]. Moreover, most supportive evidence comes from cross-sectional research using delay discounting tasks [12,13]. Evaluating inter-relationships among measures and determining their unique associations with addiction status, problem severity, and outcomes thus remain important questions for understanding impulsivity and self-control processes in substance misuse [7,38].

The present study used baseline data from a longitudinal study of natural recovery to evaluate the extent to which different BE and TP measures were uniquely associated with drinking problem severity, distinguished initial outcomes of natural recovery attempts, and shared common attributes. Hypotheses were: (1) Greater problem severity would be associated with greater demand for alcohol [16,17], stronger preference for immediate but less valuable rewards over delayed larger rewards [6,12], and present-dominated time perspectives [8–11]. (2) Participants with initial non-abstinent recoveries involving low-risk drinking would show relatively greater sensitivity to delayed outcomes than those who were abstinent [21,22].

METHODS

Sample recruitment and characteristics

The study received university Institutional Review Board approval and a U.S. federal Certificate of Confidentiality and adhered to STROBE guidelines [39] for observational studies. Community-dwelling problem drinkers in early recovery in Alabama, Georgia, Tennessee, and Florida were recruited via media advertisements and screened using the Michigan Alcoholism Screening Test (MAST) [40], Alcohol Dependence Scale (ADS) [41], and Drinking Problems Scale (DPS) [42]. Eligibility criteria included: (a) legal drinking age (≥ 21 years), (b) problem drinking history ≥ 2 years (M = 17.34 years, SD = 12.65), (c) no

current other drug misuse (except nicotine), and (d) recent cessation of high-risk drinking for 3 weeks to 3 months without alcohol-focused interventions, although limited alcohol treatment or AA attendance over 2 years ago was not exclusionary. Of 2,243 respondents screened between June 2010 and September 2014, 1,887 (84.13%) were deemed ineligible (e.g., recent help-seeking, lengthy resolutions). Of 356 who screened eligible, 245 (68.8%) could be scheduled and were consented, although 54 were later deemed ineligible post-consent and were excluded (e.g., based on their reports or conflicting reports by collateral informants).

Table 1 presents the characteristics of the recruited sample (N = 191, 146 males). All participants met diagnostic criteria for alcohol dependence (97.9%) or abuse (2.1%) [43], and the great majority were treatment-naïve (75.9%) and had attended ≤ 3 AA meetings (74.9%) on a lifetime basis. All had stopped abusive drinking on their own for 3 weeks or more (M = 9.99 weeks, SD = 4.34), either abstaining or drinking in a low-risk manner, defined as (a) no dependence symptoms (ADS), (b) no alcohol-related negative consequences (DPS), and (c) no risky drinking (> 4 standard drinks/day for men, > 3 drinks/day for women) [44]. The first day that participants stopped abusive drinking was their initial "resolution" date, either Resolved Abstinent (RA) or Resolved Non-abstinent (NRA) [28]. Gender composition approximated the problem drinker population, and race/ethnicity composition approximated the southern U.S. region where the study was conducted.

Procedures

In-person baseline interviews (1.5–3.0 hours) used for the present analyses included structured interviews, interactive voice response (IVR) telephone surveys, computer-administered tasks, and questionnaires. Interviews took place in locations convenient to participants (e.g., libraries, coffee shops). Informed consent included a request to interview a collateral informant by phone, but was not required. Sobriety was verified by breathalyzer (Lifeloc FC20, Wheat Ridge, CO), followed by measurement of drinking practices and expenditures during the pre-resolution year using an expanded Timeline Followback (TLFB) interview [45,46], the APT [16] administered via IVR using a cell phone, and the DD [47] and MM [48] choice tasks administered by laptop computer. Participants were compensated with university-issued VISA gift cards or checks ($75 for baseline data collection).

Brief phone interviews with collaterals (36.1% spouses, 36.1% other family members, 24.9% friends, 2.9% other) inquired about participants' study eligibility (e.g., recent sobriety achieved without treatment or AA) and drinking status during the 1-year follow-up. Conflicting collateral reports excluded data from 10 consented participants, whereas collaterals verified reports for 153 of 191 retained participants (80.1%).

Behavioral economic measures

Delay discounting (DD) task—The hypothetical money DD task [47] used an adjusting amount approach [49]. Participants made repeated choices between a smaller amount of money available immediately (starting at $1 U.S.) and a larger amount (i.e., $1000) available at 5 delays (1, 2, 30, 180, 365 days). Equivalence points at each delay estimated the amount

of immediate money subjectively judged equivalent to the larger later amount; from these points, a *k*-parameter was derived reflecting the slope of the hyperbolic discount function characteristic of reward devaluation over time [50]. Higher *k*-parameters indicate more immediate reward preferences. Because *k*-parameters are skewed, the natural logarithm of *k* was used for analysis. DD data also were examined using Area Under the Curve (AUC) methods [51], which make no assumption about the shape of the discount function.

Alcohol Purchase Task (APT)—Following Murphy, MacKillop, and colleagues [16,52,53], participants were instructed to imagine they were drinking in a typical bar situation and report how many drinks in standard sizes they would consume at 18 prices ($0 to $20). Using a computerized IVR platform, participants pressed phone keypads to indicate the number of drinks (including zero) at each price. Their choices yielded four observed alcohol demand measures [17], including intensity (consumption at $0), O_{max} (maximum expenditure on drinks across different prices), P_{max} (price at which O_{max} occurred), and breakpoint (price when consumption became zero), and two derived measures (elasticity of demand reflecting sensitivity to price changes; AUC reflecting total drinks purchased across all prices [52]).

Melioration-maximization (MM) task—A computerized fixed-duration choice task [14,48] resulted in either greater immediate or greater overall reinforcement in each of eight sessions. Throughout the task, participants saw an on-screen counter indicating the time in seconds remaining in each session (e.g., 600 seconds). On each choice trial, “Choice A” or “Choice B” resulted in 5 or 10 points worth of winnings, respectively, but differed in the associated inter-trial interval (ITI), with Choice A always producing an ITI three seconds longer than Choice B. As ITIs lengthened, opportunities to earn money were lost, making Choice B the immediately more valuable alternative. However, the number of “B” choices over the preceding 10 trials affected the length of ITIs; i.e., “A” choices produced a longer ITI to the next trial but shorter overall ITIs, and “B” choices produced a shorter ITI to the next trial but longer overall ITIs. Participants’ choices were quantified as the ratio of overall favorable choices (A) to locally favorable choices (B). The higher the “A” choice frequencies, the higher these values, indicating greater overall reinforcement. Participants received any money earned at the end of the session (M = $8.83, SD = 1.13).

Alcohol-Savings Discretionary Expenditure (ASDE) index—Strength of preference for alcohol was assessed by the relative amount of resource (money in this case) allocated to gain access to it in relation to other available commodities during the year prior to resolution. Participants reported in U.S. dollars their income by source and expenditures to different commodity classes using an expanded TLFB format developed in our prior research [18–21,54] that involved verification of participant reports using their available financial records (e.g., paycheck stubs, bank/credit card statements, receipts, tax returns). To compute the ASDE index, expenditures were separated into obligatory and discretionary categories. Obligatory expenditures were for essential, ongoing, and largely fixed costs (housing; food; transportation; automatic payroll deductions for health insurance, taxes, retirement etc.). Discretionary expenditures (DE) were for less essential commodities typically purchased intermittently (entertainment, recreation, alcohol, tobacco, other

consumable goods, gifts, and money saved voluntarily). The ASDE index was computed as the proportion of DE spent on drinking minus the proportion of DE put into savings. Values could range from −1.0 to 1.0; higher scores represented proportionally more spending on alcohol and less on savings.

Time perspectives

Three of five subscales from the 56-item Zimbardo Time Perspective Inventory [55] measure present- or future-dominated time perspectives associated with substance use [8,10] and were used for analysis: Present Hedonistic (a risk-taking lifestyle oriented toward present pleasure), Present Fatalistic (a pessimistic, uncontrollable view of the future), and Future (planning for and sensitivity to longer term outcomes). Cronbach's alpha for the subscales ranged from .74 to .87 [11,55], indicating good internal consistency. The Past Negative and Past Positive subscales are not associated with substance-related variables and were not analyzed [11].

Drinking problem severity measures

Drinking practices—Participants' TLFB reports of daily drinking, assessed as ounces of beer, wine, and liquor intake, during the pre-resolution year were converted to ml of 190-proof ethanol for analysis. The average quantity consumed per drinking day and the number of pre-resolution days that involved abstinence or drinking below binge drinking thresholds (< 5 drinks for men [80 ml ethanol], < 4 drinks for women [64 ml ethanol]) were calculated to reflect "days well-functioning" [56].

Drinking problems and dependence levels—The 25-item ADS [41] yielded scores ranging from 0 to 47, indicative of mild to severe dependence. A 40-item DPS [42] assessed alcohol-related problems in eight areas (e.g., social, family, and intimate relationships; finances). Higher scores (0–40) indicated greater problems.

Data analyses

Data analysis proceeded in steps. First, individual DD and APT data were examined to identify patterns sufficiently deviating from expected response ranges to warrant exclusion in the analyses [57,58]. Of the 191 participants, we excluded 5 (2.6%) who had unreasonable DD response patterns (final $k > 2$ or equivalence point for Day 365 > Day 1 delay) when calculating log k, and 18 (9%) who had non-systematic APT data (e.g., multiple instances of increasing consumption with increasing prices) when calculating AUC. In addition, 41 participants (21.6%) refused drinks on the APT at all prices, including $0, so intensity (consumption at $0) was chosen as the most informative metric because it allowed inclusion of non-purchasers in the analyses and has demonstrated predictive utility for alcohol-related symptoms [59]. Some other BE, TP, and demographic measures had missing values, but virtually no data were missing on drinking-related measures. Analyses used complete cases, with sample sizes of 152 or 153 depending on missing values. Post-hoc power analysis using G-power [60] indicated statistical power > .80 to detect a small effect size (i.e., 1~2% of unique variance explained by each predictor in the model).

Second, to evaluate unique associations of BE and TP measures with measures of drinking problem severity, multiple regression analyses were conducted using SAS 9.4. Models for continuous drinking problem severity outcomes (quantity per drinking day, days well functioning, ADS, DPS) were estimated using ordinary least squares regression. The model for initial binary drinking status (RA = 1; RNA = 0) was estimated using logistic regression. In all models, one metric from each BE task (i.e., log k, intensity, overall/local favorable choice ratio, ASDE index), the three TP subscales, and demographic characteristics often associated with problem severity (i.e., age, gender, education, race/ethnicity [white vs. other], income) were included simultaneously as predictors to evaluate the utility of each variable while controlling for the others. Additional models were evaluated using AUC as an alternative measure for DD [51] and APT [52] data to validate the findings with log k and intensity. Logistic regression analyses also compared demographic characteristics and initial resolution status of participants who refused APT drinks at any price ($n = 40$) to those who purchased drinks ($n = 146$). Given the centrality of elasticity as a metric in BE demand analyses, exploratory analyses examined the association of elasticity with problem severity indicators and initial resolution status using the subset of APT purchasers for whom a valid elasticity value could be computed (ns = 111 ~ 112). Because of the reduced sample sizes, these analyses were limited to simpler models that included significant BE predictors in the full models described above. Individual participants' elasticity was estimated by alpha parameter from Hursh's exponential demand model [61] using Graphpad Prism 6 (Graphpad Software, San Diego, CA, www.graphpad.com).

Third, we conducted confirmatory factor analysis (CFA) in Mplus 7.3 [62] to estimate the common variance among the BE and TP variables (if any), not to test hypotheses regarding factor structures. If they measured common attributes, as is often assumed, the common shared variance should be statistically significant.

RESULTS

Associations among BE and TP measures with drinking problem severity

As shown in Table 2, the APT intensity and ASDE measures showed significant associations with drinking problem severity measures. Greater alcohol demand intensity on the APT and greater proportional spending on alcohol than savings prior to resolution were associated with higher quantities consumed, greater dependence, and fewer days well-functioning. Only the ASDE, however, was associated with alcohol-related problems (DPS); higher ASDE values were associated with more problems. Other BE and TP measures were not related to any severity indicators, except that the present hedonistic subscale unexpectedly showed positive associations with more days well-functioning. The additional analyses replacing log k and intensity with AUC measures from the DD and APT tasks [51,52] did not change the pattern of results. Demographic characteristics were unrelated to drinking practices but showed some associations with dependence and drinking problems; i.e., younger age was associated with higher dependence ($p < .05$), and male gender ($p < .01$) and non-white race ($p < .05$) were associated with more alcohol-related problems.

In the elasticity analyses restricted to APT purchasers that also included significant predictors from the full sample models (i.e., ASDE and demographic variables), higher

elasticity reflecting greater sensitivity to drink price changes was significantly associated with lower quantities consumed (β = −.120, $p < .05$) and more days well functioning (β = .338, $p < .001$). Elasticity was not significantly associated with dependence levels or alcohol-related problems. Except for days well functioning, all significant ASDE results in the full models remained unchanged.

Associations with initial resolution status

At enrollment, 147 participants were RA (79.03%) and 39 were RNA (20.97%). Logistic regression analysis showed that, of the seven BE and TP measures, only the ASDE index was significantly associated with initial resolution status (Table 2). Participants with higher ASDE values were more likely to have initial RA ($M = 0.38$, $SD = 0.36$) than RNA ($M = 0.18$, $SD = 0.37$) status. No demographic differences were significant. Additional analyses with AUC or elasticity were not significant, and the significant ASDE findings were unchanged.

As noted earlier, 21.6% of participants refused all APT drinks. Compared to drink purchasers, refusers were significantly more likely to be RA than RNA, OR = 3.82 (95% CI: 1.03–14.23), $p = .046$, and to be female, OR = 3.17 (95% CI: 1.27–7.90), $p = .013$. Of the 40 drink refusers, 36 (90.0%) were RA; in contrast, 34 of 39 RNA participants purchased drinks (87.2%). Other variables showed no significant associations.

Do BE and TP variables measure common attributes?

CFA indicated a lack of common variance shared among all seven BE and TP variables in Table 2 in a one-factor model (factor variance = 1.96; SE = 2.82, n.s.). In a two-factor model, the three TP subscales shared significant common variance (factor variance = 0.07; SE = 0.03, $p < .01$), but the four BE measures did not (factor variance = 1.01; SE = 3.83, n.s.). BE measures were not correlated with one another (rs = − .01 to .13) or with any TP subscale (rs = − .1109 to .07), except APT intensity was modestly correlated with present hedonistic ($r = .17$, $p = .023$) and present fatalistic ($r = .16$, $p = .027$) scores. For the subset of APT purchasers, elasticity was modestly correlated with DD log k ($r = .23$, $p < .02$) and APT intensity ($r = -.24$, $p < .01$), but not with the ASDE index, MM choice ratio, or TP subscales (rs = .008 to .12).

DISCUSSION

As hypothesized, greater problem severity as reflected in pre-resolution drinking practices and alcohol dependence levels was associated with greater intensity of alcohol demand and greater proportion of discretionary spending on alcohol than voluntary savings during the pre-resolution year. The ASDE index also was associated with alcohol-related problems and distinguished initial resolution outcomes. As hypothesized, more balanced pre-resolution spending on alcohol relative to savings was associated with initiating low-risk drinking compared to abstinence, which replicates prior research [21,22]. The ASDE and APT intensity associations with problem severity indicators suggest that these two BE variables assess important dimensions reflecting the relative strength of preference for alcoholic

beverages under different conditions of contextual constraint and that they capture unique information about problem severity and substance-related outcomes [14,59,63].

Other BE and TP predictors were not significant in the full sample analyses. In the subsample analyses limited to APT drink purchasers, elasticity was significantly associated with drinking practices in the expected direction, but not with dependence levels, alcohol-related problems, or initial resolution status. Thus, only the ASDE index was significantly associated with all five indicator variables. Furthermore, the ASDE index alone was significantly associated with alcohol-related functional problems and distinguished initial resolution status.

These unique ASDE relationships may rest on its more comprehensive representation of contextual elements important for choice behavior, which strongly influence behavioral patterning that involves many choices over time [1,45], as required for stable moderation [27]. Specifically, the APT is limited to assessing how demand for alcohol changes as a function of changes in drink prices in a hypothetical setting. The ASDE index also captures this dimension of demand through the assessment of real-life spending on alcohol, and it further represents the relative strength of preference for drinking versus non-drinking discretionary commodities available in the context of choice. This is important because experimental work with humans and animals indicates that preference for a given commodity is context dependent [1,64] and can be changed either by increasing direct constraints on the commodity of interest (i.e., alcohol) or by enriching the environment with higher-valued alternatives (e.g., positive social, educational, and vocational opportunities [45,65,66]. Among the BE measures, only the ASDE provides a contextually sensitive measure of the reinforcement value of drinking in relation to other activities. Through comparison of proportional discretionary spending on alcohol and voluntary savings for longer term priorities, the ASDE also reflects a temporal dimension of choice that is conceptually akin to delay discounting.

The ASDE findings distinguishing initial resolution outcomes suggest that problem drinkers who can better plan for the future and organize behavior accordingly, even when drinking heavily, appear to have better behavior regulation skills to meet the day-to-day self-control challenge of limiting a previous addictive behavior within tight limits [21,22]. Abstinence requires no such daily regulatory process [27]. This may aid prognosis and identification of candidates for a low-risk drinking goal [29].

Although APT intensity was not associated with initial resolution outcomes, preliminary evidence was found for its ecological validity. Participants who refused all drinks, even when free, were significantly more likely to be initially abstinent than low-risk drinkers, and almost all low-risk drinkers purchased APT drinks. This finding deserves further inquiry because it may aid identification of problem drinkers who are relatively more committed to abstinence, at least during early resolution.

In contrast to the positive ASDE and APT findings, the DD, MM, and TP measures did not show hypothesized associations. Unexpectedly, TP Present Hedonism was positively associated with days well functioning. Despite conceptual similarities with BE measures, TP

measures have not previously been investigated using natural recovery samples. Thus, whether this result relates to unique characteristics of natural recovery samples or is spurious cannot be determined.

More importantly, the BE measures did not share common variance among themselves or with TP subscales, indicating a heterogeneous multi-dimensional nature of these measures in relation to substance-related status and outcomes that merits further study [67]. Although the MM task has not been used sufficiently to reach definitive conclusions, the present study is one of several that failed to find significant associations between the DD task (scored as log *k* or AUC) and addiction severity and outcomes [33,35,37]. One possible contributor to the mixed evidence is a growing trend to use DD tasks that involve fewer choices and/or are based on brief questionnaires [68–70]. This may constrain essential variability to fit a reliable hyperbolic discount curve and compute the *k*-parameter; it also may be contributing to use of AUC measures that make no assumption about characteristic patterns of intertemporal choice [51]. Although practical for applied work, such brief measures depart from the longstanding successful molar measurement approach of BE [1] to identify precisely quantifiable behavioral regularities that represent many discrete choices over time and coalesce into coherent patterns of behavior, including substance misuse [45,71].

Another possibility is that choices on the DD and MM analogue tasks may fluctuate more rapidly than real behavior allocation patterns, but this same logic would apply to the APT analogue task, which showed hypothesized associations with problem severity. As others have noted [72], the extent to which discounting is a state or trait variable remains undecided.

One study limitation concerns the relatively modest number of participants with initial low-risk drinking resolutions, which limited the number of measures that could be evaluated simultaneously in multivariate models. The ASDE findings replicated prior research, but the negative findings for other BE and TP variables merit further investigation using larger samples of low-risk drinkers. Second, the number of participants who refused all drinks on the APT limited the task metrics that could be computed for the full sample. Nevertheless, the APT findings suggest that intensity may be useful for assessing commitment to abstinence. Third, the elasticity sub-analyses provided some support for a BE analysis of demand for alcohol, but should be interpreted cautiously given the smaller and relatively homogeneous subsample of APT drink purchasers.

In conclusion, the APT and ASDE findings supported the utility of incorporating behavioral assessment of spending on substances into established assessment procedures to characterize the severity of drinking problems. The unique contribution of the ASDE index in distinguishing initial natural recovery outcomes suggests its potential utility for discerning problem drinkers who pursue low-risk vs. abstinent drinking goals, an enduring issue of clinical importance and consumer interest.

Acknowledgments

This research was supported in part by NIH/NIAAA grant no. 1 R01 AA017880-01A1. The authors thank Cathy A. Simpson for contributing to measurement selection; James G. Murphy for consulting on collection and analysis of data from the Alcohol Purchase Task; and Rudy E. Vuchinich for commenting on the manuscript.

References

1. Rachlin H, Battalio R, Kagel J, Green L. Maximization theory in behavioral psychology. Behav Brain Sci. 181(4):371–417.
2. Bickel, WK.; Vuchinich, RE. Reframing health behavior change with health economics. Abingdon, Oxford, UK: Psychology Press; 2000.
3. Epstein LH, Salvy SJ, Carr KA, Dearing KK, Bickel WK. Food reinforcement delay discounting and obesity. Physiol Behav. 2010; 100:438–445. [PubMed: 20435052]
4. Johnson MW, Bruner NR. The Sexual Discounting Task: HIV risk behavior and the discounting of delayed sexual rewards in cocaine dependence. Drug Alcohol Depend. 2012; 123:15–21. [PubMed: 22055012]
5. Reynolds B. A review of delay-discounting research with humans: relations to drug use and gambling. Behav Pharmacol. 2006; 17:651–667. [PubMed: 17110792]
6. Bickel WK, Jarmolowicz DP, Mueller ET, Koffarnus MN, Gatchalian KM. Excessive discounting of delayed reinforcers as a trans-disease process contributing to addiction and other disease-related vulnerabilities: emerging evidence. Pharm Ther. 2012; 134:87–97.
7. Bickel WK, Johnson MW, Koffarnus MN, MacKillop J, Murphy JG. The behavioral economics of substance use disorders: Reinforcement pathologies and their repair. Ann Rev Clin Psychol. 2014; 10:641–677. [PubMed: 24679180]
8. Henson JM, Carey MP, Carey KB, Maisto SA. Associations among health behaviors and time perspective in young adults: model testing with boot-strapping replication. J Behav Med. 2006; 29:27–37.
9. Barnett E, Spruijt-Metz D, Unger JB, ,Rohrbach LA, Sun P, Sussman S. Bidirectional associations between future time perspective and substance use among continuation high-school students. Subst Use Misuse. 2013; 48:574–580. [PubMed: 23750661]
10. Braitman AL, Henson JM. The impact of time perspective latent profiles on college drinking: A multidimensional approach. Substance Use & Misuse. 2015; 50(5):664–673. [PubMed: 25607806]
11. Zimbardo, PG.; Boyd, JN. The time paradox: The new psychology that will change your life. New York: Simon and Shuster; 2008.
12. Madden, GJ.; Bickel, WK. Impulsivity: the behavioral and neurological science of discounting. Washington, DC: American Psychological Association; 2010.
13. MacKillop J, Amlung MT, Few LR, Ray LA, Sweet LH, Munafò M. Delayed reward discounting and addictive behavior: a meta-analysis. Psychopharmacology. 2011; 216:305–321. [PubMed: 21373791]
14. Herrnstein RJ, Loewenstein GF, Prelec D, Vaughan W. Utility maximization and melioration: Internalities in individual choice. J Behav Decis Making. 1993; 6:149–185.
15. Heyman GM, Dunn B. Decision biases and persistent illicit drug use: An experimental study of distributed choice in drug clinic patients. Drug Alc Depend. 2002; 67:192–203.
16. Murphy JG, MacKillop J. Relative reinforcing efficacy of alcohol among college student drinkers. Exp Clin Psychopharmacol. 2006; 14:219–227. [PubMed: 16756426]
17. MacKillop J, Murphy JG, Tidey JW, Kahler CW, Ray LA, Bickel WK. Latent structure of facets of alcohol reinforcement from a behavioral economic demand curve. Psychopharmacology. 2009; 203:33–40. [PubMed: 18925387]
18. Tucker JA, Vuchinich RE, Rippens PD. Predicting natural resolution of alcohol-related problems: A prospective behavioral economic analysis. Exp Clin Psychopharmacol. 2002; 10:248–257. [PubMed: 12233985]

19. Tucker JA, Vuchinich RE, Black BC, Rippens PD. Significance of a behavioral economic index of reward value in predicting drinking problem resolution. J Consult Clin Psychol. 2006; 74:317–326. [PubMed: 16649876]
20. Tucker JA, Foushee HR, Black BC. Behavioral economic analysis of natural resolution of drinking problems using IVR self-monitoring. Exp Clin Psychopharmacol. 2008; 16:332–340. [PubMed: 18729688]
21. Tucker JA, Roth DL, Huang J, Crawford MS, Simpson CA. Effects of IVR self-monitoring on natural resolution of drinking problems: Utilization and behavioral economic factors. J Stud Alc Drugs. 2012; 73:686–698.
22. Tucker JA, Roth DL, Vignolo MJ, Westfall AO. A behavioral economic reward index predicts drinking resolutions: moderation revisited and compared with other outcomes. J Consult Clin Psychol. 2009; 77:219–228. [PubMed: 19309182]
23. Stanger C, Ryan SR, Fu H, Landes RD, Jones BA, Bickel WK, et al. Delay discounting predicts adolescent substance abuse treatment outcomes. Exp Clin Psychopharmacol. 2012; 20:205–212. [PubMed: 22182419]
24. Washio Y, Higgins ST, Heil SH, McKerchar TL, Badger GJ, Skelly JM, et al. Delay discounting associated with treatment response among cocaine-dependent outpatients. Exp Clin Psychopharmacol. 2011; 19:243–248. [PubMed: 21517195]
25. MacKillop J, Murphy JG. A behavioral economic measure of demand for alcohol predicts brief intervention outcomes. Drug Alcohol Depend. 2007; 89:227–233. [PubMed: 17289297]
26. Murphy JG, Dennhardt AA, Yurasek AM, Skidmore JR, Martens MP, MacKillop J, et al. Behavioral economic predictors of brief alcohol intervention outcomes. J Consult Clin Psychol. 2015 Jul 13. ePub ahead of print.
27. Marlatt, GA. Lifestyle modification. In: Marlatt, GA.; Gordon, JR., editors. Relapse prevention: maintenance strategies in the treatment of addictive behaviors. New York: Guilford; p. 280-348.
28. Sobell LC, Cunningham JA, Sobell MB. Recovery from alcohol problems with and without treatment: prevalence in two population surveys. Am J Pub Health. 1996; 86:966–972. [PubMed: 8669520]
29. Miller, WR.; Munoz, RF. Controlling your drinking: tools to make moderation work for you. New York, NY: Guilford; 2005.
30. Baumann AA, Odum AL. Impulsivity, risk taking, and timing. Behav Proc. 2012; 90:408–414.
31. Teuscher U, Mitchell SH. Relation between time perspective and delay discounting: A literature review. Psychol Rec. 2011; 61:613–632.
32. Weafer J, Mitchell SH, de Wit H. Recent translational findings on impulsivity in relation to drug abuse. Curr Addict Rep. 2014; 1:289–300. [PubMed: 25678985]
33. Cheong J, Tucker JA, Simpson CA, Chandler SD. Time horizons and substance use among African American youths living in disadvantaged urban areas. Addict Behav. 2014; 39:818–823. [PubMed: 24531637]
34. Caswell AJ, Bond R, Duka T, Morgan MJ. Further evidence of the heterogeneous nature of impulsivity. Pers Indiv Differ. 2015; 76:68–74.
35. Dennhardt AA, Yurasek AM, Murphy JG. Change in delay discounting and substance reward value following a brief alcohol and drug use intervention. J Exp Anal Behav. 2015; 103:125–140. [PubMed: 25533393]
36. Jentsch JD, Asenhurst JR, Cervantes MC, James AS, Groman SM, Pennington ZT. Dissecting impulsivity and its relationships to drug addictions. Ann NY Acad Sci. 2014; 1327:1–26. [PubMed: 24654857]
37. MacKillop J, Mattson RE, MacKillop EJ, Castelda BA, Donovick PJ. Multidimensional assessment of impulsivity in undergraduate hazardous drinkers and controls. J Stud Alc Drugs. 2007; 68:785–788.
38. Daugherty JR, Brase GL. Taking time to be healthy: Predicting health behaviors with delay discounting and time perspective. Pers Indiv Differ. 2010; 48:202–207.
39. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)

statement: Guidelines for reporting observational studies. Epidemiology. 2007; 18:800–804. [PubMed: 18049194]

40. Selzer ML. The Michigan Alcohol Screening Test: the quest for a new diagnostic instrument. Am J Psychiatry. 1971; 127:1653–1658. [PubMed: 5565851]
41. Skinner, HA.; Horn, JL. Alcohol Dependence Scale (ADS) user's guide. Toronto, Ontario: Addiction Research Foundation; 1984.
42. Cahalan, D. Problem drinkers: a national survey. San Francisco, CA: Jossey-Bass; 1970.
43. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th. Washington, DC: American Psychological Association; 2000. Text Revision
44. National Institute on Alcohol Abuse and Alcoholism. Helping patients who drink too much: a clinician's guide. Rockville, MD: National Institute on Alcohol Abuse and Alcoholism; 2005.
45. Vuchinich, RE.; Tucker, JA. The molar context of alcohol abuse. In: Green, L.; Kagel, JH., editors. Advances in behavioral economics: substance use and abuse. Vol. 3. Norwood, N. J.: Ablex Publishing Co; 1996. p. 133-162.
46. Sobell, LC.; Sobell, MB. Timeline Followback: a technique for assessing self-reported alcohol consumption. In: Litten, R.; Allen, J., editors. Measuring alcohol consumption. Totowa, NJ: Humana Press; 1992. p. 41-72.(1992)
47. Richards JB, Zhang L, Mitchell SH, de Wit H. Delay or probability discounting in a model of impulsive behavior: effect of alcohol. J Exp Anal Behav. 1999; 71:121–143. [PubMed: 10220927]
48. Kudadjie-Gyamfi E, Rachlin H. Temporal patterning in choice among delayed outcomes. Organ Behav Hum Decis Process. 1996; 65:61–67. (1996).
49. Rachlin H, Raineri A, Cross D. Subjective probability and delay. J Exp Anal Behav. 1991; 55:233–244. [PubMed: 2037827]
50. Mazur, JE. An adjusting procedure for studying delayed reinforcement. In: Mazur, JE.; Nevin, JA.; Rachlin, H., editors. Quantitative analysis of behavior (Vol. 5): the effect of delay and of intervening events on reinforcement value. Hillsdale, NJ: Lawrence Erlbaum Association; 1987. p. 55-73.(1987)
51. Myerson J, Green L, Warusawitharana M. Area under the curve as a measure of discounting. J Exp Anal Behav. 2001; 76(2):235–243. [PubMed: 11599641]
52. Amlung M, Yurasek A, McCarty KN, MacKillop J, Murphy J. Area under the curve as a novel metric of behavioral economic demand for alcohol. Exp Clin Psychopharmacol. 2015; 23(3):168–175. [PubMed: 25895013]
53. Murphy JG, Dennhardt AA, Skidmore JR, Martens MP, McDevitt-Murphy ME. Computerized versus motivational interviewing alcohol interventions: impact on discrepancy, motivation, and drinking. Psychol Addict Behav. 2010; 24(4):628–639. [PubMed: 21198224]
54. Vuchinich, RE.; Tucker, JA.; Harllee, LM. Behavioral assessment of alcohol dependence. In: Donovan, DM.; Marlatt, GA., editors. Assessment of addictive behaviors. New York: Guilford Publications; 1988. p. 51-93.
55. Zimbardo PG, Boyd JN. Putting time in perspective: A valid, reliable individual-differences metric. J Pers Soc Psychol. 1991; 77:1271–1288.
56. Maisto SA, Clifford PR, Stout RL, Davis CM. Moderate drinking in the first year after treatment as a predictor of three-year outcomes. J Stud Alcohol Drugs. 2007 May.68:419–427. Erratum in: J Stud Alcohol Drugs. 2008 Jul;69:622. [PubMed: 17446982]
57. Stein JS, Koffarnus MN, Snider SE, Quisenberry AJ, Bickel WK. Identification and management of nonsystematic purchase task data: toward best practice. Exp Clin Psychopharmacol. 2015; 23(5):377–386. [PubMed: 26147181]
58. Johnson MW, Bickel WK. An algorithm for identifying nonsystematic discounting data. Exp Clin Psychopharmacol. 2008; 16(3):264–274. [PubMed: 18540786]
59. Kiselica AM, Webber TA, Bornovalova MA. Validity of the Alcohol Purchase Task: a meta-analysis. Addiction. 2015 (Epub ahead of print).
60. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behav Res Methods. 2009; 41:1149–1160. (2009). [PubMed: 19897823]

61. Hursh SR, Silberberg A. Economic demand and essential value. Psychol Rev. 2008; 115:186–198. [PubMed: 18211190]

62. Muthén, LK.; Muthén, BO. Mplus user's guide. 7th. Los Angeles, CA: Muthén & Muthén;; 1998–2012.

63. Washio MJ, Shoptaw SJ, Bickel WK, Ling W. Using behavioral economics to predict opioid use during prescription opioid dependence treatment. Drug Alcohol Depend. 2015 Mar 1.148:62–68. Epub 2014 Dec 30. [PubMed: 25622776]

64. Vuchinich RE, Tucker JA. Contributions from behavioral theories of choice to an analysis of alcohol abuse. J Abnorm Psychol. 1988; 97:181–195. [PubMed: 3133403]

65. Murphy JG, Dennhardt AA, Skidmore JR, Bonsari B, Barnett NP, Colby SM. A randomized controlled trial of a behavioral economic supplement to brief motivational interventions for college drinking. J Consult Clin Psychol. 2012; 80:876–886. [PubMed: 22663899]

66. Moos RH. Theory-based active ingredients of effective treatments for substance abuse disorders. Drug Alcohol Depend. 2007; 88:109–121. [PubMed: 17129682]

67. Reynolds B, Ortengren A, Richards JB, de Wit HB, Ortengren A, Richards JB, de Wit H. Dimensions of impulsive behavior: Personality and behavioral measures. Pers Indiv Differ. 2006; 40:305–315. (2006).

68. Kirby KN, Petry NM, Bickel WK. Heroin addicts discount delayed rewards at higher rates than non-drug using controls. J Exp Psychol Gen. 1999; 18:78–87.

69. Koffarnus MN, Bickel WK. A 5-trial adjusting delay discounting task: Accurate discount rates in less than 60 seconds. Exp Clin Psychopharmacol. 2014; 22(3):222–228. [PubMed: 24708144]

70. Weatherly JN, Derenne A, Terrell HK. Testing the reliability of delay discounting of ten commodities using the fill-in-the-blank method. Psychol Rec. 2011:113–126.

71. Tucker JA, Vuchinich RE. Efficient and final causes of alcohol consumption. Addiction. 2015; 110:1429–1430. [PubMed: 26223172]

72. Odum, AL.; Baumann, AAL. Delay discounting: State and trait variable. In: Madden, GJ.; Bickel, WK., editors. Impulsivity: the behavioral and neurological science of discounting. Washington, DC: American Psychological Association; p. 187-210.

73. Chinn S. A simple method for converting an odds ratio to effect size for use in meta-analysis. Stad Med. 2000; 19:3127–3131.

Table 1

Sample demographic, drinking problem severity, and behavioral economic indicators

Demographic characteristics	
Gender (*n* and %)	
Male	146 (76.44)
Female	45 (23.56)
Ethnicity (*n* and %)	
White	116 (60.73)
Others	75 (39.27)
Married (*n* and %)	69 (36.32)
Employed part/fulltime (*n* and %)	72 (37.89)
Age in years (Mean and *SD*)	50.09 (11.94)
Individual income ($) (Mean and *SD*)	29,090 (34,694)
Education (in years) (Mean and *SD*)	14.11 (2.57)
Drinking problem severity (Mean and *SD*)	
Problem duration in years	17.74 (13.06)
Pre-resolution year drinking practices (TLFB)	
Days well-functioning[a]	147.78 (128.60)
Alcohol consumed per drinking day (ml ethanol)	207.22 (195.24)
Alcohol Dependence Scale (0 – 47)	20.95 (10.40)
Drinking Problems Scale (0 – 40)	17.60 (9.66)
Initial resolution status	
Resolved Abstinent (*n* and %)	152 (79.58)
Resolved Non-Abstinent (*n* and %)	39 (20.42)
Behavioral economic indicators (Mean and *SD*)	
Delay discounting (log k)[b]	− 5.71 (2.18)
Intensity of alcohol demand	6.36 (9.78)
Ratio of overall favorable to locally favorable choices	78.93 (893.23)
ASDE index[c]	0.34 (0.37)
ZTPI subscales	
Future (1 – 5)	3.69 (0.59)
Present hedonistic (1 – 5)	3.17 (0.53)
Present fatalistic (1 – 5)	2.38 (0.68)

N = 191.

Notes: Possible score ranges for scaled questionnaires are given in parentheses after the variable name. Higher Drinking Problems Scale scores indicate greater alcohol-related problems; higher Alcohol Dependence Scale scores indicate greater alcohol dependence levels. TLFB = Timeline Followback interview.

[a]Days well-functioning = abstinent days plus drinking days < 4 drinks for women and < 5 drinks for men.

[b] Delay discounting *k* parameter (log *k*) and total income were natural log transformed for analysis; participants with irrational response patterns on the DD task were excluded in calculation of log *k*.

[c] ASDE = Alcohol-Savings Discretionary Expenditure index. Values could range from 1.0 to − 1.0 (1.0 = all DE for alcoholic beverages; − 1.0 = all DE were for saving money; 0 = equal proportions of DE for alcohol and savings).

Table 2

Associations among behavioral economic and time perspective measures and drinking practices and problems during the year before initial natural resolution: Multiple regression results

Predictors	Outcomes[a]									
	Alcohol consumed per drinking day		Days well-functioning[b]		ADS[c]		DPS[d]		Initial Resolution Status	
	b (95% CI)	ES (R^2)[e]	b (95% CI)	ES (R^2)	b (95% CI)	ES (R^2)	b (95% CI)	ES (R^2)	OR (95% CI)	ES (*d*)
Log *k*	−1.27 (−18.02, 15.47)	<.001	10.15 (−0.22, 20.52)	.022	−0.63 (−1.46, 0.20)	.012	0.01 (−0.69, 0.71)	<.001	0.99 (0.79, 1.23)	−0.01
Intensity of alcohol demand	5.27** (1.84, 8.71)	.053	−2.73* (−4.86, -0.60)	.038	0.24** (0.07, 0.41)	.041	0.09 (−0.06, 0.23)	.007	1.00 (0.94, 1.06)	0
Ratio of overall to locally favorable choices	−0.10 (−0.42, 0.23)	.002	0.05 (−0.15, 0.26)	.002	−0.01 (−0.03, 0.01)	.009	−0.001 (−0.01, 0.01)	<.001	1.00 (0.99, 1.01)	0
ASDE index[f]	96.72* (5.68, 187.76)	.025	−94.08** (−150.46, -37.70)	.064	6.97** (2.46, 11.48)	.051	9.11*** (5.33, 12.90)	0.11	5.59** (1.61, 19.48)	0.95
Future Orientation	−30.48 (−96.13, 35.17)	.005	12.59 (−28.07, 53.24)	.002	−0.33 (−3.58, 2.93)	<.001	−0.15 (−2.88, 2.58)	<.001	1.17 (0.47, 2.95)	0.09
Present Hedonistic	3.24 (−63.39, 69.87)	<.001	46.09* (4.83, 87.35)	.029	−1.66 (−4.97, 1.65)	.005	0.55 (−2.22, 3.32)	<.001	0.71 (0.30, 1.72)	−0.19
Present Fatalistic	9.91 (−45.57, 65.38)	.001	−9.95 (−44.31, 24.40)	.002	2.20 (−0.55, 4.95)	.014	2.71* (0.41, 5.02)	.026	1.59 (0.74, 3.44)	0.25

[a] Regression coefficient with 95% confidence limits for the continuous outcomes (alcohol consumed per drinking day, days well-functioning, ADS, and DPS) and Odds Ratio with 95% confidence interval for the binary outcome (initial drinking status). Regression coefficients are partial regression coefficients adjusted for all demographic and the other BE and TP variables; demographic variables (age, gender, education, race/ethnicity [white vs. other], income) were included in all models but not reported in the table (refer to the text for findings);

* p < .05,

** p <.01,

*** p < .001.

[b] Days well-functioning = abstinent days plus drinking days < 4 drinks for women and < 5 drinks for men.

[c] Higher Alcohol Dependence Scale (ADS) scores (0 – 47) indicate greater alcohol dependence levels.

[d] Higher Drinking Problems Scale (DPS) scores (0 – 40) indicate greater alcohol-related problems.

[e] ES = Effect size; R^2 = squared semi-partial correlations; $d = \ln(OR)/1.82$ [73].

[f]ASDE = Alcohol-Savings Discretionary Expenditure index. Values could range from 1.0 to − 1.0 (1.0 = all DE for alcoholic beverages; − 1.0 = all DE were for saving money; 0 = equal proportions of DE for alcohol and savings).

[g]Individual income was natural log transformed for the analyses.