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4 Delayed-Reward Discounting in Alcohol Abuse

Rudy E. Vuchinich and Cathy A. Simpson

4.1 Intertemporal Choice, Discounting, and Drinking

Behavioral theory and research frame issues concerning impulsiveness and self-control within the context of intertemporal choice between smaller sooner rewards (the impulsive choice) and larger later rewards (the self-controlled choice) (e.g., Ainslie 1975, 1992; Logue 1988; Rachlin 1974; Rachlin and Green 1972). This conception of intertemporal choice has been extended to studying alcohol use and abuse (e.g., Vuchinich 1997; Vuchinich and Tucker 1988), with alcohol consumption and nondrinking activities that are more valuable in the long run (e.g., satisfying intimate, family, or social relations or academic or vocational success) being analogous, respectively, to the smaller sooner and larger later rewards used in the behavioral laboratory. Laboratory experiments with normal drinkers have found that preference for alcohol varies inversely with the amount and directly with the delay of nondrinking rewards (Chutuape, Mitchell, and de Wit 1994; Vuchinich and Tucker 1983; Vuchinich, Tucker, and Rudd 1987), and studies in the natural environment with persons with alcohol problems have found that their drinking varies directly with constraints on access to nondrinking rewards (Tucker, Vuchinich, and Gladsjo 1994; Tucker, Vuchinich, and Pukish 1995; Vuchinich and Tucker 1996).

The amounts and delays of the smaller sooner and larger later rewards are critical determinants of preference in intertemporal choice situations (Logue 1988). Another important variable that influences preference is the degree to which the value of delayed rewards is discounted during the times before they

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are available. Greater degrees of temporal discounting produce a stronger preference for the smaller sooner reward (i.e., impulsiveness). Thus, an extension of this analysis to studying alcohol use and abuse implies that alcohol consumption would vary directly with the degree of delayed-reward discounting. More generally, recent behavioral (Herrnstein and Prelec 1992), behavioral economic (Rachlin 1997), and economic (Becker and Murphy 1988) theories of addiction all hold that greater temporal discounting will increase the risk of addiction.

Two types of discount functions have been common in the relevant literatures: (1) a hyperbolic function,

$$v_p = V/(1 + kD), \tag{1}$$

which has dominated psychology (e.g., Ainslie 1992; Mazur 1987; Rachlin, Raineri, and Cross 1991), and (2) an exponential function,

$$v_p = Ve^{-kD}, \tag{2}$$

which has dominated economics (e.g., Becker and Murphy 1988; Kagel, Battalio, and Green 1995). In both equations, v_p is the present (discounted) value of a delayed reward, V is the undiscounted value of a delayed reward, D is the delay from the present to receipt of a delayed reward, and k is a constant that is proportional to the degree of discounting. Obviously, in both equations the present value of a given delayed reward varies inversely with the value of k.

Hyperbolic and exponential discount functions imply quite different choice dynamics in intertemporal choice situations, which has been discussed extensively in the psychological literature (e.g., Ainslie 1975, 1992; Rachlin and Green 1972; Rachlin, Raineri, and Cross 1991). With exponential discounting, each equal delay increment produces a constant proportional decrement in reward value. Thus, when the smaller sooner and larger later rewards are discounted by the same value of k, preference between them remains constant over time. In contrast, with hyperbolic discounting, equal delay increments produce a larger decrement in reward value at short delays than at long delays. Thus, when the smaller sooner and larger later rewards are discounted by the same value of k, preference between them will reverse as a function of time.

These relationships are shown schematically in figure 4.1, which represents a highly simplified, two-option intertemporal choice situation (alcohol consumption is available at time 6, and a more valuable nondrinking reward is available at time 10). Prior to the time that alcohol consumption is available, exponential discounting produces consistent preferences for either alcohol consumption or the nondrinking reward. An individual with higher exponential discounting (panel *B* of fig. 4.1) would consistently prefer drinking and would emit no behavior that produced access to the more valuable nondrinking reward. On the other hand, an individual with lower exponential discounting

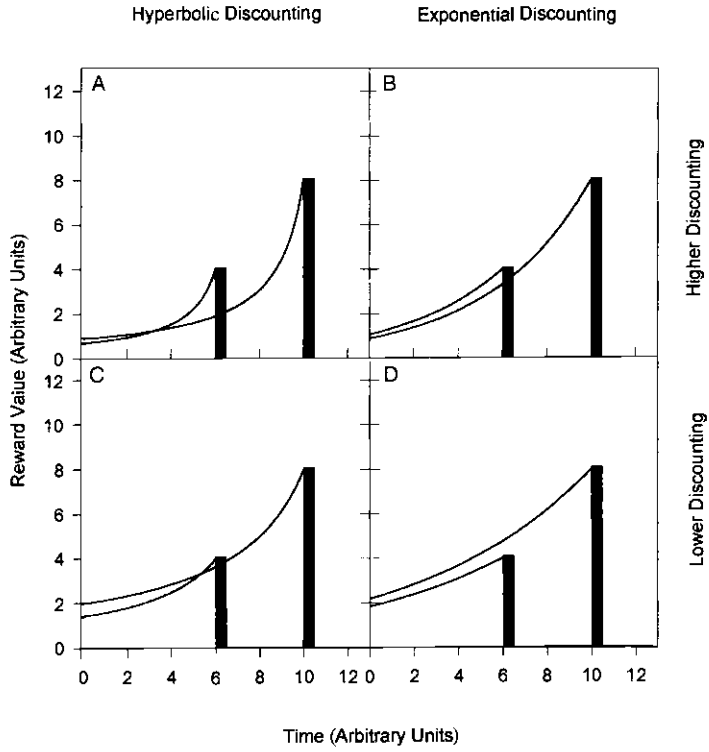

Fig. 4.1 Dynamics in intertemporal choice with relatively higher and lower degrees of hyperbolic and exponential discounting of delayed rewards

Note: The rewards are represented as vertical bars, with amount indicated by their height and time of availability indicated by their location on the abscissa. In each panel, a smaller sooner reward (e.g., alcohol consumption) is available at time 6 and a larger later reward (e.g., valuable nondrinking activity) is available at time 10. The curves to the left of the rewards are delay discount functions that represent reward value during the times before they are available; the reward with the highest value curve at the time of choice will be preferred. The two left and two right panels show hyperbolic and exponential discount functions, respectively, and the two top and two bottom panels show relatively higher and lower rates of discounting, respectively. The hyperbolic and exponential discount functions were generated from eq. (1) and eq. (2), respectively.

(panel *D* of fig. 4.1) would consistently prefer not drinking and would emit nothing but behavior that produced access to the larger later nondrinking reward. In contrast, prior to the time that alcohol consumption is available, hyperbolic discounting produces inconsistent preferences for either alcohol consumption or the nondrinking reward. An individual with higher hyperbolic discounting (panel *A* of fig. 4.1) would shift earlier in time from preferring the nondrinking reward to preferring drinking, and would emit less behavior over a shorter duration that produced access to the larger later nondrinking reward. On the other hand, an individual with lower hyperbolic discounting (panel *C*

of fig. 4.1) would shift later in time from preferring the nondrinking reward to preferring drinking, and would emit more behavior over a longer duration that produced access to the larger later nondrinking reward.

Importantly, either type of discount function predicts a positive relation between the degree of discounting and drinking. Moreover, it is possible that different groups distinguished on the basis of their drinking behavior would show different types of discount functions as well as different degrees of discounting. Despite the conceptual importance accorded temporal discounting in approaches to understanding alcohol abuse, it has received little direct empirical investigation.

4.2 Studies with the Repeated-Gambles Procedure

Sarfati and White (1991) capitalized on the work of Rachlin et al. (1986) and reported data that seemed to show that heavy social drinkers discounted delayed rewards to a greater degree than light social drinkers. Rachlin et al. (1986) proposed a synthesis of behavioral research on intertemporal choice, which focuses on reward amount and delay, with cognitive research on risky choice (e.g., Kahneman and Tversky 1984), which focuses on reward amount and probability. The crux of Rachlin et al.'s argument was that the effects on choice of probability of reward are reducible to the effects of delay of reward: Over a series of trials, an outcome with a high probability on each trial occurs more often than an outcome with a low probability; so, on average, high-probability outcomes occur sooner after a given choice than low-probability outcomes. Given this relation, it is possible that high and low probabilities in risky choice correspond to short and long delays in intertemporal choice, respectively, and risk aversion and risk seeking in risky choice are special cases of impulsiveness and self-control in intertemporal choice, respectively.

In order to evaluate this hypothesis, Rachlin et al. (1986) developed a repeated-gambles procedure in which participants repeatedly chose between two roulette-type wheels, a "sure thing" that provided a smaller amount of (hypothetical) money at a high probability, and a "risky gamble" that provided a larger amount of (hypothetical) money at a lower probability. Thus, the sure thing and the risky gamble in this probabilistic choice situation would be analogous, respectively, to the smaller sooner and larger later rewards in an intertemporal choice situation. In the repeated-gambles procedure, preference for the sure thing and risky gamble correspond to risk aversion and risk seeking, respectively. In their study, Rachlin et al. manipulated intertrial interval (ITI) across two groups of participants and found that the long-ITI group chose the sure thing option more often than the short-ITI group, which supported their synthesis of probability and delay and led them to attribute the greater risk aversion in the long-ITI group to the effects of discounting of delayed rewards (i.e., impulsiveness).

Sarfati and White (1991) applied these concepts and methods to the study of individual differences in impulsiveness among social drinkers. They reasoned that if alcohol consumption is an impulsive behavior in an intertemporal choice context, and if the repeated gambles procedure measures impulsiveness, as argued by Rachlin et al. (1986), then heavy drinkers should be more risk averse in the repeated-gambles procedure than light drinkers. Their study compared the choices of heavy and light social drinkers in the repeated-gambles procedure. Their results showed that heavy drinkers chose the sure thing option more often than light drinkers, which apparently indicated greater risk aversion among the heavy drinkers and implied that heavy social drinkers discount delayed rewards to a greater degree than light social drinkers.

Sarfati and White's (1991) finding was somewhat surprising, however, given that Silberberg et al. (1988) had reported four studies that strongly suggested that choice in the repeated-gambles procedure is not affected by temporal discounting. Moreover, the Sarfati and White study raised questions about the relation between drinking and impulsiveness as defined in behavioral research on choice, and about impulsiveness as defined in research on personality characteristics. In the personality literature, impulsiveness is viewed as a multidimensional construct that is positively correlated with risk taking (e.g., Gorenstein and Newman 1980; White et al. 1994). Also, positive relationships have been found between drinking and impulsiveness as measured by personality questionnaires (e.g., Sher and Trull 1994). Thus, Sarfati and White's (1991) results are not what would be expected from this literature. That is, if drinking and impulsiveness are positively related, and if impulsiveness (as measured by personality questionnaires) and risk taking are positively related, then heavy drinkers should be more risk seeking (not more risk averse) than light drinkers in the repeated-gambles procedure.

Because of these ambiguities, Vuchinich and Calamas (1997) attempted (i) to replicate Sarfati and White's (1991) finding that heavy drinkers are more risk averse than light drinkers in the repeated-gambles procedure, and (ii) to explore the empirical relations between drinking and impulsiveness as defined by personality questionnaires, and impulsiveness as defined by choice in the repeated-gambles procedure. The Vuchinich and Calamas study found no differences between heavy and light social drinkers in their choice in the repeated-gambles procedure, thus failing to replicate Sarfati and White's main finding. Moreover, they found that risk seeking in the repeated-gambles procedure was associated with more impulsiveness on the questionnaire measures. These results, along with Silberberg et al.'s (1988) data, indicated that the repeated-gambles procedure is not a useful method for studying delayed-reward discounting and impulsiveness. Thus, the theoretical hypothesis of a positive relation between drinking and temporal discounting was not adequately evaluated by the Sarfati and White (1991) study.

4.3 Studies with the Hypothetical Money Choice Task

4.3.1 Study 1: Comparing Temporal Discounting in Heavy and Light Social Drinkers

The primary purpose of this study (Vuchinich and Simpson 1998) was to compare delayed-reward discounting in heavy and light social drinkers using a procedure that generates a quantitative estimate of the degree of discounting for individual participants and that can distinguish between hyperbolic and exponential discount functions. This procedure, which we will call the hypothetical money choice task (HMCT), was developed by Rachlin et al. (1991) and subsequently used in several other studies (Green, Fry, and Myerson 1994; Green et al. 1996; Myerson and Green 1995; Raineri and Rachlin 1993). The theoretical prediction was that heavy drinkers would have higher discounting of delayed rewards than light drinkers. Moreover, given that several studies have found that the hyperbolic function provides a better description of temporal discounting than the exponential function (e.g., Rachlin et al. 1991; Myerson and Green 1995), we also expected the data to favor the hyperbolic function.

Method

Students ($N = 527$) at Auburn University were screened with the Khavari Alcohol Test (KAT; Khavari and Farber 1978) and the Michigan Alcoholism Screening Test (MAST; Selzer 1971) to assess their typical drinking and drinking problems, respectively. The KAT yields an annual absolute alcohol intake (AAAI) index that estimates total amount of alcohol consumption (in ounces of ethanol) during the previous year. Individuals with drinking problems, as assessed by the MAST, and those who abstained from alcohol were excluded from further participation. Students at the extremes of the remaining AAAI distribution were selected for the experimental phase of the study, resulting in a final sample of 24 heavy drinkers (12 males and 12 females) and 24 light drinkers (12 males and 12 females). The heavy and light drinkers were very different on the KAT AAAI index, with means of 404.57 and 25.98 ($p < .001$), respectively. Participants also completed a demographic questionnaire that asked about their personal and family incomes, and there were no between-group differences on these measures.

Participants came to the laboratory for individual sessions. They first completed the repeated-gambles procedure, as in Sarfati and White (1991) and Vuchinich and Calamas (1997), and then the HMCT (see Vuchinich and Simpson 1998 for details). This procedure measures the amount of immediately available (hypothetical) money that is subjectively equivalent in value to a larger amount of (hypothetical) money that is available after a series of delays. These multiple subjective equivalence points are then used to estimate the discounting parameter (i.e., k) derived from the temporal discounting equations.

During the procedure, participants repeatedly chose between a larger fixed amount of money available after a delay and a smaller amount of money that was available immediately. There were four series of trials, two each in which the delayed fixed-amount rewards were $1,000 and $10,000. On each trial series, the large delayed money amount was constant across trials, and the smaller immediate money amount was changed on each trial. The smaller immediate money amounts consisted of 30 values ranging from 0.1 to 100 percent of the larger fixed amount. Each trial series was repeated eight times at different delays of the larger fixed-amount reward: 1 week, 1 month, 6 months, 1 year, 3 years, 5 years, 10 years, and 25 years. Within each of the money amount conditions, in one trial series the immediate smaller money amounts were presented in ascending order, and in one series they were presented in descending order. The subjectivity equivalent immediate amounts for each fixed amount at each delay were calculated by averaging two values: (1) the value at which the participant switched preference from the immediate to the delayed reward when the immediate rewards were presented in descending order, and (2) the value at which the participant switched preference from the delayed to the immediate reward when the immediate rewards were presented in ascending order (cf. Green et al. 1994). Figure 4.2 shows the equivalence points for two individual participants, one with a relatively high degree of discounting (bottom panel) and one with a relatively low degree of discounting (top panel).

Results

Comparison of the drinker groups on their choices during the repeated-gambles procedure revealed no difference, which replicated Vuchinich and Calamas's (1997) main finding. Our analysis of the HMCT data first determined whether the hyperbolic (eq. [1]) or exponential (eq. [2]) discount function provided better fits to the data. Nonlinear regression was used to estimate separate k parameters based on equations (1) and (2) for both money amount conditions for each participant. The proportions of the variance in the data that were accounted for by the parameter estimates were entered into a $2 \times 2 \times 2 \times 2$ (drinker group $\times$ sex $\times$ money amount $\times$ equation) ANOVA, which revealed only a significant ($p < .001$) main effect for type of equation. Equations (1) and (2) accounted for an average of 82 percent and 69 percent of the variance, respectively, which indicates better fits to the data with the hyperbolic discount function.

In order to evaluate drinker-group differences in the discounting parameter, the hyperbolic k parameters from the $1,000 and $10,000 conditions were averaged for each participant and then entered into a 2×2 (drinker group $\times$ sex) ANOVA, which yielded only a significant ($p < .05$, one-tailed) main effect for the drinker group. Heavy drinkers ($M = .193$, SD = .450) had higher k values than light drinkers ($M = .034$, SD = .030). Because the drinker-group variances were heterogeneous, a nonparametric Mann-Whitney U test also was

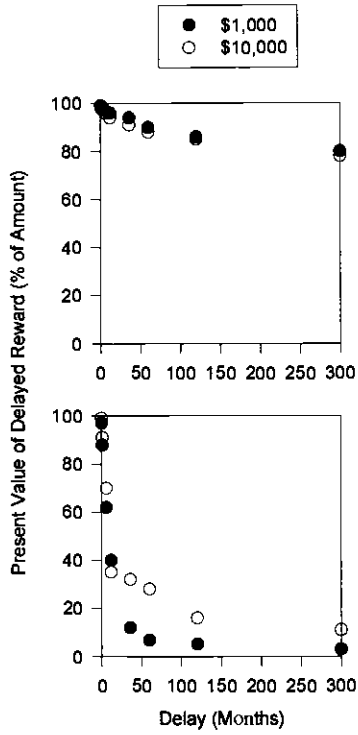

Fig. 4.2 Hypothetical money choice task: data from two individual participants
Note: The top and bottom panels illustrate relatively low and high degrees of temporal discounting, respectively. Each data point represents the amount of immediately available (hypothetical) money that is subjectively equivalent in value to a larger amount of (hypothetical) money that is available after a series of delays. The filled and unfilled circles are from the $1,000 and $10,000 conditions, respectively. Present value is scaled as the percentage of the larger, delayed money amount.

computed and yielded comparable results ($p < .09$, one-tailed). The median k values for the heavy- and light-drinker groups were .039 and .026, respectively. Figure 4.3 plots discount functions generated from equation (1) using these median k values. As can be seen in figure 4.3, the discount function for the heavy drinkers is steeper (higher k values) than the corresponding function for the light drinkers.

Discussion

The temporal discounting data clearly showed that the hyperbolic function is a more accurate description of delayed-reward discounting than the exponential function for all participants, which is consistent with previous evidence from studies that directly compared the two functions (e.g., Rachlin et al. 1991; Myerson and Green 1995). Most important, heavy drinkers showed higher hyperbolic discounting than light drinkers, as predicted from the behavioral per-

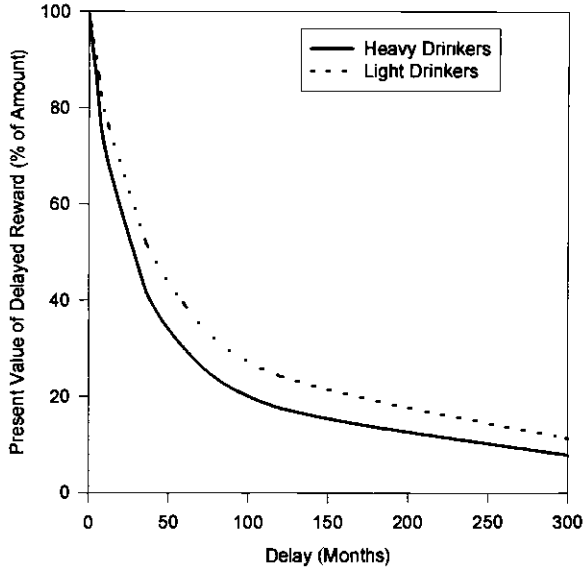

Fig. 4.3 Hyperbolic discount functions for the 50th percentile averaged *k* values for the heavy drinkers (*solid line*) and light drinkers (*broken line*) in study 1

Note: The functions were generated from eq. (1).

spective on intertemporal choice, but the level of statistical significance was marginal.

4.3.2 Study 2: Comparing Temporal Discounting in Problem Drinkers and Light Social Drinkers

Alcohol consumption obviously is a multidetermined behavior (e.g., Abrams and Niaura 1987), and it would be unrealistic to expect one, or even several, variables to account for the bulk of interindividual variability in levels of naturally occurring social drinking. This probably is especially true for drinking among college students, who are embedded in a social context in which heavy social drinking often is more normative than exceptional (e.g., Wechsler et al. 1995). Thus, the marginal significance of the discounting-drinking relation found in study 1 may reflect the fact that many other variables are also converging to produce variability in social drinking. However, as drinking escalates beyond socially acceptable levels, which do not cause significant problems, to heavier, problem drinking, then we may expect a reduction in the number of critical variables. If that is the case, and if temporal discounting is among these more critical variables that are related to alcohol abuse, then a stronger discounting-drinking relation should be found if light social drinkers without alcohol problems are compared to heavy drinkers with alcohol prob-

lems. Conducting this comparison was the primary goal of study 2 (Vuchinich and Simpson 1998).

Method

Students ($N = 380$) at Auburn University were screened using the KAT and the Young Adult Alcohol Problem Screening Test (YAAPST; Hurlbut and Sher 1992) to assess alcohol problems. The YAAPST was designed specifically for college-age samples and provides measures of both lifetime and past-year frequency of alcohol problems in legal, occupational, health, family/marital, and social areas. Potential participants were excluded if they abstained from alcohol. Problem drinkers were defined as those potential participants at the upper extreme of the AAAI distribution who also reported at least five past-year alcohol problems on the YAAPST. Light drinkers were defined as those potential participants at the lower extreme of the AAAI distribution who also reported no more than one past-year alcohol problem on the YAAPST. The final study sample consisted of 31 participants, 16 problem drinkers (8 males and 8 females) and 15 light drinkers (7 males and 8 females). The problem and light drinkers were very different on the KAT AAAI index, with means of 1,445.45 and 12.79 ($p < .001$), respectively, and on the number of alcohol problems reported on the YAAPST, with means of 8.93 and 0.00 ($p < .001$), respectively. Participants also completed a demographic questionnaire that asked about their personal and family incomes; there were no between-group differences on these measures. Only the $1,000 amount condition of the HMCT was used during the laboratory sessions.

Results

Nonlinear regression analyses were used to estimate separate k parameters based on equations (1) and (2) for the $1,000 money amount condition for each participant. The proportions of variance accounted for by each equation were entered into a 2 × 2 × 2 (drinker group × sex × equation) ANOVA, which revealed only a significant ($p < .003$) main effect for type of equation. Equations (1) and (2) accounted for an average of 80.05 percent and 70.12 percent of the variance, respectively, which indicates better fits to the data with the hyperbolic discount function.

The hyperbolic k parameters from the $1,000 condition were entered into a 2 × 2 (drinker group × sex) ANOVA, which showed only a significant ($p < .025$, one-tailed) main effect for drinker group. Problem drinkers ($M = .104$, SD = .162) had higher k values than light drinkers ($M = .018$, SD = .025). Because the drinker group variances again were heterogeneous, a nonparametric Mann-Whitney U test also was computed and yielded comparable results ($p < .01$, one-tailed). The median k values for the problem and light drinkers were .034 and .008, respectively. Figure 4.4 plots discount functions generated from equation (1) using these median k values. As figure 4.4 shows, the discount function for the problem drinkers is steeper (higher k values) than the

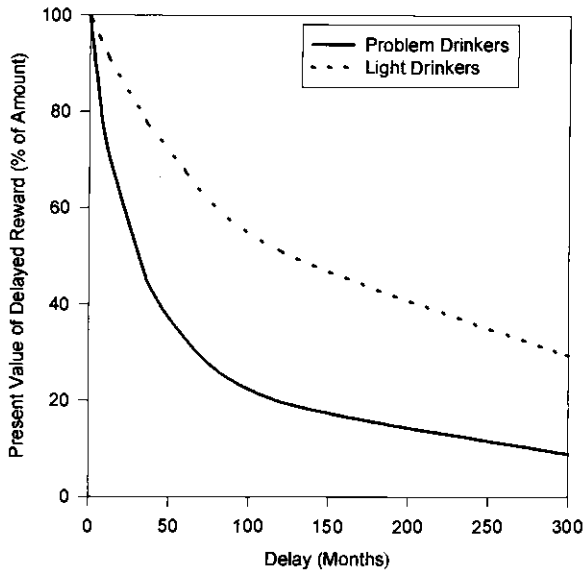

Fig. 4.4 Hyperbolic discount functions for the 50th percentile *k* values for the problem drinkers (*solid line*) and light drinkers (*broken line*) in study 2
Note: The functions were generated from eq. (1).

corresponding function for the light drinkers, and the groups are more widely separated than in study 1.

Discussion

As in study 1, the hyperbolic function was a more accurate description of discounting than the exponential function, and the problem drinkers had higher *k* values than the light drinkers. This discounting-drinking relation replicated and was stronger than the one found in study 1, and involved fewer participants. The finding that heavy social drinkers and problem drinkers discount delayed rewards at a higher rate than light drinkers is similar to the results of Madden et al. (1997), who found greater temporal discounting among opioid-dependent patients than among non-drug-using control participants.

There are four issues that are particularly relevant to comparing the discount functions in figures 4.3 and 4.4 from the two studies. First, the functions in figure 4.3 from study 1 were generated from averaging the *k* parameters from the $1,000 and $10,000 money amount conditions, whereas the functions in figure 4.4 from study 2 were generated from the *k* parameters from the $1,000 condition only. In study 1, the $10,000 *k* values generally were higher than the $1,000 *k* values. Thus, the discount functions in figure 4.3 are generally lower (higher *k* values) than those in figure 4.4 because of the averaging of the two money amount conditions in study 1.

Second, the context surrounding the HMCT was slightly different in the two studies. Study 1 participants completed the repeated-gambles procedure prior to the HMCT, whereas participants in the second study did not. Also, participants in study 1 knew they would be making choices in both money-amount conditions and study 2 participants knew they would be making choices in only one money-amount condition. Given that subtle contextual cues can have important effects on choice in such laboratory preparations (e.g., Kahneman and Tversky 1984; Silberberg et al. 1988), these procedural differences may have affected participants' choices in the two studies.

Third, the participant groups differed across the two studies in terms of both drinking behavior and the occurrence of alcohol problems. The problem drinkers in study 2 drank more and had more problems than the heavy drinkers in study 1, whereas the light drinkers in both studies were comparable in terms of drinking. Thus, comparisons across the two studies cannot determine if the larger discounting difference in study 2 was due to the difference in drinking behavior, the difference in alcohol problems, or both. Disentangling these relations would seem to be a worthwhile empirical question for future research.

Finally, comparison of absolute values of data points across studies of this sort with relatively small samples is hazardous. This is especially true when the comparison is made on the basis of data values at certain percentile ranks, as opposed to means and standard deviations, as representative of central tendency and dispersion of the distributions. Thus, the most important comparison is between groups within a single study, as in any between-groups design. Different studies then can be compared on the basis of the strength of the between-group differences found within each study, rather than on the basis of absolute data values. By this criterion, the difference between the problem and light drinker groups in study 2 was considerably stronger than the difference between the heavy and light social drinker groups in study 1.

It is significant that the drinker groups in these laboratory studies could be distinguished on the basis of the degree to which they discounted the value of money, a commodity that has no apparent connection with their alcohol consumption. This is consistent with the notion that behavior with respect to valuable commodities other than alcohol is at least as important as behavior with respect to alcohol in understanding the determinants of alcohol consumption, which is a major premise of a behavioral economic analysis of alcohol abuse (Vuchinich and Tucker 1988). Although the monetary discounting difference between the drinker groups presumably reflects general tendencies, in future research on the discounting-drinking relation it may be advantageous to explore the specificity of discounting the value of particular nondrinking activities. This would be the case because degrees of discounting differ for different nondrinking rewards (Raineri and Rachlin 1993), and there likely are important between-individual differences and within-individual changes over time (e.g., Green et al. 1994) both in these particular degrees of discounting

and in the types of particular nondrinking activities that enter into intertemporal choice relations involving alcohol consumption (Vuchinich and Tucker 1988). Significant discounting-drinking relations were found in the present research for a single nondrinking reward (i.e., money), but stronger such relations may be found in future studies that measure discounting for nondrinking rewards that are individually relevant for particular participants (Vuchinich and Tucker 1996).

The behavioral economic theoretical terms and methods employed in the current studies connect with a much broader theoretical and empirical literature on behavioral allocation, intertemporal choice, and economics (e.g., Kagel et al. 1995; Loewenstein and Elster 1992) that has been usefully applied to the study of substance use and abuse (e.g., Bickel, DeGrandpre, and Higgins 1993; DeGrandpre and Bickel 1996; Green and Kagel 1996; Vuchinich 1995). Behavioral allocation, in general, and drug self-administration, in particular, by animals and humans in laboratory preparations and by humans in the natural environment can be described with the same theoretical terms, although their empirical interpretations differ across the different situations. Thus, the generality of relations found in one situation can be evaluated by applying the same theoretical terms, with appropriate empirical interpretations, to other situations. For example, it is intriguing that Poulos, Le, and Parker (1995) found that rats' preferences for a smaller sooner food reward over a larger later food reward were positively related to the amounts of alcohol they self-administered, which can be viewed as a discounting-drinking relation similar to that found in the present laboratory research with humans. The generality of the present findings to other participant populations in other situations with other abused substances remains to be evaluated.

4.4 Study 3: Predicting Natural Resolutions of Alcohol Problems

Most persons with alcohol problems never enter formal treatment (e.g., Room 1989), yet many of those who remain untreated somehow resolve their drinking problem (Sobell, Cunningham, and Sobell 1996). One of us (Vuchinich) is currently involved in a longitudinal study (with Jalie A. Tucker, principal investigator) of untreated problem drinkers who attempted to quit problem drinking. The goal of this study is to identify pre- and postresolution variables that predict, promote, and hinder natural resolutions of alcohol problems. Of particular interest is whether the proportion of monetary resources allocated to alcohol consumption and other commodity classes during periods of problem drinking can serve as a viable measure of the value of drinking and other activities. If so, then such measures derived from the time period prior to attempts to quit problem drinking may be useful in predicting outcomes and in understanding the dynamics of changes in drinking behavior. Some of the preliminary data from this study may be relevant to the discounting-drinking relation.

4.4.1 Method

Participants were solicited through media advertisements in major metropolitan areas of Alabama and Georgia; 58 individuals met DSM-IV (American Psychiatric Association 1994) diagnostic criteria for alcohol dependence, among other alcohol-problem criteria, and had never participated in an alcohol treatment program or Alcoholics Anonymous. In addition, participants had quit problem drinking for no less than two months and no more than six months (M = 3.85 months) when inducted into the study.

Several measures were included that assessed the extent of drinking problems and levels of alcohol dependence. An expanded version of the Time Line Follow Back interview procedure (described in Vuchinich, Tucker, and Harllee 1988) was used to assess daily drinking, life events, and monetary variables over the 12-month period prior to the resolution date, and then at 12- and 24-month follow-up intervals. The monetary variables are recorded during the interviews so that amounts of income and expenditures are coded in specific categories (e.g., wage, salary, and pension for income; housing, transportation, food, entertainment, and savings for expenditures). The amount of money spent on alcohol also is recorded and can be expressed as a proportion of total income or expenditures or of the sums of groups of subcategories of either. The data presented here are from the 46 participants who have so far completed the 12-month follow-up assessment.

4.4.2 Results

Regarding the preresolution monetary variables, most participants had middle- to upper-level incomes (M = \$41,688; range = \$3,300–\$250,000) and had organized their expenditures and lifestyles accordingly. For conceptual reasons and to reduce variance, we focused on discretionary expenditures, as opposed to total income or expenditures, as the pool of monetary resources. Discretionary expenditures included entertainment, tobacco, money given to another, alcohol, and savings, as contrasted with more obligatory expenditure categories such as housing, utilities, transportation, medical, food, and loan payments. Discretionary expenditures thus represents the allocation of unobligated income and seemed to be a suitable starting point for this generally economically advantaged sample.

Of the 46 participants, 16 had relapsed to problem drinking and 30 had maintained their resolutions one year after their quit dates. We conducted three discriminant function analyses (DFAs) that investigated predictors of the one-year outcome classification, one DFA each that included only pre- or post-resolution variables and one DFA that included both.

The DFA for preresolution variables included alcohol dependence levels, income, heavy drinking days, legal problems, physical health problems, and the proportion of discretionary expenditures allocated to alcohol (Discretionary Ethanol Expenditures [DEE] index). These variables were included for con-

ceptual reasons, their demonstrated utility in past research with treated samples (e.g., Moos, Finney, and Cronkite 1990), or their ability to discriminate between the outcome groups. A significant discriminant function was found that included the DEE index ($p < .01$), with relapsed participants having higher scores than resolved participants, and physical health problems ($p < .05$), with resolved participants having more problems than relapsed participants. This DFA achieved an overall correct (jack-knifed) classification rate of 78 percent.

The DFA for postresolution predictors included total positive and total negative life events, negative physical health events, and negative work events. This DFA also revealed a significant function that included negative work events ($p < .01$), with relapsed participants reporting more events than resolved participants, and negative physical health events ($p < .05$), with resolved participants reporting more events than relapsed participants. This DFA produced an overall correct classification rate of 74 percent. The DFA that included both pre- and postresolution variables also produced a significant function that included the DEE index ($p < .01$) and postresolution negative health events ($p < .01$), and correctly classified 78 percent of the participants.

As discussed earlier, the behavioral economic perspective views drinking as an impulsive behavior, as contrasted with behavior patterns that invest current resources in future activities of greater value. We therefore explored how the resolved and relapsed participants had allocated their discretionary expenditures to savings, as well as to drinking, during the preresolution year. The proportion of preresolution discretionary expenditures that were allocated to drinking and to savings by both participant groups were entered into a 2×2 (outcome group $\times$ expenditure type) ANOVA. A significant interaction effect ($p < .01$) showed that the difference between the proportional alcohol and savings expenditures was greater for the relapsed participants ($M = 59$ percent and 4 percent, respectively) than for the resolved participants ($M = 34$ percent and 17 percent, respectively). Moreover, the outcome groups were similar in their expenditures in other categories, in their preresolution incomes and total expenditures, and in their preresolution drinking patterns.

4.4.3 Discussion

These results are preliminary and do not permit firm inferences. Nevertheless, the data are relevant in two particular ways to the present topic. First, the DEE index was the best predictor from the preresolution variables of the one-year outcomes. It is interesting that the DEE index was a better outcome predictor than more conventional variables, such as alcohol dependence levels, drinking practices, and income. This suggests that monetary resource allocation to alcohol consumption may be a useful way to represent its reward value in relation to nondrinking activities. Because discretionary expenditures are much less constrained than more obligatory expenditures, which often involve commitments over months or years, the former may be the arena in individuals' personal economies where an increasing preference for alcohol consumption

is initially manifested and most clearly seen. Obligatory expenditure categories may initially be more durable in the face of escalating problem drinking, but eventually would be affected if problems become severe enough, as is often seen in treatment samples. The DEE index thus may be a good early indicator of the growing reward value of alcohol relative to nondrinking activities that is not highly correlated with drinking practices (the DEE correlated .22 with number of preresolution heavy drinking days and .46 with quantities of alcohol consumed per drinking day). Being able to measure the shift in resource allocation toward drinking and away from nondrinking activities would be useful in studying the dynamics of drinking problems in the natural environment.

Second, to the extent that savings is inversely related to temporal discounting, the degree of temporal discounting during the preresolution year appears to have been a relevant variable in distinguishing the outcome groups. Participants who were resolved at the one-year follow-up allocated proportionally less money to alcohol and more to savings than those who were relapsed. This suggests that problem drinkers whose behavior is organized more around delayed outcomes (i.e., as reflected in savings), even during periods of problem drinking, are more likely to succeed in attempts to recover from their drinking problem.

4.5 General Discussion

The main results of these studies supported predictions derived from extending behavioral conceptions of intertemporal choice to an analysis of the determinants of alcohol consumption. These results also are consistent with more general, formal theories (Becker and Murphy 1988; Herrnstein and Prelec 1992; Rachlin 1997) that propose different choice dynamics to account for addiction but that all predict a positive relation between rates of temporal discounting and addiction. The current data are consistent with but cannot distinguish between these theories, except that Herrnstein and Prelec and Rachlin incorporate hyperbolic discount functions, whereas Becker and Murphy incorporate an exponential discount function. Although the use of hypothetical rewards in these laboratory studies demands caution in interpreting these data, the finding that a hyperbolic function provides a better description of temporal discounting than an exponential function appears to be quite general. As noted by Loewenstein (1996, 279), "The non-exponential discounting perspective has been bolstered by findings from hundreds of experiments showing that humans and other animals display hyperbolic discount functions of the type predicted to produce impulsive behavior." The behavioral implications of hyperbolic discounting are discussed extensively by Ainslie (1992).

Because these studies were correlational, they cannot address the temporal priority of higher discount rates or heavy drinking. At this point, either preceding the other is equally plausible (Becker and Mulligan 1997), but this issue would appear to be fairly easily disentangled in longitudinal studies. If such

studies find that higher discounting more often precedes than follows heavy drinking, then measuring discounting before the initiation of drinking potentially could aid in the identification of individuals at risk for developing heavy drinking and alcohol problems. Moreover, identifying the determinants of discounting and manipulating them could produce low discounting and potentially help to prevent the development of heavy drinking and alcohol problems and to treat them once they occur. On the other hand, if higher discounting is found more often to follow than to precede heavy drinking, it would remain possible for higher discounting to be an important factor in the perpetuation of heavy drinking regardless of the initiating conditions. Although the data from study 3 are preliminary, it appears that temporal discounting may have been a factor that distinguished successful and unsuccessful attempts to quit problem drinking without treatment.

These data also cannot address the conditions that generated the particular degrees of discounting manifested by our participants. It is possible, for example, that the heavy and problem drinkers showed higher discounting because their past and current environments had a sparsity of larger later nondrinking rewards relative to the light drinkers. If that is the case, however, the difference in larger later rewards must have been in areas other than socioeconomic, because the drinker groups in the laboratory studies were sampled from the same student population and did not differ on family or personal income, and the relapsed and resolved participants in study 3 were not significantly different in income. On the other hand, it also is possible that the heavy/problem drinkers, the light drinkers, and the relapsed and resolved drinkers had similar reward structures in their environments but that some factor distinguished them as individuals or affected how they interacted with their environments, thus generating the different discount rates. There are, of course, other possibilities, and the point is that identifying the determinants of temporal discounting is an important topic for future research.

References

Abrams, David B., and Raymond S. Niaura. 1987. Social learning theory. In *Psychological theories of drinking and alcoholism*, ed. Howard T. Blane and Kenneth E. Leonard, 131–78. New York: Guilford.

Ainslie, George. 1975. Specious reward: A behavioral theory of impulsiveness and impulse control. *Psychological Bulletin* 82:463–96.

———. 1992. *Picoeconomics: The strategic interaction of successive motivational states within the person.* Cambridge: Cambridge University Press.

American Psychiatric Association. 1994. *Diagnostic and statistical manual of mental disorders,* 4th ed. Washington, D.C.: American Psychiatric Association.

Becker, Gary S., and Casey B. Mulligan. 1997. On the endogenous determination of time preference. *Quarterly Journal of Economics* 112:729–58.

Becker, Gary S., and Kevin Murphy. 1988. A theory of rational addiction. *Journal of Political Economy* 96:675–700.

Bickel, Warren K., Richard J. DeGrandpre, and Stephen T. Higgins. 1993. Behavioral economics: A novel experimental approach to the study of drug dependence. *Drug and Alcohol Dependence* 33:173–92.

Brown, Morton B., and Alan B. Forsythe. 1974a. The small sample behavior of some statistics which test the equality of several means. *Technometrics* 16:129–32.

———. 1974b. Robust tests for the equality of variances. *Journal of the American Statistical Association* 69:364–67.

Chutuape, Mary Ann D., Suzanne H. Mitchell, and Harriet de Wit. 1994. Ethanol preloads increase ethanol preference under concurrent random-ratio schedules in social drinkers. *Experimental and Clinical Psychopharmacology* 2:310–18.

DeGrandpre, Richard J., and Warren K. Bickel. 1996. Drug dependence as consumer demand. In *Advances in behavioral economics*, vol. 3, *Substance use and abuse*, ed. Leonard Green and John H. Kagel, 1–36. Norwood, N.J.: Ablex.

Gallant, Ronald A. 1987. *Nonlinear statistical models*. New York: Wiley.

Gorenstein, Ethan E., and Joseph P. Newman. 1980. Disinhibitory psychopathology: A new perspective and a model for research. *Psychological Review* 87:301–15.

Green, Leonard, Astrid F. Fry, and Joel Myerson. 1994. Discounting of delayed rewards: A life-span comparison. *Psychological Science* 5:33–36.

Green, Leonard, and John H. Kagel, eds. 1996. *Advances in behavioral economics*, vol. 3, *Substance use and abuse*. Norwood, N.J.: Ablex.

Green, Leonard, Joel Myerson, David Lichtman, Suzanne Rosen, and Astrid Fry. 1996. Temporal discounting in choice between delayed rewards: The role of age and income. *Psychology and Aging* 11:79–84.

Herrnstein, Richard J., and Drazen Prelec. 1992. A theory of addiction. In *Choice over time*, ed. George Loewenstein and Jon Elster, 331–60. New York: Russell Sage Foundation.

Hurlbut, Stephanie, and Kenneth Sher. 1992. Assessing alcohol problems in college students. *Journal of Studies on Alcohol* 41:49–58.

Kagel, John H., Raymond C. Battalio, and Leonard Green. 1995. *Economic choice theory: An experimental analysis of animal behavior*. Cambridge: Cambridge University Press.

Kahneman, David, and Amos Tversky. 1984. Choices, values, and frames. *American Psychologist* 39:341–50.

Khavari, Khalil A., and Phillip D. Farber. 1978. A profile instrument for the quantification and assessment of alcohol consumption: The Khavari Alcohol Test. *Journal of Studies on Alcohol* 39:1525–39.

Kirk, Roger E. 1968. *Experimental design: Procedures for the behavioral sciences*. Belmont, Calif.: Brooks/Cole.

Loewenstein, George. 1996. Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes* 65:272–92.

Loewenstein, George, and Jon Elster, eds. 1992. *Choice over time*. New York: Russell Sage Foundation.

Logue, Alexandra W. 1988. Research on self-control: An integrating framework. *Behavioral and Brain Sciences* 11:665–709.

Madden, Gregory J., Nancy M. Petry, Gary J. Badger, and Warren K. Bickel. 1997. Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: Drug and monetary rewards. *Experimental and Clinical Psychopharmacology* 5:256–63.

Mazur, James E. 1987. An adjusting procedure for studying delayed reinforcement. In *Quantitative analyses of behavior*, vol. 5, *The effect of delay and of intervening events on reinforcement value*, ed. Michael L. Commons, James E. Mazur, John A. Nevin, and Howard Rachlin, 55–73. Hillsdale, N.J.: Erlbaum.

Moos, Rudolph H., John W. Finney, and Ruth C. Cronkite. 1990. *Alcoholism treatment: Context, process, and outcome.* New York: Oxford University Press.

Myerson, Joel, and Leonard Green. 1995. Discounting of delayed rewards: Models of individual choice. *Journal of the Experimental Analysis of Behavior* 64:263–76.

Poulos, Constantine X., A. D. Le, and J. L. Parker. 1995. Impulsivity predicts individual susceptibility to high levels of alcohol self-administration. *Behavioural Pharmacology* 6:810–14.

Rachlin, Howard. 1974. Self-control. *Behaviorism* 2:94–107.

———. 1992. Teleological behaviorism. *American Psychologist* 47:1371–82.

———. 1994. *Behavior and mind: The roots of modern psychology.* New York: Oxford University Press.

———. 1997. Four teleological theories of addiction. *Psychonomic Bulletin and Review* 4:462–73.

Rachlin, Howard, and Leonard Green. 1972. Commitment, choice, and self-control. *Journal of the Experimental Analysis of Behavior* 17:15–22.

Rachlin, Howard, Alexandra W. Logue, John Gibbon, and Marvin Frankel. 1986. Cognition and behavior in studies of choice. *Psychological Review* 23:33–45.

Rachlin, Howard, Andres Raineri, and David Cross. 1991. Subjective probability and delay. *Journal of the Experimental Analysis of Behavior* 55:233–44.

Raineri, Andres, and Howard Rachlin. 1993. The effect of temporal constraints on the value of money and other commodities. *Journal of Behavioral Decision Making* 6: 77–94.

Room, Robin. 1989. The U.S. general population's experiences of responding to alcohol problems. *British Journal of Addiction* 84:1291–1304.

Sarfati, Peter, and K. Geoffrey White. 1991. Impulsivity in social drinkers. *New Zealand Journal of Psychology* 20:41–48.

Selzer, M. L. 1971. The Michigan Alcoholism Screening Test: The quest for a new diagnostic instrument. *American Journal of Psychiatry* 127:1653–58.

Sher, Kenneth J., and Timothy J. Trull. 1994. Personality and disinhibitory psychopathology: Alcoholism and antisocial personality disorder. *Journal of Abnormal Psychology* 103:92–102.

Silberberg, Alan, Paul Murray, Joyce Christensen, and Toshio Asano. 1988. Choice in the repeated-gambles experiment. *Journal of the Experimental Analysis of Behavior* 50:187–95.

Sobell, Linda C., John A. Cunningham, and Mark B. Sobell. 1996. Recovery from alcohol problems with and without treatment: Prevalence in two population surveys. *American Journal of Public Health* 86:966–72.

Tucker, Jalie A., Rudy E. Vuchinich, and Julie A. Gladsjo. 1994. Environmental events surrounding natural recovery from alcohol-related problems. *Journal of Studies on Alcohol* 55:401–11.

Tucker, Jalie A., Rudy E. Vuchinich, and Michelle A. Pukish. 1995. Molar environmental contexts surrounding recovery from alcohol problems in treated and untreated problem drinkers. *Experimental and Clinical Psychopharmacology* 3:195–204.

Vuchinich, Rudy E. 1995. Alcohol abuse as molar choice: An update of a 1982 proposal. *Psychology of Addictive Behaviors* 9:223–35.

———. 1997. Behavioral economics of drug consumption. In *Drug addiction and its treatment: Nexus of neuroscience and behavior,* ed. Bankole A. Johnson and John D. Roache, 73–90. Philadelphia: Lippincott-Raven.

Vuchinich, Rudy E., and Maria L. Calamas. 1997. Does the repeated gambles procedure measure impulsivity in social drinkers? *Experimental and Clinical Psychopharmacology* 5:157–62.

Vuchinich, Rudy E., and Cathy A. Simpson. 1998. Hyperbolic temporal discounting in social drinkers and problem drinkers. *Experimental and Clinical Psychopharmacology* 6:1–14.

Vuchinich, Rudy E., and Jalie A. Tucker. 1983. Behavioral theories of choice as a framework for studying drinking behavior. *Journal of Abnormal Psychology* 92: 408–16.

———. 1988. Contributions from behavioral theories of choice to an analysis of alcohol abuse. *Journal of Abnormal Psychology* 97:181–95.

———. 1996. Alcoholic relapse, life events, and behavioral theories of choice: A prospective analysis. *Experimental and Clinical Psychopharmacology* 4:19–28.

Vuchinich, Rudy E., Jalie A. Tucker, and Lynn M. Harllee. 1988. Behavioral assessment of alcohol dependence. In *Assessment of addictive behaviors*, ed. Dennis M. Donovan and G. Alan Marlatt, 51–93. New York: Guilford Publications.

Vuchinich, Rudy E., Jalie A. Tucker, and Edmund J. Rudd. 1987. Preference for alcohol consumption as a function of amount and delay of alternative reward. *Journal of Abnormal Psychology* 96:259–63.

Wechsler, Henry, George W. Dowdall, Andrea Davenport, and Sonia Castillo. 1995. Correlates of college student binge drinking. *American Journal of Public Health* 85:921–26.

White, Jennifer L., Terrie E. Moffit, Avsholom Caspi, Dawn J. Bartusch, Douglas J. Needles, and Magda Stouthamer-Loeber. 1994. Measuring impulsivity and examining its relationship to delinquency. *Journal of Abnormal Psychology* 103:192–205.

Comment on Chapters 3 and 4

Michael E. Hilton

The two papers in this section both conduct behavioral research to clarify the underpinnings of economic approaches to addiction. Beyond that commonality, the two are quite dissimilar. One studies laboratory rats, while the other studies undergraduate students. One is concerned with testing the tenets of a well-known model, the other with finding a relationship between drinking behavior and reward discounting. As such, they lend themselves to separate discussions of their merits and weaknesses.

Price Changes in Alcohol-Experienced Rats

The first paper, "The Effects of Price Changes on the Consumption of Alcohol in Alcohol-Experienced Rats" by Solomon Polachek, Norman Spear, and Jeffrey Sarbaum, comes from the world of laboratory rat behavioral experimentation. I must confess at the outset that this research is quite outside of my expertise, but I nonetheless found much in it that would interest any reader who cares about the addictions field. In fact, I found it a gem of a study.

To begin with, Polachek and colleagues address a leading theoretical position, the theory of rational addiction proposed by Becker and Murphy (1988) and Becker, Grossman, and Murphy (1991). Furthermore, they address some of the key elements of that theory: (i) For addictive goods, consumption at time zero affects the utility of consumption at some future time. (ii) The con-

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sumption of addictive substances can be reduced by changes in price. This is, of course, the key policy implication of the theory. (iii) Current consumption of an addictive good will change in response to an anticipated future price increase. This is the hallmark feature that allows us to distinguish the rational addiction model from myopic models of addiction. Indeed, it is rare that we see an experiment designed to address so directly the central tenets of the theory with which it is working.

The paper also does an effective job of working across disciplinary boundaries, which is very important for this conference. It shows an accurate understanding of a theoretical development in microeconomics and translates it into an experiment that can be performed in an animal lab.

I appreciated that the paper was very clearly written. This is essential when communicating across disciplinary boundaries. The rational addiction theory is clearly explained. The experimental procedures are specified precisely; the main points are made without unnecessary elaboration or speculation; and the researchers are careful not to overstate results or to hide ambiguous or contradictory evidence.

All in all, this is an outstanding paper, but any paper can be improved, and my (rather difficult) task is to suggest where such improvements could be made. I list the following in no particular order of importance.

I would have preferred that the article report either the blood-alcohol content (BAC) achieved by the rats or the grams of alcohol consumed per kilogram of body mass of the rats. Otherwise, it is difficult to interpret the 3 to 4 ml of alcohol consumption reported in the study. In a human, would this correspond to a two-drink buzz or a profound state of intoxication?

The authors should have described, very briefly, the Samson alcohol-fading technique. Laboratory experimentalists will be familiar with it, but the economic audience will not. This lapse is an exception to the bulk of the paper, which does a very fine job of explaining the details of the experimental procedure.

The paper contains a brief discussion of the idea that addiction depends on an interaction of the good and the consumer. That is to say, alcohol is not inherently addicting; much depends on the characteristics of the drinker. This is an important point, even more so for alcohol than for such other substances as tobacco or heroin. Hence, I thought the idea should be given a bit more discussion than the brief acknowledgment that was given.

It is unfortunate that "return to baseline" data were not collected and presented for subjects other than subject 1. It is always more satisfying and informative to have the same data available for all subjects.

Also, the combination of aberrant results for subject 1 and the small number of subjects involved creates uncertainty about the reliability of the results. This should invite replication, and I hope that somebody will pick up that challenge.

One facet of the rational addiction model that was not really tested here is that long-run responses to a price change are expected to be relatively larger

than short-run responses. First, this aspect of the theory should not have been mentioned so prominently in the opening paragraphs if it wasn't put to test in the research. Second, in fact, some of the results in figures 3.5*B*, 3.6*B*, and 3.7*B* do seem to bear on the notion, and these seem to contradict the expected result. This, however, was not discussed.

Finally, it is important to consider the paper's impact within the interdisciplinary context that surrounds it. I fear that it will be easy for economists to dismiss this research. It's about rats rather than about people, and it seems far afield of the economist's typical fare. Despite these considerations, there is a very important reason for doing this research. The authors hint at this reason, but it does not receive the emphasis that it deserves. The reason is that there are limits to what can be done with epidemiological and survey data sets. Even when a wide variety of control variables are present in the dataset, epidemiological analyses are limited in their ability to disentangle causation from association and rule out competing hypotheses. Once the limits to what can be learned from cross-sectional and longitudinal surveys have been reached, it makes sense to employ experimental designs, with their greater power, to investigate these issues.

Another interdisciplinary consideration is the impact of empirical findings achieved in one discipline on theoretical thinking in another. Will economists seriously use the results of animal behavior experiments to refine their models? The results of experiment B show a lack of support for the degree of consumer foresight that might be supposed by the rational addiction model. As the results filter back from the world of the laboratory experimenters to the world of the economists, those results won't carry much weight with them beyond the simple message that the hypothesis was not supported. There isn't additional discussion here that might help guide the economists in thinking about how the model might be altered to take these results into account. This is important because it will be hard to send scientific messages across disciplinary boundaries, and without this additional discussion it may be too tempting for economists to simply ignore the results rather than engage in the difficult work of revising the theory.

Let us hope that this is not the case and that this excellent article is able to influence the thinking of economists and behavioral experimenters alike.

Delayed-Reward Discounting in Alcohol Abuse

The second paper to be reviewed here, "Delayed Reward Discounting in Alcohol Abuse," by Rudy Vuchinich and Cathy Simpson, reports a series of four studies conducted on human subjects. The first study (see section 4.2 of the paper) investigates the relationships among subjects' alcohol consumption, outcomes on a repeated-gambles task, and personality test measures of impulsivity. The findings indicate that outcomes of the repeated-gambles task were not related to subjects' alcohol consumption and that the repeated-gambles outcomes were not related to test-based personality measures of impulsivity.

The second study (in subsection 4.3.1) investigated the relationships among subjects' alcohol consumption, personality test measures of impulsivity, outcomes on the repeated-gambles task, and outcomes on a delayed-money-choice procedure. The findings indicated that a hyperbolic function provided a better fit than an exponential function to the delayed-money-choice data, that heavy drinkers had a lower discount rate than lighter drinkers (this was unexpected), that outcomes on the repeated-gambles task were not related to subjects' alcohol consumption, and that personality test items generally did not correlate to other variables in the study.

The third study (in subsection 4.3.2) collected data on subjects' alcohol consumption, subjects' alcohol problems, response to time orientation items on a personality test, and outcomes on a delayed-money-choice task. The results indicated that a hyperbolic function provided a better fit than an exponential function to the delayed-money-choice data, that heavy drinkers had higher scores than light drinkers on items measuring present time orientation, and that there was no relationship between time orientation and outcomes on a money-choice task.

The fourth study (in section 4.4) was rather different than the first three. Instead of undergraduate students, the subjects were alcohol-dependent individuals who were attempting to recover. Among these individuals, retrospective data were collected on the proportion of discretionary expenditures that was spent on alcohol and the proportion of discretionary expenditures that was allocated to savings. A discriminant function analysis was conducted to compare relapsers against those who were successfully recovering after 12 months. Findings indicated that the proportion of discretionary income spent on alcohol was the best predictor of recovery success and that savings rate prior to recovery attempt was related to recovery status.

The research area studied here is one of great interest and promise. It has long been thought that the personality trait of impulsivity was related to heavy drinking (Cahalan and Room 1974). This may be a clue that different preferences for future versus present rewards (temporal discounting) could also be related to heavy or problem drinking. If true, this relationship would have a number of important implications. It might tell us something about how the goal of future sobriety and its benefits should be presented to treatment clients in order to optimize their motivation for recovery. It might improve our ability to predict successful treatment outcomes. It might shed some light on whether the "one step at a time" outlook emphasized in 12-step treatment approaches has a therapeutic value. With regard to health services, the relationship between time discounting and heavy drinking raises an important contradiction. It would posit that those most likely to need insurance coverage for alcoholism treatment are least likely to choose to purchase that coverage. Unfortunately, a number of problems with the present paper limit its ability to make contributions in these fascinating areas.

The introduction shifts frequently between comparisons of different sets of

key ideas. Too often the connections between the different sets of concepts are not explained. The paper begins with a discussion of impulsiveness compared to time preference, but it shifts shortly to alcohol consumption compared to rate of discounting, a different set of concepts. It then goes on to discuss hyperbolic versus exponential functions as models of discounting, probability of reward versus delay of reward, and, finally, impulsivity as measured in the repeated-gambles task versus impulsivity as measured by personality tests. Too often it is not clear what the chain of logic is in moving from one topic to the next.

From study to study, the basis of dividing drinkers up into heavier and lighter categories shifts without explanation or discussion of the significance of these shifts. In the first and second studies, heavy and light social drinkers are compared. The third study contrasts *problem* drinkers with light social drinkers. The fourth study is conducted among persons found to be alcohol dependent according to DSM-IV criteria.

Another problem is the unspecified selection process between the total pool of available subjects and the set of subjects reported on. For example, in the first study, we are not told how a set of 380 subjects who completed the instruments is winnowed down to a set of 31 students who participated in the study. What opportunities for selection bias might there have been in the winnowing, and how were they countered?

Measurement techniques change between studies. If the Young Adult Alcohol Problem Screening Test (YAAPST) is superior for use in the student population employed here, why is it not used in the first two studies as well as in the third? Also in the third study, why do the researchers find it necessary to substitute two unspecified questionnaires that measure time orientation for the personality test instruments on impulsivity? Is it only because the results from the second study did not turn out as hoped that the substitution was made?

Finally, the fourth study relies entirely on retrospective data, but the validity and reliability of retrospective recall in these circumstances has not been discussed.

In short, I think there is potential here to open up inquiry into a very important area of research: the connection between time discounting and alcohol abuse. Unfortunately, several improvements need to be made in order to realize that potential.

Looking Ahead

I interpret the dissimilarity of these two papers to be a reflection of the newness of the enterprise of blending behavioral research and economic research in the addictions field. An older, more mature subdiscipline might have elicited papers with greater similarities as research traditions and focal questions might be more well established. This is reason to be optimistic, because it indicates that there is substantial room for development in the business of simultaneously applying economic and behavioral research approaches to addiction.

This conference as a whole shows that the two sides can productively communicate and share ideas. Hopefully, it will be the first of many such efforts at cross-fertilization.

References

Becker, Gary S., Michael Grossman, and Kevin M. Murphy. 1991. Rational addiction and the effect of price on consumption. *American Economic Review* 84:237–41.

Becker, Gary S., and Kevin M. Murphy. 1988. A theory of rational addiction. *Journal of Political Economy* 96:675–700.

Cahalan, Don, and Robin Room. 1974. *Problem drinking among American men.* Brunswick, N.J.: Rutgers Center on Alcohol Studies.

Comment on Chapters 3 and 4

Thomas F. Babor

Because economists and behavioral scientists employ different conceptual approaches and different research methods, there has been little communication and even less research collaboration between the two disciplines. In general, noneconomists have tended to ignore economic variables, while economists have tended to ignore noneconomic factors. These two studies suggest the value of econometric theory to the analysis of addictive behavior and indicate a need for greater collaboration between economists and behavioral scientists. In particular, they focus on the contrasting theoretical approaches these two disciplines bring to the analysis of drinking behavior and alcohol dependence, demonstrate the potential contributions of laboratory research to an understanding of the economic behavior of excessive drinkers, and suggest the interdependence of theory, methods, and practical knowledge.

The ingenious experiments conducted by Dr. Polachek and his colleagues demonstrate the compatibility between operant methods and economic theory, as well as the utility of animal models for hypothesis testing and theory development. The studies demonstrate that in animals, current ethanol consumption varies with past exposure, and that while price changes affect short-term drinking behavior, ethanol exposure reduces responsivity to price changes in the long run. Studies of single animals in laboratory cages fitted with operant devices are unlikely to provide convincing evidence of the dynamics of human drinking behavior in the natural environment. Nevertheless, when the animal findings are evaluated in relation to experimental findings with humans, they have the potential to contribute to a better understanding of the causal mechanisms and biological processes that account for pathological drinking. This research becomes particularly interesting in light of analogous studies con-

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ducted in the 1970s with humans who differed in the extent of their prior exposure to alcohol. When alcoholic and nonalcoholic social drinkers were allowed to work for money or alcohol in a closed residential setting for periods of up to a month, the results of several studies showed that alcoholics will modify and even moderate their drinking in response to economic contingencies, including the price of alcohol, delay of reinforcement for altemative activities, and payment for temporary abstinence (Babor 1985). Despite this responsivity to economic contingencies, alcoholics and heavy drinkers over time retum to the high levels of alcohol consumption that reflect their prior dependence history. In many respects, these findings are consistent with the animal research reported by Polacek and colleagues.

The animal findings are also interesting in light of the findings reported by Vuchinich and Simpson. Their studies suggest that the proportion of monetary resources allocated to alcohol consumption relative to other commodity classes during periods of problem drinking can serve as an index of the reward value of drinking. Moreover, a more general tendency to delay reinforcement through saving rather than spending money on alcohol seems to be a significant predictor of recovery from alcohol problems.

This research suggests that time costs constitute an important influence on the demand for alcoholic beverages. In addition to prices and income, the consumer's time is a constraint that affects the quantity, frequency, and perhaps even the type of alcohol consumed. The fact that time spent drinking could be better expended in other kinds of economic or social activity may account for the apparent differences in alcohol consumption across income levels and occupational categories. The relative time costs of spending several afternoons at a bar may be far greater to a professional accountant than to a day laborer. This may also explain why drinking tends to be concentrated during evenings and weekends, when alcohol consumption does not preclude other kinds of economic activity, and why advertisers emphasize the compatibility of drinking with other time-consuming activities such as eating, outdoor sports, and television viewing. Demand would be expected to be especially sensitive to time costs under conditions of low price.

In contrast to theories that postulate motivational factors (e.g., craving) or psychological states (e.g., mood elevation) as the basis of alcohol's reinforcing effects, the approach described by Vuchinich and Simpson focuses directly on how behavior is allocated among a set of available activities as a function of the reinforcement contingencies associated with these activities. From this perspective, the allocation of behavior to drinking, as opposed to altemative activities, is a function of the consequences of each kind of behavior (e.g., type or amount of reinforcement) and the constraints imposed on gaining access to the consequences (e.g., amount of effort, delay of reinforcement). According to this view, alcoholism is an "economic" disease condition manifested through its effects on motivation. Regardless of the compelling nature of the motivation to drink, alcohol consumption is a voluntary response expressed in the ordinary

marketplace of choice like any other source of motivational pressure. The supposed irrationality of the alcoholic's behavior is explained on the basis of temporal proximity. Alcohol is preferred because it is typically available while more socially acceptable alternatives are more distal. This perspective makes it important to analyze the drinking contexts to which alcoholics are typically exposed, because these settings presumably maximize the availability of alcohol and minimize access to other desirable alternatives. One implication of this model is that procedures that delay the availability of alcohol increase the likelihood that more desirable alternatives will be chosen, since the value of various long-term (e.g., family harmony) and short-term (e.g., getting drunk) rewards change as a function of delay.

These papers indicate the value of combining operant, cognitive, and even personality research methods with economic theory and models. Together, they suggest new ways to

model dependence phenomena using economic concepts;
develop better operational definitions of key dependence constructs (e.g., relative salience of alcohol);
test the effects of price and income on alcohol consumption;
study the effects of ethanol intoxication, alternative reinforcers, and drinking history on drinking behavior, in the context of addiction theory.

The studies suggest that despite the assumptions of classic economic theory, human beings and animals do not react to alcohol-related stimuli as automatons. In order to understand the economics of alcohol consumption, biological processes (e.g., tolerance), psychological considerations (e.g., impulsivity), and subjective variables must be incorporated in the analysis.

In the field of alcohol studies, researchers should be skeptical about broad generalizations that posit invariable relationships between one independent and one dependent variable. In contrast to this overly simplified view of economic behavior, the papers in this section recognize the complexities of drinking behavior by showing how drinking decisions are made under different environmental and organismic conditions. The conditions of decision formation encompass both external events and psychobiological states. As these studies suggest, psychology in economic research can fill the need to identify and analyze the forces behind economic processes—the forces responsible for actions, decisions, and choices connected with moderate and excessive drinking.

The crucial question is, What difference does it make whether psychological considerations are introduced into economic analysis? Both studies get at why alcohol is preferred by some people over alternative commodities; for example, past history of exposure, low price, immediate reinforcement value, delay of alternative rewards, preexisting personality traits (impulsivity, sensation seeking), tolerance/satiation, and the relative value of nonalcohol alternatives. It is interesting to compare these factors to the elements of alcohol dependence that

have been postulated in recent years as the core syndrome of alcoholism. The alcohol dependence syndrome, as currently conceived in addiction theory and diagnostic classification systems (Babor 1992), is a biobehavioral disorder consisting of neuroadaptation (tolerance to alcohol, a physical withdrawal state), relief drinking to prevent withdrawal, impaired control over the timing and amount of drinking, increased salience of drink-seeking behavior, the narrowing of the drinking behavior repertoire, and a preoccupation with alcohol consumption. Many of these elements can be formulated in behavioral-economic terms and studied with the methods of experimental psychology.

In summary, the studies presented in this section provide important insights into the etiology and maintenance of heavy drinking and of the experimental methods that can improve our understanding of human drinking behavior.

References

Babor, Thomas F. 1985. Alcohol, economics and the ecological fallacy: Toward an integration of experimental and quasi-experimental research. In *Public drinking and public policy*, ed. Eric Single and Thomas Storm, 161–89. Toronto: Addiction Research Foundation.

———. 1992. Nosological considerations in the diagnosis of substance use disorders. In *Vulnerability to drug abuse*, ed. Meyer D. Glantz and Roy Pickens, 53–73. Washington, D.C.: American Psychological Association Press.

III Illicit Drug Use