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Prospective Analysis of Behavioral Economic Predictors of Stable Moderation Drinking Among Problem Drinkers Attempting Natural Recovery

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Abstract

Background—As interventions have expanded beyond clinical treatment to include brief interventions for persons with less severe alcohol problems, predicting who can achieve stable moderation drinking has gained importance. Recent behavioral economic (BE) research on natural recovery has shown that active problem drinkers who allocate their monetary expenditures on alcohol and saving for the future over longer time horizons tend to have better subsequent recovery outcomes, including maintenance of stable moderation drinking. The present study compared the predictive utility of this money-based “Alcohol-Savings Discretionary Expenditure” (ASDE) index with multiple BE analogue measures of behavioral impulsivity and self-control, which have seldom been investigated together, to predict outcomes of natural recovery attempts.

Methods—Community-dwelling problem drinkers, enrolled shortly after stopping abusive drinking without treatment, were followed prospectively for up to a year ($N = 175$ [75.4% male], M age = 50.65 years). They completed baseline assessments of pre-resolution drinking practices and problems; analogue behavioral choice tasks (Delay Discounting, Melioration-Maximization, and Alcohol Purchase Tasks); and a Timeline Followback interview including expenditures on alcohol compared to voluntary savings (ASDE index) during the pre-resolution year.

Results—Multinomial logistic regression models showed that, among the BE measures, only the ASDE index predicted stable moderation drinking compared to stable abstinence or unstable resolutions involving relapse. As hypothesized, stable moderation was associated with more balanced pre-resolution allocations to drinking and savings (OR = 1.77, 95% CI = 1.02 ~ 3.08, $p < .05$), suggesting it is associated with longer term behavior regulation processes than abstinence.

Conclusions—The ASDE's unique predictive utility may rest on its comprehensive representation of contextual elements to support this patterning of behavioral allocation. Stable low risk drinking, but not abstinence, requires such regulatory processes.

Keywords

Natural recovery; behavioral economics; moderation drinking; behavioral impulsivity

An enduring question of clinical and consumer interest in the alcohol field is predicting whom among persons with established alcohol-related problems can safely resume drinking in a non-problem manner. This issue has become more important as interventions have expanded beyond abstinence-oriented treatments for alcohol dependent persons to include brief, less intensive interventions for the majority with less severe problems for whom moderation drinking is a preferred and potentially attainable goal (Miller and Munoz, 2005; Tucker et al., 2009). Stable moderation outcomes are relatively more common among untreated problem drinkers who quit on their own compared with the minority who seek treatment, in part because more serious problems motivate treatment-seeking (Klingemann and Sobell, 2007). Natural recoveries are the dominant pathway to problem resolution and offer opportunities to study how stable moderation is achieved and maintained among former problem drinkers.

Early theorizing (Marlatt, 1985) viewed successful moderation as entailing repetitive choices to drink temperately within the boundaries of the extreme restraint of continuous abstinence on the one hand and drinking abusively on the other. In contrast to this regulated behavioral patterning within a low-risk band of alcohol consumption, abstinence and relapse were considered opposite ends of the same dynamic behavioral process involving over- and under-control of drinking, respectively. In a related analysis, Miller and colleagues (1992) found that moderators who later changed to abstinence reported they did not like the feeling of “walking a tightrope.”

Early treatment research found moderation to be associated with lower problem severity, younger age, and stable life circumstances (Miller and Munoz, 2005). Our previous research on natural recovery guided by behavioral economics (BE; Rachlin et al., 1981; Bickel and Vuchinich, 2000) added support for a BE predictor with incremental utility over and beyond established predictors. Specifically, a composite measure of monetary spending on rewards available over different intervals, the Alcohol-Savings Discretionary Expenditure (ASDE) index, measured among active problem drinkers, improved prediction of outcomes of subsequent natural and treatment-assisted quit attempts over 1 to 2 years of follow-up (Tucker et al., 2002, 2006, 2008, 2009, 2012). Compared to unstable resolutions involving relapse, stable resolutions were associated with lower ASDE values indicating more balanced discretionary spending on voluntary savings and less on alcohol, which reflects the

relative value of longer-term priorities made possible by savings over short-term drinking. The relationship was particularly strong for non-abstinent resolutions involving moderation drinking among problem drinkers attempting natural recovery (Tucker et al., 2009, 2012); i.e., stable moderation was associated with lower pre-resolution ASDE values compared to stable abstinence or unstable resolutions involving relapses. Consistent with Marlatt (1985), this suggests that problem drinkers with relatively greater behavioral self-control, even when drinking abusively, were more likely to achieve stable moderation. Spending current income on alcohol while drinking heavily was universal, but those who allocated a relatively greater proportion of expenditures to voluntary savings had a better long-term prognosis.

The predictive utility of such individual differences in balancing spending for alcohol now and saving for the future is consistent with other BE research establishing that a defining feature of addictive behavior is control of current behavior by low-value, short-term outcomes with harmful delayed effects and insensitivity to higher-value, delayed outcomes (Bickel and Vuchinich, 2000; Madden and Bickel, 2010). In addition to the ASDE index based on actual spending patterns, brief BE analogue measures of behavioral impulsivity shown to predict addiction status and outcomes include discounting tasks that assess how delayed rewards lose value as a function of time to availability (MacKillop et al., 2011; Madden and Bickel, 2010); distributed choice tasks in which local and overall reinforcement contingencies are opposed (Heyman and Dunn, 2002), and demand for substances at varying prices (MacKillop et al., 2009; Murphy and MacKillop, 2006). Relatively stronger preference for immediate but less valuable rewards over delayed larger rewards and higher demand for substances are associated with greater problem severity in cross-sectional studies (e.g., Christiansen et al., 2012; MacKillop et al., 2010, 2011; cf. Kiselica et al., 2016) and with poorer outcomes of treatment (e.g., Murphy et al., 2015; Stanger et al., 2012; cf. Stevens et al., 2014) and natural recovery attempts (e.g., Tucker et al., 2006, 2009).

Despite apparent conceptual similarities among BE measures and findings, studies that examined multiple measures simultaneously are limited, and results have been mixed. For example, MacKillop et al. (2010) found that steeper delay discounting and higher intensity of demand for alcohol were both associated with more alcohol use disorder symptoms among among male and female heavy drinkers ($M = 29.1$ drinks per week over the past 3 months) who were not seeking alcohol treatment (cf. MacKillop and Murphy, 2007; Weafer et al., 2014). Other studies, however, observed discordance among measures (e.g., Dennhardt et al., 2015; MacKillop et al., 2007; cf. Stevens et al., 2014); e.g., in Dennhardt et al. (2015), discretionary spending on alcohol, but not delay discounting, predicted brief intervention outcomes at six months among heavy-drinking college students, many of whom smoked marijuana. Furthermore, although relevant longitudinal investigations are accruing (e.g., Fernie et al., 2013; Landes et al., 2012; McCarthy et al., 2016), the bulk of supportive evidence comes from cross-sectional research (MacKillop, 2016), primarily using delay discounting tasks (MacKillop et al., 2011). Thus, it remains undecided whether BE measures assess common or different dimensions of the reinforcement value of substances and whether they distinctively predict addiction status and outcomes (MacKillop & Murphy, 2007; Reynolds et al., 2006).

The present research extended this work by evaluating the predictive utility of the ASDE index (Tucker et al., 2006, 2009) over and beyond multiple BE analogue choice tasks assessed shortly after initial cessation of problem drinking to predict drinking outcomes up to one year later (i.e., continuous abstinence, stable moderation, or unstable resolution with relapse events). BE analogue tasks that provided quantitative metrics of intertemporal choice or demand for alcohol included a delay discounting hypothetical money task (Richards et al., 1999), a “melioration-maximization” distributed choice task (Heyman and Dunn, 2002), and the Alcohol Purchase Task (Murphy and MacKillop, 2006). As previously found, participants with stable non-abstinent resolutions involving moderation drinking were predicted to show greater sensitivity to delayed outcomes than those with stable abstinent resolutions or unstable resolutions, evidenced as more balanced pre-resolution discretionary spending on voluntary savings relative to spending on alcohol, as measured by the ASDE index. For the BE analogue measures, similar relationships would be manifested as lower delay discounting rates, higher ratio of overall to local favorable choices, and lower demand for drinks as a function of price. Stable moderation also was predicted to be associated with lower problem severity (e.g., alcohol-related problems, dependence levels) during the pre-resolution year.

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 (von Elm et al., 2007) for observational studies. From 2010 through 2014, problem drinkers residing in Alabama, Florida, Georgia, and Tennessee were recruited via media advertisements shortly after initial resolution and screened for eligibility by phone and then by questionnaire: (a) legal drinking age (≥ 21 years), (b) problem drinking history ≥ 2 years ($M = 17.80$ years, $SD = 13.17$), (c) no current misuse of illicit (e.g., marijuana, cocaine, heroin) or prescription (e.g., opioids, benzodiazepines) drugs, and (d) recent cessation of high-risk drinking for 3 weeks to 3 months without alcohol-focused interventions ($M = 9.99$ weeks resolved, $SD = 4.34$). Tobacco use was not exclusionary.

Of the 356 ad respondents 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 interview reports or conflicting collateral reports). Of the resulting sample of 191 assessed at enrollment, 175 were eligible for the present analyses as they provided sufficient follow-up data to establish drinking outcomes at 6 to 12 months after initial resolution. Table 1 presents the sample characteristics assessed at enrollment as a function of post-resolution drinking status. Problem histories were similar to typical outpatient treatment samples (Miller and Munoz, 2005). Although not required for inclusion, 97.9% fulfilled alcohol dependence criteria (American Psychiatric Association, 2000). Gender composition approximated the problem drinker population, and race/ethnicity composition approximated the southern U.S. region where the study was conducted; 92.4% of non-white participants were African American.

Resolution onset was defined as the most recent date that participants began abstaining (resolved abstinent [RA]) or drinking moderately (resolved non-abstinent [RNA]) for 3 weeks or more. A minimum 3-week initial resolution was required to obtain a sample that had made a serious quit attempt but was early in recovery when outcomes are unstable, thereby facilitating a final distribution at one year with the variation of outcomes (RA, RNA, UR) needed to evaluate the hypotheses. At enrollment, 78.3% of participants were RA, and 21.7% were RNA. At all assessments, RNA status was defined as any post-resolution drinking below risky drinking thresholds with no heavier drinking (< 4 standard drinks/day for men, < 3 drinks/day for women; National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2005), no symptoms on the Alcohol Dependence Scale (ADS; Skinner and Horn, 1984), and no negative consequences on the Drinking Problems Scale (DPS; Cahalan, 1970). Those who abstained or drank below risky drinking thresholds without problems throughout the entire follow-up period were considered to have maintained stable resolutions, either RA or RNA.

Measures and Procedures

Overview—The data collection schedule included 1.5 to 3.0 hour in-person assessments at enrollment and 12 months later and brief phone interviews at 3, 6, and 9 months. The in-person assessments included structured interviews, interactive voice response (IVR) telephone surveys, computer-administered tasks, and questionnaires and provided the primary data for the present analyses. The phone interviews maintained contact with participants and assessed their current drinking status. In-person assessments were held in locations convenient for participants, and participant sobriety was verified by breathalyzer (Lifeloc FC20, Wheat Ridge, CO). Informed consent included a request to interview a collateral informant (e.g., spouse, other family members) by phone to verify participant reports of eligibility criteria and post-resolution drinking (completed for 82.3% of participants). An expanded Timeline Followback (TLFB) interview (Sobell and Sobell, 1992; Vuchinich et al., 1988) at enrollment and 12 months later assessed drinking practices, income, and expenditures covering the pre- and post-resolution years, respectively. Choice tasks were then administered by laptop computer or via IVR using a cell phone. After each in-person assessment, participants received \$75 university-issued VISA gift cards or checks and any money earned on the distributed choice task. They received a \$50 bonus for completing all study procedures after the follow-up interview. Procedures that yielded study predictor and dependent variables are described next in order of administration.

Drinking practices and spending on alcohol—The first TLFB assessment covered the year before resolution onset up to the initial interview; the second assessment covered the interval since resolution onset up to the 1-year follow-up interview. Following Sobell and Sobell (1992), memorable anchor events recorded on calendars served as recall aids, and participants reported daily drinking as ounces of beer, wine, and liquor intake and daily spending on alcoholic beverages in dollars regardless of whether the beverages were consumed (Vuchinich et al., 1988). Reports of daily drinking were converted to milliliters of 190-proof ethanol for analysis. TLFB reports of the number of pre-resolution days involving abstinence or drinking below binge drinking thresholds (< 5 drinks for men [80 ml ethanol], < 4 drinks for women [64 ml ethanol]; NIAAA, 2015) were calculated for analysis to reflect

“days well functioning” (Maisto et al., 2007). The TLFB interview yields reliable and accurate drinking reports over the timeframes assessed in this study (Robinson et al., 2014; Tucker et al., 2007, 2010).

Behavioral Economic Predictors

Alcohol-Savings Discretionary Expenditure (ASDE) index: The relative amount of resources (money in this case) allocated to gain access to a given activity reflects its value in relation to other available activities and commodities (Rachlin et al., 1981). Strength of preference for alcohol was assessed comprehensively using an expanded TLFB format covering monetary allocation patterns during the year prior to resolution onset (Vuchinich et al., 1988). Using the same TLFB interview techniques employed to collect reports of drinking practices and spending on alcohol, participants reported in dollars income received by source (e.g., weekly paychecks, monthly pension payments) and expenditures in different commodity classes (e.g., monthly mortgage/rent and utility costs, intermittent payments for entertainment, voluntary savings etc.) for each day that an economic exchange occurred. These time-stamped reports in each category typically involved many transactions during pre-resolution year, which were summed to obtain category totals for analysis. TLFB reports of money spent on alcohol and other commodities have been empirically verified through comparisons with available financial records (Vuchinich et al., 1988; Tucker et al., 2002, 2006, 2007).

To compute the Alcohol-Savings Discretionary Expenditure (ASDE) index, expenditures were separated into obligatory and discretionary categories. Obligatory expenditures were for essential, ongoing, and largely fixed costs (e.g., housing, food, automatic payroll deductions). Discretionary expenditures (DE) were for less essential commodities typically purchased intermittently (entertainment, recreation, alcohol, tobacco, other consumable goods, gifts, money saved voluntarily) and where shifts in strength of preference for alcohol should be more readily seen. 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.

Delay discounting (DD) task: The hypothetical money DD task (Richards et al., 1999) used an adjusting amount procedure and involved repeated choices between smaller amounts of money available immediately (lowest possible amount = \$1) and a larger amount (i.e., \$1000) available at a series of 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; each point was ascertained by adjusting the smaller, immediately available amounts based on the participant's responses until the lowest amount chosen over \$1000 available after a delay was identified. A k -parameter derived from these points reflected the slope of the hyperbolic discount function characteristic of reward devaluation over time (Mazur, 1987). Higher k -parameters indicate more immediate reward preferences. Because k -parameters are skewed, they were log-transformed for analysis.

Alcohol Purchase Task (APT): Participants reported how many drinks in standard sizes they would consume across 18 prices (\$0 to \$20) in an imaginary drinking setting (Murphy

and MacKillop, 2006), which yields multiple indices reflecting sensitivity to price changes (MacKillop et al., 2009) that correspond closely with actual alcohol use. Using an IVR platform, participants pressed phone keypad numbers to indicate the number of drinks (including zero) at each price. Their choices yielded four observed alcohol demand measures (MacKillop et al., 2009), 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 a derived measure of elasticity of demand reflecting sensitivity to price changes. Intensity (consumption at \$0) was chosen for analysis because, of the APT metrics, it has demonstrated incremental utility to predict alcohol use disorder symptoms beyond drinking practices (Kiselica et al., 2015) and can be computed for all participants, including those who refused drinks at all prices and for whom elasticity coefficients could not be computed.

Melioration-maximization (MM) task: A computerized distributed choice task involved real money (Heyman and Dunn, 2002) and measured the extent to which participants' choices were sensitive to overall reinforcement rates from both response options (maximization) or to local reinforcement rates from each individual response option (melioration) (see Herrnstein et al., 1993; Heyman and Dunn, 2002, for details of the theoretical rationale and procedures). A pattern of choices that maximizes higher overall reinforcement rate is indicative of greater self-control and is inversely related to substance use status (e.g., Heyman and Dunn, 2002). The task included eight sessions, each with multiple two-option choice trials in which local and overall reinforcement rates were opposed. The important difference between the two options was the length of the inter-trial interval (ITI) that followed choosing each option. As overall ITIs lengthened, opportunities to earn money were lost. Option B choices always produced an ITI 3 seconds shorter than Option A choices. However, the ITI duration was proportional to the number of B choices over the previous 10 trials. Thus, B choices produced a shorter ITI to the next trial but longer overall ITIs, and A choices produced a longer ITI to the next trial but shorter overall ITIs. Hence, Option B choices produced a higher local reinforcement rate, while Option A choices produced a higher overall reinforcement rate. Participants' choices were quantified for analysis as the ratio of overall favorable choices to locally favorable choices; higher values indicated greater sensitivity to overall reinforcement than immediate local reinforcement. Participants received any money earned at the end of the session ($M = \$8.83$, $SD = 1.13$).

Pre-resolution Problem Severity and Demographic Covariates—Problem severity indicators included the 25-item ADS that yields scores from 0 to 47, indicating mild to severe alcohol dependence, and the 40-item DPS that assesses alcohol-related problems in eight areas of functioning (e.g., relationships, finances, legal status), with higher scores (0-40) indicating greater problems. Questionnaires completed before the initial interview assessed demographic characteristics used as covariates in the analyses (age, gender, education, income, race [white vs. non-white, primarily African American] and marital status [married or not]). Other substance-related covariates included current use of tobacco products (yes or no) and TLFB reports of pre-resolution days well functioning.

Post-resolution Drinking Status Outcomes—Following prior relapse and recovery literature (e.g., Hunt et al, 1971; Marlatt, 1985; Tucker et al., 2012), terminal outcomes were based on the entire follow-up interval, and a minimum 6-month follow-up was required because relapse rates decelerate rapidly and outcomes begin to stabilize after the first 3 months of recovery. Of the 175 participants with sufficient data to establish outcomes at 6 to 12 months, 33 (18.9%) could not be reached at 12 months, so their outcome status was based on the last available phone follow-up assessment at either 6 ($n = 15$; 8.6%) or 9 ($n = 18$; 10.4%) months. As previously found (e.g., Tucker et al., 2006, 2012), attrition did not differ across terminal drinking status groups, and, with the exception of age, there were no significant differences in demographic characteristics, drinking history, and tobacco use between participants with and without follow-up data at 6 (175 participants present vs. 16 missing) or 12 (142 present vs. 33 missing) months. Participants with missing assessments were older ($p < .05$), so age was included as a covariate in the analyses. Of the 175 participants, 58.9% were RA ($n = 103$), 13.6% were RNA ($n = 24$), and 27.4% were UR ($n = 48$). RNA participants were within NIAAA (2005) gender-adjusted guidelines for low-risk drinking (men: $M = 34.6$ ml of 190-proof ethanol per post-resolution drinking day, $SD = 37.6$; women: $M = 37.7$ ml, $SD = 12.1$). UR participants were above thresholds for high-risk drinking (men: $M = 87.8$ ml, $SD = 75.9$; women: $M = 78.6$ ml, $SD = 72.9$). Most UR participants relapsed before the end of the first 6 months (79.2%), but 35.4% of them had resumed abstinence or moderation by the end of the 1-year follow-up, a pattern characteristic of unstable natural resolutions (Tucker et al., 2006).

Data Analyses

Multinomial logistic regression analyses were conducted using SAS 9.4 to examine the utility of BE variables in predicting drinking status group membership (RA, UR, and RNA) in relation to demographic and problem severity predictors. Given the study focus on identifying predictors of low risk drinking outcomes, the RNA group was used as the referent to be compared to the RA or UR groups. To handle the limited participants with RNA outcomes, separate models were estimated with select variables according to the hypotheses. First, we examined whether the ASDE index differentiated post-resolution drinking status over and beyond drinking practices during the same 1-year pre-resolution period (i.e., days well functioning) to verify previously observed relationships. Then, two more complex models were estimated separately using two different sets of additional predictor variables. Model 1 included the ASDE index and other BE measures simultaneously to evaluate the predictive utility of the ASDE index over and beyond analogue choice measures. Model 2 examined the predictive utility of the ASDE index, controlling for multiple problem severity predictors (ADS, DPS, days well functioning) of resolution outcomes found in earlier studies. In addition to the predictors of interest in Models 1 and 2, age, gender, education, income, race, marital status, and current tobacco use were initially included as covariates, and non-significant ones were excluded from the models; only age and pre-resolution year days well functioning remained in the final models. All continuous predictors were standardized prior to analysis to have a mean of 0 and a standard deviation (SD) of 1, so the scale unit of each predictor was its own SD.

Sample sizes were 155, 167, or 169 depending on the model. The missing data sources were: (1) Six participants had unreasonable response patterns on the DD task (i.e., final $k > 2$ or equivalence point for Day 365 > Day 1 delay) or never chose a locally favorable option throughout the MM task, which precluded computation of a choice ratio; and/or (2) participants had missing values on various predictors included in the different models. In addition to the main analyses, we conducted exploratory analyses with APT elasticity, replacing intensity, using the reduced sample ($n = 101$) for whom elasticity could be computed; i.e., elasticity could not be calculated for 38 participants (21.7%) who refused purchasing drinks at all prices and 36 (20.6%) who had missing or inconsistent APT response patterns (e.g., multiple instances of increasing consumption with increasing price). Individual elasticity coefficients were estimated by alpha parameter from Hursh and Silberberg's (2008) exponential demand model using Graphpad Prism 6 (Graphpad Software, San Diego, CA, www.graphpad.com).

Results

Predictors of Resolution Outcomes

Our prior findings were replicated when examining the utility of the ASDE index to discriminate the three drinking status outcome groups over and beyond pre-resolution year daily drinking practices. The ASDE index significantly differentiated both the RA vs. RNA outcome groups (OR = 2.08, 95% CI = 1.28 ~ 3.38, $p < .01$) and the UR vs. RNA outcome groups (OR = 1.77, 95% CI = 1.03 ~ 3.03, $p < .05$). As predicted, the RNA group had relatively lower ASDE values indicating more balanced monetary allocations to alcohol and savings, even when drinking abusively, compared to the other two groups (see Table 1). Both contrasts also were significant for gender-adjusted days well functioning (RA vs. RNA: OR = 1.94, 95% CI = 1.11 ~ 3.38, $p < .05$; UR vs. RNA: OR = 2.53, 95% CI = 1.39 ~ 4.59, $p < .01$). However, the direction of group differences was opposite that found previously, with the RNA group showing fewer days well functioning compared to each of the other two groups.

The next set of analyses involved more complex models that evaluated whether the ASDE index had incremental predictive utility over and beyond the analogue BE measures and drinking problem indicators (ADS, DPS). As shown in Model 1 in Table 2, of the four BE variables, only the ASDE index was a significant predictor differentiating stable resolutions that involved moderation (RNA) or abstinence (RA). The pre-resolution ASDE index did not, however, differentiate the RNA and UR groups significantly when other BE variables and age were included in the model. Other BE variables showed no significant associations. Furthermore, BE measures were not correlated with one another ($r_s = - .01$ to $.13$) and did not share significant common variance (Tucker et al., in press).

In Model 1, pre-resolution days well-functioning and age also differentiated RNA outcomes. RNA participants reported fewer pre-resolution days well-functioning compared to RA or UR participants and were older than RA participants.

The results from Model 2 (Table 2) were essentially identical to Model 1. The ASDE index significantly differentiated RNA and RA outcomes. Pre-resolution year days well

functioning and age also differentiated RNA outcomes from RA or UR outcomes. The directions of the parameter estimates were the same as in Model 1.

Finally, in an exploratory analysis with a reduced sample of participants with valid elasticity estimates, in which elasticity replaced intensity in Model 1, there was no significant association between elasticity and drinking outcomes. Results remained unchanged for the ASDE index and age as found in Model 1, but the unexpected result for days well functioning became non-significant.

Discussion

There have been few advances in knowledge about predictors of moderation since early treatment studies established associations between moderation and lower problem severity, younger age, and stable life circumstances (Miller & Munoz, 2005). To these predictors, the present study added a BE measure of strength of preference for drinking based on proportionate alcohol-related monetary allocation aggregated over the pre-resolution year. Consistent with our previous research (Tucker et al., 2009, 2012), non-abstinent resolutions were associated with more balanced pre-resolution allocations to drinking and savings, suggesting that stable moderation is associated with longer term behavior regulation processes than abstinence. Problem drinkers who organize their behavioral allocation over relatively longer intervals, even while drinking heavily, thus appear better able to transition to stable moderation compared to those with shorter allocation time horizons.

Despite apparent conceptual similarities among the multiple BE measures, only the ASDE index predicted stable resolutions involving moderation versus abstinence or unstable resolutions, and the BE measures were not correlated with one another (Tucker et al., in press). Although the BE analogue measures distinguished active substance misusers from other groups in earlier cross-sectional studies and predicted aggregate treatment outcomes for substance use disorders (MacKillop, 2016; MacKillop et al., 2011), they did not improve on established predictors of stable moderation among recovering problem drinkers. In our own cross-sectional research with the present sample (Tucker et al., in press), both the ASDE index and APT intensity showed significant associations with initial natural resolution status in the predicted direction, but only the ASDE remained significant as an outcome predictor in the present longitudinal design. This discrepancy between cross-sectional and longitudinal findings is similar to Murphy et al. (2015), who found that both demand intensity and discretionary alcohol expenditures predicted early outcomes of a brief alcohol intervention, but only discretionary spending predicted outcomes at six months. These studies highlight the importance of verifying cross-sectional associations in longitudinal research (MacKillop, 2016).

The ASDE's unique utility to distinguish non-abstinent resolutions from other outcomes may be due to its comprehensive representation of contextual elements to support this behavioral patterning. Other BE measures are more limited in scope. For example, both the ASDE and the APT assess demand for alcohol; however, the APT is limited to assessing alcohol demand as a function of drink price changes in a single hypothetical drinking episode, whereas the ASDE index assesses alcohol demand based on real spending patterns over long

intervals. Perhaps most importantly, the ASDE index represents the relative value of drinking in the context of other activities available now and in the future in the environments in which drinking problems develop and change. It is a ratio reflecting how total discretionary spending in multiple categories, the pool within which current preferences should be readily expressed, is allocated to alcohol vs. savings, which captures a temporal dimension of choice that is conceptually akin to discounting. It is not a measure of absolute dollars spent on alcoholic beverages, nor does it depend directly on income (Tucker et al., 2006, 2009).

These contextual dimensions unique to the ASDE are important because experimental work with humans and animals has robustly demonstrated that preference for a given activity (e.g., drinking) depends on the other options available in the choice context and on the constraints on access to them (e.g., price, time, effort to obtain; Rachlin et al., 1981). Substance use can be reduced by increasing direct constraints on substances or by enriching the environment with valuable substance-free alternatives, such as positive social, educational, and vocational opportunities (Murphy et al., 2012; Moos, 2007). The ASDE index provides a representation of contextual elements that influence behavioral patterning that involves many choices over time (Rachlin et al., 1981), as required for stable moderation that entails day-to-day regulation of a previous addictive behavior within tight limits (Marlatt, 1985). Abstinence requires no such daily regulatory process.

The money-based ASDE index thus may aid identification of problem drinkers who are relatively better candidates for a moderation drinking goal. Other recent intervention studies (Murphy et al., 2015; Worley et al., 2015) have similarly found that spending on substances contributed to the prediction of substance-related outcomes; e.g., Murphy and colleagues (2015) found that lower discretionary spending on alcohol predicted reduced drinking and alcohol problems six months after a brief motivational intervention among college drinkers. Together with the present study, these findings support the utility of adding assessment of real spending on substances to established assessment procedures to predict outcomes of natural and treatment-assisted resolution attempts.

Although the main ASDE findings replicated our earlier research, other results were inconsistent. First, as previously found (e.g., Tucker et al., 2009), the ASDE index significantly discriminated the RNA group from both the RA and UR groups in the simpler model with days well functioning, but the contrast between the RNA and UR groups became nonsignificant in the more complex models. In this study, the ASDE index was a more robust predictor of the type of resolution (abstinence or moderation) among problem drinkers who succeeded with their recovery than it was in predicting who, among those who resumed drinking, remained within low-risk drinking guidelines or exceeded them. The attenuation of the RNA-UR contrast involving smaller groups may be due to reduced power in the more complex model with multiple BE predictors. The number of participants in the RNA group was relatively small, which is a general study limitation that also qualifies the non-significant results for the choice analogue tasks, including the subsample elasticity analysis. Replication with larger samples is warranted.

Second, compared to prior studies, the present RNA group had some atypical characteristics. Whereas RNA groups in earlier studies (Tucker et al., 2006, 2009) tended to be relatively younger (mean age < 50 years), with less severe drinking practices and problems than RA and UR groups, the present RNA group was significantly older (M age = 59.13 years) and had fewer pre-resolution days well functioning than the RA and UR groups. We apparently sampled an older cohort of successful low risk drinkers who had been drinking heavily prior to resolution. It cannot be determined whether this was due to chance and repeated sampling over multiple studies by the research team or reflects a different pattern of stable low risk drinking among older adults. Other evidence suggests that older age alone is not a contradiction for moderation drinking in the absence of health or other problems requiring abstinence (Ferreira and Weems, 2008).

In summary, the ASDE index contributed unique information in an account of resolution outcomes that was useful for identifying problem drinkers with a higher probability of achieving stable moderation. The multiple replications of the utility of the ASDE index to predict stable moderation (Tucker et al., 2002, 2006, 2008, 2009, 2012), coupled with similar money-based findings from other research groups (Murphy et al., 2015; Worley et al., 2015), support adding assessment of spending on substances to established substance-related assessment procedures. However, the discordance observed here among the BE measures adds to evidence that the reinforcement value of substances is a multi-dimensional construct in need of further explication.

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Table 1
Sample characteristics at initial assessment as a function of post-resolution drinking status

Variable	Total Sample (N = 175)		Resolved abstinent (n = 103)		Unstable resolution (n = 48)		Resolved nonabstinent (n = 23)		Test statistic
	M	(SD)	M	(SD)	M	(SD)	M	(SD)	
Demographic characteristics									
Gender (n and %)	Male	132 (75.4%)	77 (74.76%)		38 (70.8%)		21 (87.5%)		$\chi^2(2) = 2.46$
	Female	43 (24.6%)	26 (25.24%)		14 (29.2%)		3 (12.5%)		
Race/Ethnicity (n and %)	White	104 (59.4%)	63 (61.2%)		24 (50.0%)		17 (70.8%)		$\chi^2(2) = 3.19$
	Non-white	71 (40.6%)	40 (38.8%)		24 (50.0%)		7 (29.2%)		
Marital status (n and %)	Married	65 (37.4%)	41 (40.2%)		14 (29.2%)		10 (41.7%)		$\chi^2(2) = 1.92$
	Unmarried	109 (62.6%)	61 (59.8%)		34 (70.8%)		14 (58.3%)		
Tobacco use (n and %)	Current use	78 (46.7%)	46 (46.9%)		26 (55.3%)		6 (27.3%)		$\chi^2(2) = 4.74$
	Not using	89 (53.3%)	52 (53.1%)		21 (44.7%)		16 (72.7%)		
Age (years)		50.65 (11.82)	49.42 (11.64) ^a		49.04 (11.05) ^a		59.13 (10.92) ^b		$F(2, 172) = 7.73^{***}$
Years of education		14.14 (2.62)	13.71 (2.55)		14.66 (2.95)		14.91 (1.83)		$F(2, 169) = 3.35^*$
Annual income (\$)		52,326 (52,093)	49,313 (51,326)		50,485 (55,350)		68,938 (47,444)		$F(2, 172) = 1.43$
Drinking problem history									
Problem duration (years)		17.80 (13.17)	17.77 (12.94)		17.27 (12.19)		18.98 (16.23)		$F(2, 171) = 0.13$
Alcohol Dependence Scale (ADS)		20.50 (10.32)	22.37 (10.79)		18.27 (9.25)		17.08 (8.84)		$F(2, 170) = 4.24^*$
Drinking Problems Scale (DPS)		17.33 (9.64)	18.62 (9.50)		16.42 (9.79)		13.58 (9.07)		$F(2, 172) = 3.02$
Pre-resolution year drinking practices (TLFB)									
Days well functioning		147.41 (129.34)	143.47 (129.23) ^{ac}		184.88 (120.63) ^a		89.42 (127.51) ^{bc}		$F(2, 172) = 4.66^*$
Drinking quantity/drinking day (ml ethanol)		205.91 (201.17)	247.06 (243.48) ^{ac}		145.44 (97.05) ^b		150.29 (74.67) ^{bc}		$F(2, 172) = 5.51^{**}$
Behavioral economic variables									
Log k parameter (DD) ^d		-5.74 (2.21)	-5.72 (2.21)		-5.61 (2.29)		-6.19 (2.10)		$F(2, 156) = 0.48$
Demand intensity (APT)		6.10 (9.70)	6.39 (11.87)		6.34 (6.06)		4.38 (2.37)		$F(2, 171) = .044$
Ratio of overall to local favorable choices (MM) ^e		13.31 (95.71)	15.42 (119.55)		11.69 (44.09)		6.24 (17.41)		$F(2, 163) = 0.08$
Alcohol-Savings Discretionary Expenditure Index (ASDE)		0.17 (0.23)	0.20 (0.24) ^a		0.15 (0.21) ^{ab}		0.08 (0.20) ^b		$F(2, 172) = 3.33^*$

Notes: N = 175. Means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Higher ADS (0 – 47) and DPS (0 – 40) scores indicate greater alcohol dependence and alcohol-related consequences, respectively.

^d Participants with irrational response patterns on DD task were excluded in the calculation of mean log k.

^e Calculation of mean choice ratio excluded one participant for whom a ratio could not be computed because a locally favorable option was never chosen.

* p < .05;
** p < .01;
*** p < .001;

Significance tests were carried out using one-way ANOVA or chi-square analyses comparing the three drinking status outcome groups. Means with different superscripts were significantly different in pairwise comparisons using Tukey's Honestly Significant Difference test or multinomial bivariate logistic regression. The ASDE index is computed as a difference of proportions: ASDE = [(\$ spent on alcoholic beverages/total discretionary expenditures) – (\$ saved/total discretionary expenditures)]. Values could range from -1 to 1 (-1 = all discretionary expenditures [DE] were used for saving money and 1 = all DE were for alcoholic beverages; 0 = equal proportions of DE for alcohol and savings). Days well functioning = abstinent days plus drinking days below binge drinking thresholds (< 4 drinks for women, < 5 drinks for men) during the pre-resolution year; APT = Alcohol Purchase Task; DD = delay discounting task; MM = melioration/maximization task; TLPB = Timeline Followback interview.

Table 2
Multinomial logistic regression results to predict post-resolution drinking status

Predictors	Resolved abstinent vs. Resolved nonabstinent		Unstable resolution vs. Resolved nonabstinent	
	B (SE)	OR (95% CI)	B (SE)	OR (95% CI)
Model 1 with ASDE index and other BE variables (<i>N</i> = 155)				
Log k DD parameter ^a	-0.01 (0.30)	0.99 (0.55, 1.79)	0.03 (0.32)	1.03 (0.55, 1.94)
Demand intensity (APT)	0.37 (0.57)	1.44 (0.48, 4.40)	0.44 (0.58)	1.56 (0.50, 4.84)
Ratio of overall to local favorable choices (MM)	0.09 (0.43)	1.09 (0.47, 2.55)	0.05 (0.45)	1.05 (0.43, 2.55)
Alcohol-Savings Discretionary Expenditure Index (ASDE)	0.57 (0.28) *	1.77 (1.02, 3.08)	0.41 (0.31)	1.50 (0.82, 2.76)
Pre-resolution year days well functioning	0.72 (0.34) *	2.05 (1.05, 3.98)	1.01 (0.36) **	2.75 (1.35, 5.60)
Age	-0.69 (0.33) *	0.50 (0.26, 0.95)	-0.66 (0.35)	0.52 (0.26, 1.03)
Model 2 with ASDE index and other established predictors (<i>N</i> =167)				
Alcohol-Savings Discretionary Expenditure Index (ASDE)	0.58 (0.28) *	1.78 (1.02, 3.08)	0.43 (0.31)	1.55 (0.84, 2.83)
ADS	0.03 (0.04)	1.03 (0.96, 1.11)	-0.01 (0.04)	0.99 (0.91, 1.07)
DPS	-0.02 (0.04)	0.99 (0.91, 1.06)	0.001 (0.04)	1.00 (0.92, 1.09)
Pre-resolution year days well functioning	0.62 (0.29) *	1.87 (1.06, 3.29)	0.81 (0.31) **	2.25 (1.23, 4.13)
Age	-0.76 (0.32) *	0.47 (0.25, 0.87)	-0.90 (0.34) **	0.41 (0.21, 0.79)

Note. Resolved nonabstinent group is the referent group.

* $p < .05$,

** $p < .01$.

ASDE = Alcohol-Savings Discretionary Expenditure index; OR = odds ratio; CI = confidence interval; Days well functioning = abstinent plus drinking days below binge drinking thresholds during the pre-resolution year (adjusted for gender). Continuous predictors were standardized. Participants ($n = 6$) who had unreasonable DD response patterns or never chose a locally favorable option throughout entire MM task sessions were excluded in the analyses.