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A Behavioral Economic Reward Index Predicts Drinking Resolutions: Moderation Revisited and Compared With Other Outcomes

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Data were pooled from 3 studies of recently resolved community-dwelling problem drinkers to determine whether a behavioral economic index of the value of rewards available over different time horizons distinguished among moderation ($n = 30$), abstinent ($n = 95$), and unresolved ($n = 77$) outcomes. Moderation over 1- to 2-year prospective follow-up intervals was hypothesized to involve longer term behavior regulation processes than abstinence or relapse and to be predicted by more balanced preresolution monetary allocations between short-term and longer term objectives (i.e., drinking and saving for the future). Standardized odds ratios (ORs) based on changes in standard deviation units from a multinomial logistic regression indicated that increases on this "Alcohol-Savings Discretionary Expenditure" index predicted higher rates of abstinence (OR = 1.93, $p = .004$) and relapse (OR = 2.89, $p < .0001$) compared with moderation outcomes. The index had incremental utility in predicting moderation in complex models that included other established predictors. The study adds to evidence supporting a behavioral economic analysis of drinking resolutions and shows that a systematic analysis of preresolution spending patterns aids in predicting moderation.

Keywords: problem drinking, natural resolution, moderation, behavioral economics

Behavioral economic models of choice behavior have been widely applied to an analysis of substance misuse and other addictive behaviors in humans (e.g., Bickel & Marsch, 2001; Green & Kagel, 1996; Vuchinich & Tucker, 1996, 1998). Behavioral economics involves a merger of operant approaches to understanding choice behavior, particularly impulsive choice (Ainslie, 1975), with microeconomic models of consumer behavior (Rachlin, Battalio, Kagel, & Green, 1981). Both focus on how individuals allocate limited resources such as time, money, and behavior to obtain commodities available at different costs and over different delays, and strength of preference for a given commodity (e.g., drug use) is inferred from the relative resources or behavior allocated to obtain it (Premack, 1965; Rachlin, 1971). For example, the well-established *matching law* quantifies how humans and animals alike distribute or "match" relative response rates in proportion to the relative rates of reinforcement available from different activities (Herrnstein, 1970).

This approach is well suited to studying demand for drugs in relation to other commodities available in the natural environment (Vuchinich & Tucker, 1996, 1998). Behavioral economic models view substance misuse as a persistent preference for short-term rewards and a devaluation of larger, delayed rewards that support adaptive functioning. Research has consistently shown that preference for substance use decreases as constraints on access to the substance increase and as constraints on access to valued nondrug-related alternatives decrease (Vuchinich & Tucker, 1998). Moreover, persons with addictive behavior problems tend to devalue, or *discount*, delayed rewards more than normal controls (Bickel & Marsch, 2001). Control of their current behavior is less sensitive to delayed consequences, such as the adverse long-term effects of substance use.

As applied to attempts to resolve alcohol problems, these findings suggest that problem drinkers with greater sensitivity to longer term contingencies, even when drinking heavily, should have a better prognosis and that shifting control of behavior from shorter to longer term contingencies should promote resolution stability. Our earlier prospective studies of resolution attempts by community-dwelling treated and untreated problem drinkers supported this hypothesis (Tucker, Foushee, & Black, 2008; Tucker, Vuchinich, Black, & Rippens, 2006; Tucker, Vuchinich, & Rippens, 2002). Shortly after initiation of abstinence or problem-free moderation drinking, participants reported their monetary expen-

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ditures on alcoholic beverages and other commodities during the year before resolution onset using an expanded Timeline Followback (TLFB) interview (Sobell & Sobell, 1992). Establishing relative preference for alcohol through allocation of monetary resources is based on experimental work showing that the relative values of different, concurrently available commodities can be quantified by measuring choice among the commodities under varying constraints (Herrnstein, 1970; Premack, 1965). Many different activities are available in the natural environment, and monetary allocation offers a common metric to assess their relative reinforcement value (Vuchinich, Tucker, & Harllee, 1988).

Our main research focus was on studying successful natural recoveries achieved without treatment. Natural recovery samples typically include middle-income to upper income individuals (Sobell, Sobell, & Toneatto, 1992) who have complex, fixed, and recurring expenditures (e.g., mortgages, automatic payroll deductions) as well as considerable discretionary expenditures (e.g., for recreation, alcohol, voluntary savings). Because their preferences should be more readily expressed within discretionary, as opposed to fixed, spending patterns, the proportion of discretionary spending on alcoholic beverages was compared with money put into savings for future use, which was conceptualized as representing the value of rewards available over shorter and longer time horizons, respectively. Greater relative allocation to savings than to drinking, reflected in lower values on this Alcohol-Savings Discretionary Expenditure (ASDE) index, was viewed as indicating higher relative preferences for delayed rewards made possible by savings compared with more immediate rewards from drinking.

As hypothesized, problem drinkers who maintained stable resolutions had lower preresolution ASDE values than those who had unstable resolutions and relapsed at any point during the 1- to 2-year follow-ups (Tucker et al., 2002, 2006, 2008). The ASDE index had unique incremental utility in predicting stable versus unstable resolutions after controlling for established outcome predictors (e.g., problem severity, drinking practices), and it had predictive utility across intervention-naive and intervention-exposed resolution groups (Tucker et al., 2006). In addition to predicting long-term resolution stability, the ASDE index predicted drinking patterns during the early months of the postresolution period in a study that implemented Interactive Voice Response (IVR) self-monitoring with recently resolved, untreated problem drinkers (Tucker et al., 2008).

This research showed that contextually sensitive measures of the reward value of drinking in relation to other activities added unique information in an account of resolution outcomes. However, in these studies many more participants achieved stable abstinent than nonabstinent resolutions, so predictors of moderation apart from abstinence could not be investigated in the studies individually. A more extensive analysis with a larger sample that includes more participants who drank in a sustained nonproblem manner is needed to examine specific predictors of moderation. This issue has gained renewed importance as interventions continue to expand beyond abstinence-oriented treatments for alcohol-dependent persons, to include population-based public health interventions for the untreated majority with less severe problems for whom moderation is a more common and acceptable outcome (Tucker, 2003). Moderation outcomes are more common among untreated problem drinkers who quit on their own compared with the minority who seek treatment, partly because treatment seekers have more serious problems. Although early treatment research found moderation to be associated with lower problem severity, younger age, and stable life circumstances (reviewed by Miller & Munoz, 2005; Rosenberg, 2004), there have been few recent advances, with the exception that higher self-efficacy to resist drinking in high risk situations has been associated with moderation outcomes (Saladin & Santa Ana, 2004).

To obtain a sufficient sample to investigate stable moderation apart from other outcomes, we pooled the data from our three prior studies and conducted new analyses to evaluate the utility of the ASDE index in distinguishing stable nonabstinent resolutions from stable abstinent resolutions and unstable resolutions that involved problem drinking at some point over the 1- to 2-year follow-ups. Our interest in examining this issue in a re-analysis comes from early theorizing about the processes involved in moderation (Marlatt, 1985) and from preliminary findings in our IVR study (Tucker et al., 2008) that supported the theorizing. Over two decades ago, Marlatt (1985, pp. 329–344) raised the interesting but still unstudied hypothesis that abstinence and relapse are opposite ends of the same dynamic behavioral regulation process, reflecting over- and undercontrol of the daily act of drinking, respectively. Moderation was thought to involve a different regulation process that depends on "lifestyle balance" and repetitive choices to drink well within the boundaries of extreme restraint or loss-of-control drinking. To the extent that the ASDE index is a functional measure of preference for alcohol in relation to delayed rewards made possible by savings, one would expect successful moderate drinkers to organize their behavioral allocation (tracked via financial expenditures) over longer intervals compared with those who relapse or abstain. Framing Marlatt's (1985) "differential regulation" hypothesis within behavioral economic theory, lower ASDE values, reflecting more balanced monetary allocations between short-term and longer term objectives (i.e., drinking and saving for the future), should predict moderation compared with other outcomes.

The pooled data set included 30 drinkers with moderation outcomes, which was sufficient to evaluate the hypothesis that stable resolutions involving some moderation drinking over 1 to 2 years would be predicted by lower preresolution ASDE values compared with other outcomes. After this primary behavioral economic hypothesis was evaluated, established moderation predictors assessed at baseline, including problem severity, alcohol dependence, and self-efficacy, were included with the ASDE index in multinomial logistic regression models to determine if the index had unique incremental predictive utility in distinguishing outcomes among participants who resumed drinking (relapse or moderation) and among those who remained resolved (abstinence or moderation). A series of multivariable models were used to subject the ASDE index to a rigorous systematic evaluation after controlling for multiple covariates and to maintain favorable events-to-predictor ratios in each model (Peduzzi, Concato, Kemper, Holford, & Feinstein, 1996) within the limits set by the number of moderation cases in the pooled data set. We hypothesized that the ASDE index would provide significant incremental predictive utility over predictors suggested by prior research and would be particularly sensitive for distinguishing moderated and relapsed outcomes—that is, the differential regulation processes theorized by Marlatt (1985) and assessed by our behavioral economic index should be most apparent among participants who engaged in some postresolution drinking.

Method

Sample Selection and Characteristics

Participants were recruited from the community via media advertisements in metropolitan areas in Alabama, Florida, Georgia, Mississippi, and Tennessee. The advertisements asked for research volunteers who had recently overcome a drinking problem with or without treatment. Respondents to the advertisements called a toll-free number, received a description of the research, and were screened with the Michigan Alcoholism Screening Test (MAST; Selzer, 1971), Alcohol Dependence Scale (ADS; Skinner & Horn, 1984), and Drinking Problems Scale (DPS; Cahalan, 1970). Eligible participants were scheduled for interviews in a place convenient for them. All studies were conducted in compliance with university institutional review board and American Psychological Association ethical standards for research with humans. Participants were informed that the research was covered by a confidentiality shield issued by the U.S. Department of Health and Human Services.

Eligibility criteria included a minimum 5-year drinking problem history (M = 16.70 years, SD = 9.31), no current other drug misuse (except nicotine), and recent cessation of problem drinking (M = 3.93 months resolved, SD = 1.78). Resolution onset was defined as the most recent date that participants began abstaining or drinking in a nonproblem manner without further heavy drinking. At all assessments, moderation was determined using criteria associated with low health risks related to drinking (Sobell et al., 1992): (a) $<$55 g (70 ml) of 190-proof ethanol consumed per drinking day; (b) no dependence symptoms (as assessed by the ADS); and (c) no alcohol-related negative health, psychosocial, vocational, financial, or legal consequences (as assessed by the DPS). These criteria are consistent with other drinking guidelines (e.g., National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2005; World Health Organization, 2000) that generally set upper limits at $\leq$4 drinks/day for men and $\leq$3 drinks/day for women.

All of the studies included untreated problem drinkers who had initiated natural resolutions, and Tucker et al. (2006) also included a group that had received alcohol treatment from a qualified provider or attended more than two Alcoholics Anonymous meetings within about 12 months of resolution onset. Two studies (Tucker et al., 2002, 2006) required an initial resolution of 2 to 6 months and had a 2-year follow-up; the third study that involved IVR self-monitoring (Tucker et al., 2008) required a shorter initial resolution of 1 to 3 months and had a 1-year follow-up. Otherwise, the studies used identical selection criteria and follow-up procedures. Summed across studies, 205 (81.03%) of the 253 initially enrolled participants completed the 1-year follow-up required for inclusion in the pooled sample; 202 provided useable income and expenditure data and were included in the data analyses. Attrition was due to participant withdrawal or lost contact (42), significant discrepancies between participant and collateral reports of drinking (5), or death (1).

Although not an inclusion criterion, all participants met third- (Tucker et al., 2002) or fourth- (Tucker et al., 2006, 2008) edition *Diagnostic and Statistical Manual of Mental Disorders* criteria for alcohol dependence (American Psychiatric Association, 1987, 1994). As shown in Table 1, ADS scores fell in the moderate to low substantial dependence range (Skinner & Horn, 1984). Consistent with research showing that seeking help is associated with more severe problems, ADS, MAST, and DPS scores were relatively higher in the one study that included participants with a help-seeking history (Tucker et al., 2006). Otherwise, no differences were found across studies in preresolution drinking practices, postresolution outcomes, demographic characteristics, and preresolution income and expenditures on alcoholic beverages and money put into savings.

Because our goal was to predict stable moderation apart from other outcomes, we classified participants conservatively into mutually exclusive groups based on drinking practices and problems over the entire follow-up. Those who abstained or drank moderately without problems at all follow-up points were considered to have stable resolutions, either resolved abstinent (RA) or resolved nonabstinent (RNA). Those who engaged in any problem drinking were considered to have unstable resolutions (UR), even if they later abstained or moderated.

Table 1 summarizes the sample characteristics as a function of participants' postresolution drinking status based on all follow-up data. During the initial resolution period required for inclusion, 89.1% of participants had abstained continuously and 10.9% had engaged in moderate drinking. Most participants' current drinking goal choice was informed by personal experience; 85% had made one or more serious resolution attempts in the past, with moderation attempts outnumbering abstinence attempts by about 4:1. During the present 1- to 2-year follow-up, 47.0% of participants maintained continuous or nearly continuous abstinence, 14.9% engaged in some moderate drinking with no problem drinking, and 38.1% engaged in problem drinking at some point. Of those who drank moderately, women consumed a mean of 27.5 ml of 190-proof ethanol per drinking day (SD = 8.56), and men consumed a mean of 38.9 ml (SD = 19.0), which fall within NIAAA (2005) gender-adjusted guidelines for low-risk drinking. Of those who drank heavily, over half relapsed during the first postresolution year. Mean quantities consumed per postresolution drinking day were 93.8 ml (SD = 51.1) for women and 123.8 ml (SD = 75.0) for men. During the first postresolution year, the mean and median number of drinking days for RNA participants was 73.93 (SD = 111.51) and 5.50 days, respectively, and the mean and median for UR participants was 44.23 (SD = 67.23) and 20.0 days, respectively.

Procedure

A trained interviewer conducted 1.5- to 3.0-hour individual interviews at baseline and at the annual follow-up points. After giving written informed consent, participants were administered a noninvasive breath test (Alco-Sensor III; Intoximeters, Inc., St Louis, MO) to verify sobriety. All predictors were derived from the initial interview, which covered drinking practices, life contexts, and monetary allocation during the year before participants' recent resolution up to the time of the interview. The follow-up assessments covered the time since the last interview. Brief phone interviews conducted midway between the annual follow-ups assessed drinking and help-seeking status and maintained contact. Participants received $40 for each annual interview and completion of questionnaires that they returned by mail, $10 for each phone interview, and a $50 bonus if they completed all assessments. The procedures that provided the data for the analyses are

Table 1
Sample Characteristics at Initial Assessment as a Function of Resolution Status at Follow-Up

Variable	Resolved nonabstinent (n = 30)			Resolved abstinent (n = 95)			Unstable resolution (n = 77)			p
	M	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	
Demographic characteristics										
Male			53.33			65.26			67.53	*ns*
Female			46.67			34.74			32.47	
White			83.33			75.53			81.58	*ns*
Other race/ethnicity			16.67			24.47			18.42	
Married			73.33			39.78			42.11	.004
Employed full or part time			66.67			60.87			48.68	*ns*
Age (years)	48.27	11.97		44.27	9.26		43.97	12.61		*ns*
Years of education	15.55_{a}	2.38		14.10_{b}	2.82		13.84_{b}	2.64		.014
History of drinking problems										
Positive family history			74.07			78.26			76.32	*ns*
Positive help-seeking history			10.00			41.05			40.26	.002
Drinking problem duration (years)	14.10	8.43		17.44	8.77		16.45	10.22		*ns*
Alcohol Dependence Scale (47 maximum)	17.33_{a}	7.19		23.72_{b}	8.98		23.05_{b}	8.58		.002
Michigan Alcoholism Screening Test (25)	10.83_{a}	4.34		14.41_{b}	4.38		14.86_{b}	4.57		.0001
Drinking Problems Scale (40)	11.00_{a}	6.35		17.38_{b}	7.55		18.14_{b}	8.13		.0001
Preresolution year drinking practices (TLFB)										
Total drinking days	296.77	96.62		291.88	100.04		262.47	106.24		*ns*
Days well functioning	160.40_{a}	143.12		99.02_{b}	121.72		$137.36_{a,b}$	116.44		.026
Mean quantity per drinking day (ml ethanol)	103.53_{a}	54.96		228.47_{b}	183.02		$212.64_{a,b}$	136.74		.0005
Physical health (HDL Form; 90)	8.68_{a}	6.22		13.17_{b}	8.47		12.93_{b}	9.76		.051
Situational Confidence Questionnaire (800)	754.58_{a}	75.36		731.28_{a}	108.70		668.82_{b}	146.50		.0012

Note. Maximum possible scores for scaled questionnaires are given in parentheses after the variable name. p values are from one-way analyses of variance or chi-square analyses comparing the resolved nonabstinent, resolved abstinent, and unstable resolution groups; means with different subscripts were significantly different in pairwise comparisons using Tukey's honestly significant difference test. TLFB = Timeline Followback interview; Days well functioning = abstinent plus light drinking days (adjusted for gender); HDL Form = Health and Daily Living Form.

summarized in the next section and in Tucker et al. (2002, 2006, 2008).

Drinking practices and money spent on alcohol. Established TLFB procedures (Sobell & Sobell, 1992) were used to assess daily drinking practices during the preresolution year and again at each annual follow-up point. Participant reports of ounces of beer, wine, and liquor intake were converted to milliliters of 190-proof ethanol for analysis. Participants also reported how much money they spent each day on alcoholic beverages, regardless of whether the beverages were consumed. This was not excessively difficult because alcoholic beverages are sold in standard quantities, and problem drinkers typically buy and consume large quantities of a limited range of preferred beverages. As needed, TLFB interviewing techniques were used to facilitate reports of money spent on alcohol (e.g., use of anchor events, identification of sustained behavior patterns).

Monetary allocation. Participants reported their monetary income and expenditures during the same periods using an expanded set of commodity classes derived from U.S. federal consumer expenditure surveys (Vuchinich & Tucker, 1996). They were instructed to bring in financial records (e.g., bank records, paycheck stubs), and documented information was recorded first; 59.4% of participants provided some financial records. Then TLFB interviewing techniques were used to complete the financial assessment. Income in dollars was reported by source (e.g., work income, unemployment benefits, pensions, loans). Expenditures were reported in three general categories, each with subcategories, including housing (e.g., mortgage, rent, utilities), consumable goods (e.g., food, tobacco, alcohol), and other (e.g., entertainment, transportation, loan payments, money saved). Reports in each category typically involved many transactions during the assessment interval, which were summed to obtain category totals for analysis. In addition to direct verification using financial records, internal consistency and reliability checks on participants' reports of monetary allocation patterns supported their accuracy (reported in Tucker et al., 2006).

As described in Tucker et al. (2002, 2006, 2008), expenditures during the preresolution year were separated into obligatory and discretionary categories. Obligatory expenditures were for essential, ongoing, and largely fixed costs of living, including housing, food, transportation, medical, loan, and automatic payroll deductions (e.g., taxes, retirement, health insurance). Discretionary expenditures were for less essential commodities that could be purchased intermittently, including recreation, entertainment, alcohol, tobacco, other consumable goods, gifts, and elective savings. The ASDE index was computed as the proportion of discretionary expenditures summed over the preresolution year spent on alcohol minus the proportion of preresolution discretionary expenditures put into savings. ASDE values could range from 1.0 to –1.0, with lower scores representing proportionally less spending on alcohol and more on savings.

Questionnaires. After each interview, participants completed questionnaires that assessed moderation predictors in addition to those assessed during screening. Self-efficacy expectations to re-

sist urges to drink heavily in high-risk situations were assessed using the Situational Confidence Questionnaire (SCQ; Annis & Graham, 1988), and health status was assessed using the health portion of the Health and Daily Living Form (HDL; Moos, 1985). Questionnaires were scored using established methods. Table 1 presents the total scores from the initial assessment.

Checks on data quality. In every study, in addition to checks on participants' financial reports, their reports relevant to the inclusion criteria and follow-up drinking status were assessed through collateral interviews or participant reliability checks when collaterals were unavailable. These data, summarized here, were reported previously (Tucker et al., 2002, 2006; Tucker, Foushee, Black, & Roth, 2007). Summed across studies, collaterals were interviewed at least once for 75.61% of the enrolled sample. Participant data were excluded when collaterals failed to verify participant reports relevant to the inclusion criteria or their drinking status during the follow-up. This rarely occurred (less than 2% of the initial sample of 253). For participants' retained for analysis, good to excellent agreement levels were found for drinking dimensions that could be directly observed by collaterals (e.g., alcohol-related problems, types of beverages consumed, date of initial resolution). The reliability of participant reports of drinking practices and money spent on alcohol also was examined for participants in the IVR study and was found to be excellent (Tucker et al., 2007). These findings strongly suggest that participants retained in the sample were reporting accurately.

Statistical Analysis

The mutually exclusive outcome groups were based on participants' drinking practices and problems over the entire follow-up interval: RA ($n = 95$)—continuous abstinence; RNA ($n = 30$)—some low-risk drinking with no problem drinking; or UR ($n = 77$)—one or more drinking episodes that exceeded the moderation criteria at any point. These conservative operational definitions deliberately separated recovering problem drinkers who resumed alcohol consumption into outcome groups on the basis of whether they engaged in any high-risk drinking, regardless of their terminal outcome status.

To evaluate the main behavioral economic hypotheses, the preresolution year monetary allocations to alcohol and savings, computed as a proportion of discretionary expenditures, were first examined as a function of drinking outcome status in a 3 (outcome status) $\times$ 2 (allocation type) analysis of variance (ANOVA) with repeated measures on the second factor. The Outcome $\times$ Allocation interaction effect from this analysis was used to determine whether the difference in these allocations, which constituted the ASDE index, was significantly related to outcome group membership. Once confirmed, we used a series of three-group multinomial logistic regression analyses to examine the utility of the ASDE index in predicting outcome group membership in relation to established predictors, including measures of problem severity (MAST, ADS, HDL physical health subscale, problem duration, help-seeking history), TLFB reports of preresolution drinking (days well functioning [abstinent and light drinking days combined], mean milliliters of ethanol consumed per drinking day), self-efficacy to resist heavy drinking (SCQ), and demographic characteristics.

Because these analyses focused on identifying predictors of moderated outcomes, the RNA group was the referent group so that the results yielded RA versus RNA and UR versus RNA contrasts and associated odds ratios (ORs) that indicated effect sizes. Although the limited RNA participants (30) prohibited comprehensive multivariable models that included all predictors simultaneously (Peduzzi et al., 1996), the RNA sample was sufficient to maintain a favorable event-to-variable ratio in a series of multinomial logistic regressions that included, first, the ASDE index alone, and then, in subsequent models, the ASDE index plus one other predictor. The latter analyses determined if the predictive utility of the ASDE index was independent of the predictive effects of each established predictor. Significant effects from the two-predictor models were then used to construct three-predictor models that evaluated whether the ASDE index continued to predict RNA outcomes beyond significant problem severity and drinking quantity measures. A final four-variable model examined whether the ASDE continued to have unique predictive utility when three other significant predictors from the three-variable models were included simultaneously. Continuous predictor variables in all logistic regression models were standardized to have a mean of 0 and a standard deviation of 1. The ORs and associated 95% confidence intervals (CIs) were based on a 1-standard deviation change in the predictors and allowed direct comparisons across predictors.

Results

Tests of the Behavioral Economic Hypotheses

Table 1 summarizes univariate differences between the three outcome groups for established moderation predictors, and Table 2 summarizes group differences for the expenditure data from the preresolution year, including the ASDE index and expenditure components from which it was derived. The 3 $\times$ 2 ANOVA on the proportions of discretionary expenditures indicated an expected allocation main effect, $F(1, 199) = 78.56$, $p < .0001$, which reflected greater overall proportional allocation to drinking than savings prior to resolution. More important, as shown in Figure 1, a significant interaction effect was obtained that supported the hypotheses, $F(2, 199) = 11.12$, $p = .0001$. Comparisons using Tukey's honestly significant difference test showed that, as predicted, RNA participants had significantly lower discrepancies between alcohol and savings allocation proportions than both UR participants ($p < .05$) and RA participants ($p < .05$). RNA participants allocated proportionally less discretionary spending to alcohol and more to savings compared with UR participants ($ps < .05$) and less to alcohol than RA participants ($p < .05$).

The multinomial logistic regression analysis that included the ASDE index as the sole predictor revealed significant effects for both the UR versus RNA contrast (OR = 2.89, 95% CI = 1.77, 4.73, $p < .0001$) and the RA versus RNA contrast (OR = 1.93, 95% CI = 1.23, 3.02, $p = .004$). The OR from the first contrast indicated that a 1-standard-deviation increase in the ASDE index was associated with a 2.89-fold increase in the odds of resuming problem drinking compared with stable moderation. The OR from the second contrast indicated that a 1-standard-deviation increase in the ASDE index was associated with a 1.93-fold increase in the odds of stable abstinence compared with moderation.

Table 2
Behavioral Economic Variables Based on Preresolution Monetary Allocation Patterns as a Function of Resolution Status at Follow-Up

Variable	Resolved nonabstinent		Resolved abstinent		Unstable resolutions		
	M	*SD*	*M*	*SD*	*M*	*SD*	*p*
Total income (dollars)	$65{,}042_{a}$	54,259	$36{,}634_{b}$	32,747	$39{,}776_{a,b}$	66,330	.028
Total expenditures	$66{,}670_{a}$	55,637	$35{,}415_{b}$	34,663	$35{,}084_{b}$	51,155	.004
Discretionary expenditures (DE)	14,406	10,080	10,265	7,671	11,211	10,200	*ns*
Expenditures on alcohol (A)	1,849	2,265	2,925	2,910	3,071	2,818	*ns*
Money saved (S)	$2{,}791_{a}$	6,570	$1{,}217_{a,b}$	3,104	573_{b}	2,912	.025
Alcohol/Savings DE index	$.05_{a}$	.32	$.25_{b}$	.31	$.36_{c}$	.30	.0001

Note. Means with different subscripts differed significantly in pairwise comparisons using Tukey's honestly significant difference test. Means are in dollars except for the Alcohol-Savings Discretionary Expenditure (ASDE) index, which is computed as a difference of proportions: (A/DE) − (S/DE). ASDE 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).

The preceding logistic regression used drinking outcome assignments based on all available data from the 202 participants who had an ASDE score and at least 1 year of follow-up data. When this analysis was restricted to participants who were followed for 2 years ($n = 152$) and thus provided the longest continuous behavioral records, the ASDE index remained a significant predictor of both the UR versus RNA contrast (OR = 2.79, CI = 1.56, 5.00, $p = .0006$) and the RA versus RNA contrast (OR = 1.95, CI = 1.14, 3.32, $p = .014$). The same pattern of results was observed in an additional sensitivity analysis ($n = 193$) that excluded 4 RNA and 5 UR participants who were mostly abstinent but occasionally drank either moderately or heavily (UR vs. RNA: OR = 2.55, CI = 1.54, 4.21, $p = .0003$; RA vs. RNA: OR = 1.74, CI = 1.10, 2.75, $p = .017$). Consistent with the main behavioral economic hypothesis, frequent moderate drinkers had the lowest and frequent heavy drinkers had the highest mean ASDE scores.

Overall, these results supported the hypotheses concerning the ASDE index. The composite index separated the RNA group from the RA and UR groups, which were more similar.

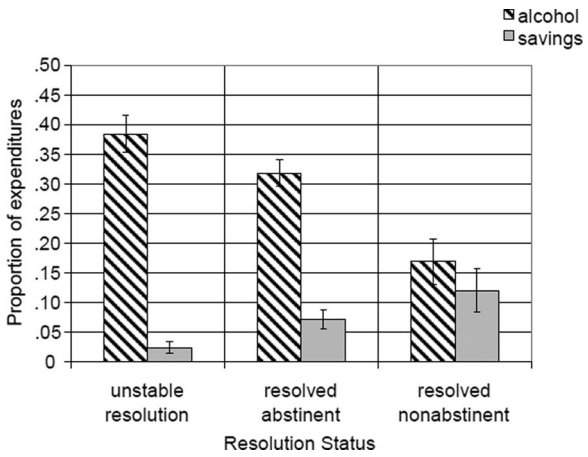

Figure 1. Resolution Status × Allocation Type interaction among components of the Alcohol-Savings Discretionary Expenditure (ASDE) index based on the proportion of discretionary expenditures for alcohol and savings during the year prior to resolution onset (*y* axis). The error bars represent the standard errors of the drinking outcome group means.

Predictive Utility of the ASDE Index Relative to Established Moderation Predictors

Table 3 summarizes the results of logistic regressions that included the ASDE index and one other moderation predictor and also presents the correlations between the ASDE index and the other predictors. Four findings are noteworthy. First, the ASDE index showed low to modest correlations with all other predictors, ranging from .00 to .36 ($rs > .14$ or $< -.14$ were significant at $p < .05$), indicating that the ASDE was largely unrelated to the other predictors and capable of contributing new information to the prediction of outcomes in the multivariable models. Second, the analyses replicated many established moderation predictors, including lower dependence, fewer psychosocial and health problems, shorter problem durations, lower quantities consumed on drinking days, absence of help seeking, stable sociodemographic characteristics, and higher self-efficacy. Third, when the two-predictor models were run, the ASDE index remained a robust predictor of outcomes among the subset of participants who drank during the follow-up. The UR versus RNA contrast was significant in all models that included another predictor, indicating that the ASDE index explained unique variance after accounting for the other predictor. Fourth, the ASDE index distinguished outcomes among the subset of participants who maintained resolution. The RA versus RNA contrast was significant for the index when it was included with another predictor in all but two models that included either the MAST or mean milliliters per drinking day.

On the basis of these results, additional three-variable logistic regressions were conducted that included the ASDE index and two other variables of conceptual interest or empirical utility. The MAST and ADS were not included in the same model because they were highly correlated ($r = .68$, $p < .001$) and would, therefore, be largely redundant in the same model. Table 4 presents the results of the three-variable models that we examined. In all eight complex models, the ASDE index continued to separate the UR and RNA groups. The index was not highly effective in separating the RA and RNA groups, although trends that approached significance for the ASDE were observed in Models 1, 3, and 8. A positive help-seeking experience and mean milliliters ethanol/drinking day consistently separated all three outcome groups, with absence of help seeking and lower quantities con-

Table 3
Multinomial Logistic Regressions Using the ASDE Index and One Established Moderation Predictor

		Unstable vs. nonabstinent resolutions						Abstinent vs. nonabstinent resolutions					
		EP			ASDE			EP			ASDE		
Established predictor (EP)	*r*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
Demographic characteristics													
Age (years)	−.04	0.66	0.42, 1.04	.072	2.99	1.80, 4.95	.0001	0.67	0.44, 1.03	.066	2.03	1.26, 3.18	.003
Female gender	.05	0.44	0.17, 1.10	.078	3.05	1.84, 5.05	.0001	0.51	0.21, 1.22	*ns*	2.03	1.28, 3.22	.003
Preresolution year income	−.33	0.93	0.66, 1.30	*ns*	2.86	1.71, 4.78	.0001	0.68	0.43, 1.06	.089	1.73	1.08, 2.76	.022
Education (years)	−.26	0.62	0.38, 1.00	.052	3.06	1.81, 5.19	.0001	0.62	0.38, 0.98	.039	2.00	1.24, 3.22	.005
Married	−.26	0.41	0.15, 1.10	.076	2.58	1.56, 4.26	.0002	0.31	0.12, 0.80	.015	1.63	1.03, 2.59	.038
Drinking history and problems													
Alcohol Dependence Scale	.31	1.69	1.00, 2.85	.052	2.64	1.57, 4.44	.0003	2.07	1.25, 3.45	.005	1.66	1.03, 2.66	.038
Michigan Alcoholism Screening Test	.36	2.08	1.22, 3.55	.007	2.32	1.38, 3.90	.002	2.11	1.27, 3.53	.004	1.54	0.95, 2.49	.077
Physical Health subscale (HDL form)	.17	1.64	0.91, 2.93	.099	2.87	1.70, 4.85	.0001	1.77	1.00, 3.13	.05	1.74	1.08, 2.81	.023
Drinking problem duration <10 years	−.02	0.42	0.16, 1.09	.076	3.30	1.94, 5.60	.0001	0.25	0.10, 0.63	.003	2.19	1.34, 3.57	.002
Positive help-seeking history	.13	4.09	1.33, 18.08	.017	2.63	1.61, 4.31	.0001	5.35	1.50, 19.18	.01	1.75	1.11, 2.75	.016
Family history of drinking problems	.00	1.22	0.42, 3.51	*ns*	2.92	1.76, 4.86	.0001	1.39	0.50, 3.84	*ns*	1.93	1.21, 3.06	.006
Preresolution drinking practices (TLFB)													
Days well functioning	−.32	1.21	0.77, 1.91	*ns*	3.18	1.88, 5.39	.0001	0.71	0.47, 1.10	*ns*	1.75	1.10, 2.78	.019
Mean ml ethanol per drinking day	.28	8.14	3.05, 33.21	.0006	2.18	1.24, 3.84	.007	10.07	3.05, 33.21	.0001	1.40	0.82, 2.34	*ns*
Situational Confidence Questionnaire	−.02	0.33	0.15, 0.73	.006	3.58	2.01, 6.37	.0001	0.60	0.27, 1.31	*ns*	1.82	1.12, 2.96	.016

Note. Resolved nonabstinent group is the referent group. Continuous predictor variables were *z* transformed to allow direct comparisons among ORs adjusted to indicate a 1-standard deviation change in the predictor variable; dichotomous variables (gender, married, positive help-seeking history, positive family history) were not *z* transformed; *p* values are for the associated 95% CIs. ASDE = Alcohol-Savings Discretionary Expenditure index; OR = odds ratio; CI = confidence interval; *r* = Pearson correlation between EP and ASDE; HDL = Health and Daily Living Form; TLFB = Timeline Followback interview; Days well functioning = abstinent plus light drinking days (adjusted for gender).

sumed being associated with an RNA status. The MAST, ADS, and SCQ contributed significantly to the separation of the UR and RNA groups. The MAST and ADS also separated the RA and RNA groups in models that did not include drinks per drinking day, but inclusion of that variable attenuated their predictive utility for the RA–RNA contrast.

A final, comprehensive four-variable model was constructed from the strongest predictors identified in Table 3, namely the MAST, SCQ, mean milliliters ethanol/drinking day, and ASDE index. For the UR–RNA contrast, the SCQ (OR = 0.30, CI = 0.12, 0.74, $p = .009$), mean milliliters ethanol/drinking day (OR = 7.26, CI = 1.77, 29.74, $p = .006$), and ASDE (OR = 2.46, CI = 1.27, 4.77, $p = .008$) were statistically significant unique predictors, whereas for the RA–RNA contrast, the MAST (OR = 1.96, CI = 1.03, 3.72, $p = .04$) and mean milliliters ethanol/drinking day (OR = 9.54, CI = 2.37, 38.33, $p = .002$) were the statistically significant unique predictors.

Discussion

The findings add to evidence supporting a behavioral economic analysis of drinking resolutions and extend the utility of a measure of preference for alcohol derived from preresolution spending patterns to predict moderation. Stable resolutions involving moderate alcohol use over 1- to 2-year follow-ups were associated with proportionally more preresolution discretionary monetary allocation to savings and less to alcohol compared with continuously abstinent resolutions and unstable resolutions that involved some problem drinking. Lower ASDE values presumably reflect more balanced monetary allocations between short-term and longer term objectives, suggesting that the temporal intervals over which problem drinkers organize and allocate their behavior, even while drinking heavily, may help identify those most able to make a transition to stable moderate use.

The support for the ASDE index in this re-analysis of pooled data from prior studies was obtained in conjunction with results that replicated established moderation predictors. As found during the controlled drinking debate (cf. Marlatt, 1983), moderation was associated with greater social stability and with lower problem severity, including shorter drinking histories, lower alcohol dependence and quantities consumed per drinking day, and fewer alcohol-related psychosocial problems (Miller & Munoz, 2005; Rosenberg, 2004). Higher self-efficacy to resist heavy drinking in high-risk situations also predicted moderation, which replicated recent findings that added this variable to those identified during the controlled drinking debate (Saladin & Santa Ana, 2004).

When included in models with other significant predictors, the ASDE index added unique information to the prediction of moderation and was especially effective in distinguishing outcomes among participants who engaged in postresolution drinking. The ASDE index was significant for the RNA–UR contrast in all models evaluated. Drinkers who maintained moderation had lower ASDE, MAST, and ADS scores and higher self-efficacy scores than those who relapsed.

The ASDE index also predicted outcomes among participants who remained resolved, separating the abstinent and moderation groups in models that included the ASDE alone or with one other predictor. The index was less effective in separating these groups in complex models that included quantities consumed, an attenu-

Table 4
Multinomial Logistic Regression Models Using the ASDE Index With Two Moderation Predictors

Predictor	Unstable vs. nonabstinent resolutions			Abstinent vs. nonabstinent resolutions		
	OR	95% CI	*p*	OR	95% CI	*p*
Model 1: Alcohol Dependence Scale	1.73	1.01, 2.95	.046	2.01	1.20, 3.36	.0008
Days well functioning	1.31	0.82, 2.09	*ns*	0.82	0.52, 1.27	*ns*
ASDE index	2.91	1.68, 5.05	.0001	1.58	0.97, 2.57	.068
Model 2: Alcohol Dependence Scale	1.16	0.64, 2.08	*ns*	1.35	0.76, 2.39	*ns*
Mean ml ethanol per drinking day	7.20	2.02, 25.74	.002	8.62	2.43, 30.54	.0008
ASDE index	2.18	1.23, 3.86	.008	1.34	0.78, 2.28	*ns*
Model 3: Alcohol Dependence Scale	1.36	0.75, 2.46	*ns*	2.03	1.16, 3.54	.013
Situational Confidence Questionnaire	0.33	0.15, 0.74	.007	0.62	0.28, 1.36	*ns*
ASDE index	3.44	1.87, 6.30	.0001	1.55	0.93, 2.58	.092
Model 4: Michigan Alcoholism Screen Test	2.07	1.21, 3.54	.008	2.08	1.24, 3.49	.006
Days well functioning	1.29	0.81, 2.06	*ns*	0.76	0.49, 1.18	*ns*
ASDE index	2.60	1.50, 4.50	.0007	1.43	0.87, 3.49	*ns*
Model 5: Michigan Alcoholism Screening Test	1.69	0.95, 3.03	.076	1.64	0.93, 2.88	.088
Mean ml ethanol per drinking day	6.52	1.92, 22.16	.003	8.11	2.41, 27.31	.0007
ASDE index	1.88	1.04, 3.37	.036	1.21	0.69, 2.10	*ns*
Model 6: Michigan Alcoholism Screening Test	1.87	1.00, 3.49	.049	2.41	1.34, 4.33	.004
Situational Confidence Questionnaire	0.35	0.15, 0.80	.013	0.67	0.30, 1.50	*ns*
ASDE index	2.95	1.61, 5.39	.0004	1.37	0.81, 2.30	*ns*
Model 7: Situational Confidence Questionnaire	0.27	0.11, 0.66	.004	0.48	0.20, 1.15	*ns*
Mean ml ethanol per drinking day	8.13	2.06, 32.10	.003	10.99	2.84, 42.46	.0005
ASDE index	2.82	1.50, 5.30	.001	1.33	0.77, 2.31	*ns*
Model 8: Married	0.50	0.18, 1.37	*ns*	0.38	0.15, 1.00	.051
Positive help-seeking history	4.43	1.18, 16.60	.027	4.67	1.28, 16.99	.020
ASDE index	2.44	1.48, 4.03	.0005	1.54	0.97, 2.45	.070

Note. Resolved nonabstinent group is the referent. Adjusted ORs indicate a 1-standard deviation change in the predictor variable, except for married and positive help-seeking history, where simple indicator variables (1 vs. 0) were used. ASDE = Alcohol-Savings Discretionary Expenditure index; OR = odds ratio; CI = confidence interval.

ation that may be due in part to heterogeneity in the RA group. Some abstainers may be able to drink moderately but have not exposed themselves to postresolution alcohol use, whereas others might resume problem drinking. This unobserved moderation versus relapsed outcome among abstainers can, therefore, limit the full predictive significance of individual predictors of moderation outcomes. Given this attenuated separation, for purposes of choosing an initial abstinence or moderation drinking goal, it seems prudent clinically to require multiple favorable indicators of likely success at moderation until further research can establish decision-making algorithms that satisfactorily separate all three outcome groups. The present findings suggest that supplementing the MAST, ADS, and SCQ with questions about consumption quantities on drinking days and money spent on alcohol and put into savings provides a sound basis for making clinical judgments about initial drinking goal choice.

The ASDE findings also have implications for behavioral economic research and addictive behavior change applications. Evidence is accumulating that addictive behaviors are characterized by a foreshortened view of the future and that successful behavior change will likely involve a shift from a shorter to a longer view of the future and organizing behavior accordingly. In addition to the present support based on money allocation patterns in the natural environment, behavioral economic research on temporal discounting of hypothetical money and health outcomes has consistently found steeper discount functions in smokers, problem drinkers, opiate addicts, and gamblers (Bickel & Marsch, 2001). Social psychological studies have similarly found that the time perspectives of substance abusers are more present oriented and less future oriented than for normal controls (Henson, Carey, Carey, & Maisto, 2006; Keough, Zimbardo, & Boyd, 1999). Addiction treatment outcomes also are predicted by behavioral impulsivity measures that span laboratory and naturalistic assessments, including delay discounting of hypothetical rewards (e.g., Yoon et al., 2007), demand curve analysis based on hypothetical alcohol purchase tasks (MacKillop & Murphy, 2007), questionnaire measures of relative reinforcement value (e.g., Murphy, Correia, Colby, & Vuchinich, 2005; Schmitz, Sayre, Hokanson, & Spiga, 2003), and experiential discounting tasks that assess delay discounting using real, rather than hypothetical, monetary rewards (Krishnan-Sarin et al., 2007).

Such measures of behavioral impulsivity developed within a behavioral economic framework guided by the matching law (Herrnstein, 1970) show inconsistent relationships with personality questionnaires that assess traitlike impulsive tendencies, and the latter measures have no utility in predicting treatment outcomes (e.g., Krishnan-Sarin et al., 2007). Although it remains to be determined the extent to which the behavioral economic measures assess common or different dimensions of behavioral impulsivity and the relative reinforcing efficacy of substances (MacKillop & Murphy, 2007; Reynolds, Richards, Horn, & Karraker, 2004), they appear to measure functional changes in preferences for substance use and nondrug alternatives that are at the core of the dynamic addictive process. The ASDE index as currently assessed is decidedly among the more molar behavioral economic measures and appears to measure the relative reinforcement value of alcohol in

the context of resource allocation to commodities available over different temporal intervals. Although the ASDE may prove to be less sensitive to short-term preference shifts than are brief measures of the current demand for drugs, it provides a comprehensive benchmark based on behavior patterns in the natural environment against which to evaluate the utility of briefer measures of relative preferences, including laboratory preparations.

Regardless of whether foreshortened views of the future are a cause or consequence of the addictive process, or both, it seems likely that interventions may facilitate positive change by promoting contact with the set of delayed positive consequences, or the sober "consumption bundle," that typically flows from a sober lifestyle. Behavior patterns with delayed positive consequences often are more valuable as a whole compared with discrete acts chosen day-to-day (Rachlin, 1995), and the likelihood of maintaining longer term, higher yield patterns is presumably greater once contact is made with the delayed positive consequences. Drawing attention to delayed consequences or signaling their future availability (e.g., via self-monitoring, motivational interviewing, or decisional balance exercises) is one way to shift behavioral organization toward the future. Such approaches may reduce the appeal of short-term discrete rewards, like substance use, by helping people frame choices as involving an extended series of linked behaviors, events, and outcomes with higher overall value (Chapman, 1996; Rachlin, 1995).

The present research has limitations that merit attention in future studies. First, despite pooling across studies, the number of participants with stable moderation resolutions was still relatively small, which limited the number of predictors that could be evaluated simultaneously in multivariate models. Although quite coherent across models, the results merit replication with a larger sample of moderate drinkers. Second, because two of the earlier studies (Tucker et al., 2002, 2006) included too few moderate drinkers to analyze them separately from abstainers, the positive ASDE findings in those studies may have been amplified by including RNA participants in the stable resolution group along with RA participants. However, RNA participants constituted less than 12% of the stable resolution groups in these studies, suggesting that the overall ASDE results and interpretation were appropriate. Third, future studies of resolution should expand the window of selection to include problem drinkers who have resolved quite recently or are contemplating doing so. Participants with drinking problems that fall short of clinical diagnostic criteria also should be studied, and drinking-related inclusion criteria should be relaxed to allow research on outcomes that fall short of stable moderation but entail substantial reductions in drinking and related harm.

Pursuing the public health implications of understanding pathways to and predictors of moderation will require expanding the scope of research to include new concepts and methods, such as those provided by behavioral economics. Better characterizing the moderate use of alcohol by individuals with a history of problem drinking may provide new insights about the behavior regulation processes involved in resolution and relapse and help guide innovative behavior change strategies that increase contact with the population with problems.

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