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A Comparison of Delay Discounting Among Smokers, Substance Abusers, and Non-Dependent Controls

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Abstract

Previous studies have shown that smokers and substance-dependent individuals discount rewards that are available after a delay more than individuals without a history of substance dependence. However, it is not clear whether delay discounting is similar among smokers and substance-dependent individuals. Further, the influence of the combination of smoking and other substance dependence on delay discounting remains unknown. The present study compared the performance of four groups of individuals on a delay discounting task. The groups were (a) heavy smokers with comorbid substance dependence, (b) heavy smokers with no history of substance dependence, (c) never smokers withcomorbid substance dependence, and (d) never smokers with no history of substance dependence. Analysis revealed that individuals who smoked and/or were dependent on another substance discounted delayed rewards more than individuals with no history of smoking or other substance dependence. No differences in the task performance of heavy smokers and substance-dependent individuals were found. Notably, participants who were dependent on multiple substances did not discount delayed rewards more than those dependent on only one substance. Overall, findings indicate that smoking and other substance dependence are similarly related to delay discounting.

Keywords

Delay Discounting; Smokers; Substance Use Disorders; Decision-making

1. Introduction

Numerous studies have shown that individuals with substance use disorders (SUDs) tend to prefer smaller immediate rewards over larger, more delayed rewards to a greater extent than individuals with no SUD history. Delay discounting tasks (e.g., Rachlin et al., 1991) have been used to assess this type of decision-making. Research has demonstrated that heavy drinkers discount delayed rewards more than light drinkers (Bobova et al., 2009; Petry, 2001; Vuchinich and Simpson, 1998). Similarly, individuals dependent on opiates (Kirby et

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al., 1999; Madden et al., 1996), cocaine (Coffey et al., 2003; Heil et al., 2006) methamphetamine (Hoffman et al., 2006; Hoffman et al., 2008; Monterosso et al., 2007), and heterogeneous groups of substance abusers discount delayed rewards on more than non-dependent controls (Ainslie and Haendel, 1983; Bretteville-Jensen, 1999; Petry and Casarella, 1999). In addition, several studies have shown that the subjective value of delayed rewards is diminished more in current smokers than in nonsmokers (e.g., Baker et al., 2003; Bickel et al., 1999; Kirby and Petry, 2004; Mitchell, 1999; Reynolds et al., 2004).

Although delay discounting tasks have been used to distinguish heavy smokers and individuals with other SUDs from those with no SUD history, further research is needed to determine whether delay discounting rates are similar among heavy smokers, individuals with other SUDs, and individuals who both smoke and have another SUD. This is important because approximately 80% of individuals with SUDs also smoke (Batel et al., 1995; Kalman et al., 2005). Thus, it is possible that the effect of smoking on delay discounting may confound the relation between other SUDs and delay discounting.

The purpose of the present study was to compare the discounting of delayed rewards across four groups of individuals: 1) heavy smokers with another SUD, 2) heavy smokers without another SUD, 3) never smokers with a SUD, and 4) controls with no smoking or SUD history. First, it was hypothesized that heavy smokers with another SUD would discount delayed rewards more than each of the other three groups. Second, it was hypothesized that the discounting rate of heavy smokers without a history of another SUD would be similar to that of individuals with a SUD and no history of smoking. Finally, it was hypothesized that those without a SUD or smoking history would discount delayed rewards less than all other groups.

2. Methods

2.1 Participants

Data for the current study were taken from a larger study that examined the relation between substance dependence and risk taking (see Businelle et al., 2008). Participants were recruited through fliers and other advertisements posted in the general community and at local substance abuse clinics. Individuals were eligible to participate if they had at least eight years of education and were at least 25 years of age. In addition, individuals were required to meet criteria for one of the following four groups: 1) heavy smokers with another SUD; 2) heavy smokers without another SUD; 3) never smokers with a SUD; and 4) never smokers without a SUD. Participants met inclusion criteria for the “heavy smoker” groups if they reported smoking at least 20 cigarettes per day and had been smoking for at least eight years. “Never smokers” reported smoking 10 or fewer cigarettes in their lifetime. The SUD groups included individuals who met DSM IV (American Psychiatric Association, 2000) criteria for a SUD other than Nicotine Dependence within the past six months. Those included in the “no history of SUD” groups had no previous history of a SUD (excluding Nicotine Dependence). Individuals who previously met criteria for a SUD and ex-smokers were excluded from participating in this study.

2.2 Measures

Study Screening Questionnaire (SSQ)—The SSQ inquired about sociodemographic variables such as age, gender, education, income, and race/ethnicity, as well as the amount and frequency of past and present substance use (i.e., alcohol, cigarettes, cocaine, opiates, marijuana, amphetamines, and sedatives).

The Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991)—The FTND is a six-item measure designed to assess level of nicotine dependence.

Expired Carbon Monoxide (CO)—Self-reported smoking status was verified by measuring expired CO levels with a Vitalograph portable CO monitor (Vitalograph Incorporated, Lenexa, KS, USA).

Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; Kranzler et al., 1996)—In order to identify alcohol or drug dependence, the SUD sections of the SCID were administered for any drug that prospective participants reported using in their lifetime.

Delay Discounting Task—The Petry and Casarella (1999) version of the Delay Discounting Task (DDT) was used in the current study. The DDT is a forced choice task where participants are asked if they would prefer a smaller sum of hypothetical money available immediately or a larger sum of hypothetical money available at some point in the future. Two index cards with printed hypothetical monetary amounts were placed in front of the participant and the participant chose which card he/she preferred. One index card displayed the option of $1000 that was available after some delay, while the other card displayed an alternative option. Alternative option cards in the following amounts were presented in descending order across successive trials: $1000, $999, $995, $990, $960, $940, $920, $850, $800, $750, $700, $650, $600, $550, $500, $450, $400, $350, $300, $250, $200, $150, $100, $80, $60, $40, $20, $10, $5, and $1 (Petry and Casarella, 1999). The task continued until the participant chose between each of the previously specified monetary amounts and $1000.

After the task was completed for one time delay, the procedure was repeated for the next time delay. The delay intervals were as follows: 6 hours, 1 day, 1 week, 2 months, 6 months, 1 year, 5 years, and 25 years. For each delay interval, the point at which the individual switched from preferring the smaller immediate amount to the larger delayed amount was noted and the last immediate amount selected was recorded as the indifference point. Following the procedures of Petry and Casarella (1999), instructions were read to each participant before starting the task.

Consistent with previous research, Mazur's (1987) hyperbolic decay equation was used to estimate discounting rates: $V = A / (1 + kD)$. V represents the smaller amount of immediately available money that is equal in subjective value to the larger amount of delayed money (i.e., indifference point). A represents the amount of money that is available after the delay. D represents the delay in months and k represents the discounting rate. Non-linear regression (GraphPad Prism®) was used to fit the indifference points into the above equation, thus yielding the best fit discounting rate (i.e., k value) for each participant (Motulsky and Christopoulos, 2004).

2.3 Procedure

Potential participants were screened over the telephone or in person to determine eligibility for this study via the SSQ and the SUD portions of the SCID. The study was described and informed consent was obtained from each participant before beginning the experimental session. Participants provided breath samples for CO analysis to verify self-reported smoking status. The FTND and DDT were administered to all participants, in addition to the risk taking and expectancy measures that were collected for the larger study. All study procedures took approximately one hour to complete. Following completion of all measures, participants were debriefed and paid for their time. Subject payment was initially $15, but

was later increased to $25 to increase recruitment. Payment was not dependent on task performance.

3. Results

3.1 Participants

A total of 121 participants completed all study measures. However, the DDT was improperly administered to six individuals. These six participants were dropped from all analyses. Thus, the sample size for this study was 115 participants. The number of participants in each group was as follows: (a) heavy smokers with another SUD ($n = 36$); (b) heavy smokers without another SUD ($n = 20$); (c) never smokers with a SUD ($n = 25$); and (d) never smokers without a SUD ($n = 34$).

Overall, participants were 40.8 years old ($SD = 11.0$), 58.3% male, 60% Caucasian, 37% African American, had a household income of $29,788 ($SD = $26,865), and completed 13.4 years of education ($SD = 2.3$). The four groups were tested for demographic differences using chi-square analysis for categorical data and analysis of variance for continuous data. Analyses indicated that the groups were similar in age, gender, race/ethnicity, and annual household income. However, the groups differed in education level, $F(3, 111) = 11.89$, $p < .001$. A Tukey post hoc analysis revealed that never smoker without a SUD group had more years of education than each of the other three groups. Since groups differed in years of education, all between-group analyses include this variable as a covariate.

On average, the smokers smoked 25.9 cigarettes per day ($SD = 9.0$), had been smoking for 24.0 years ($SD = 10.5$), had relatively high FTND scores ($M = 6.5$; $SD = 2.1$), and had CO levels consistent with heavy smoking ($M = 25.9$ parts per million; $SD = 9.0$). More than half of the participants in the SUD groups were dependent on alcohol (61.8%), 43.6% were marijuana dependent, 18.2% were opiate dependent, 5.5% were hallucinogen dependent, 65.5% were cocaine dependent, 12.7% were amphetamine dependent, and 12.7% were sedative/hypnotic dependent. Most of the participants in the SUD groups (78.2%) had multiple SUDs. See Businelle et al. (2008) for additional sample characteristics (e.g., demographic and SUD characteristics by group).

3.2 Delay Discounting Task Performance

Delay discounting rates were derived for each participant using Mazur's (1987) equation. See Table 1 for the median k (based on individuals) for each group. Planned comparisons were conducted to test the hypotheses that heavy smokers and individuals with other SUDs would discount delayed rewards more than those with no history of SUDs and that heavy smokers who were dependent on another substance would discount delayed rewards more than those with only one or neither of these characteristics. In these analyses, group was the independent variable, log transformed discounting rate was the dependent variable, and years of education was included as a covariate. Results revealed that individuals in the never smoker without a SUD group discounted delayed rewards less than individuals in the heavy smoker with another SUD group ($p = .02$, one-tailed, $\eta_p^2 = .050$) and the heavy smoker without another SUD group ($p = .01$, one-tailed, $\eta_p^2 = .093$). However, the delay discounting rates of never smokers without a SUD were marginally lower than the never smoker with a SUD group ($p = .05$, *ns*, one-tailed, $\eta_p^2 = .070$). No other significant differences were found between groups (all $\eta_p^2 < .008$). Notably, the discounting rates of those who were heavy smokers and/or had another SUD were nearly identical. Figure 1 depicts the hyperbolic delay curves for each group. Data were also analyzed using the area under the discounting function as the dependent variable (see Myerson et al., 2001). Results were consistent with the findings of the analyses that utilized k.

A number of follow-up analyses were conducted to further examine the data. Since the majority (78.2%) of the participants in the SUD groups had multiple SUDs, an analysis was conducted to determine if number of SUDs was related to DDT performance. Results indicated that number of SUDs was not significantly related to DDT performance ($p = .23$, $\eta_p^2 = .055$). Since seven of the 12 participants who reported only one SUD were alcohol dependent, we conducted an exploratory analysis to determine if these participants' discounting rates were different from those with other SUD(s). Results indicated that the alcohol dependent individuals and those with other SUD(s) had comparable discounting rates ($p = .76$, $\eta_p^2 = .002$). The small number of individuals who reported that their sole SUD was Marijuana Dependence ($n = 1$), Cocaine Dependence ($n = 3$), or Opiate Dependence ($n = 1$) precluded further comparison of discounting rates for these individual substances. We also conducted analyses to determine if there were gender differences in DDT performance. Results indicated that gender was not significantly related to DDT performance (all p's > .15, all $\eta_p^2 < .025$).

4. Discussion

The current study generated three key findings. Consistent with previous studies, heavy smokers and individuals with SUDs discounted delayed rewards more than controls with no smoking or SUD history. Of particular note, study findings indicated that individuals who smoked, those who had an SUD, and those who both smoked and had an additional SUD had very similar discounting rates. Finally, the total number of SUDs was not found to be significantly related to delay discounting. Overall, findings suggest that the influence of smoking on discounting rates is similar to that of other substances, and there does not appear to be an additive effect of multiple SUDS on discounting rates.

In the current study, smokers had discounting rates that were similar to the discounting rates of a heterogeneous group of individuals with one or multiple SUDs. This finding supports the hypothesis that that there is a common underlying variable, present in both smokers and those with other SUDs, that influences delay discounting. However, it is notable that several recent studies have shown delay discounting rates may not be equal across all substances of abuse (e.g., Johnson et al., 2010; Kirby and Petry, 2004). For example, Kirby and Petry (2004) found that heroin and cocaine abusers, but not alcohol abusers, had greater discounting rates than controls. It should be noted, however, that several studies have shown that alcohol abusers do discount delayed rewards more than controls (e.g., Bobova et al., 2009; Petry, 2001; Vuchinich and Simpson, 1998). Future research will be needed to determine whether delay discounting rates are relatively similar across SUDS or whether certain SUDs have a greater impact than others on discounting rates.

Given the high comorbidity of smoking with other SUDs, in combination with the findings of the current study, it appears that future studies of delay discounting among individuals who abuse substances must also consider the influence of concurrent cigarette smoking. Researchers have suggested that delay discounting rates may be used to aid development of SUD prevention and treatment programs (e.g., Kirby & Petry, 2004). However, cigarette smoking must be considered as this behavior may continue to influence task performance in the absence of other substance use. It may also be pertinent to consider smoking status (and other SUD status) in future studies that examine delay discounting in individuals with other areas of attenuated self-control (e.g., gambling addiction, binge eating).

The present study has a number of limitations that should be noted. First, the small number of participants within each cell may have limited the ability to detect actual differences between the smoking and SUD groups. In other words, larger sample sizes may be needed in order to detect significant differences that may exist between SUD groups. Second, many

participants in the SUD groups had multiple SUDs. Thus, detecting any additional effect of smoking on DDT performance in the SUD groups may have been unlikely. Third, the groups differed in years of education. Although we controlled for differences in education across groups, additional group differences may have been present and not controlled (e.g., differences in IQ across groups, potential group differences in the experimenter-participant interactions during flash card presentations). Finally, the results of this study are limited by the lack of biological confirmation of SUD status (with the exception of smoking status).

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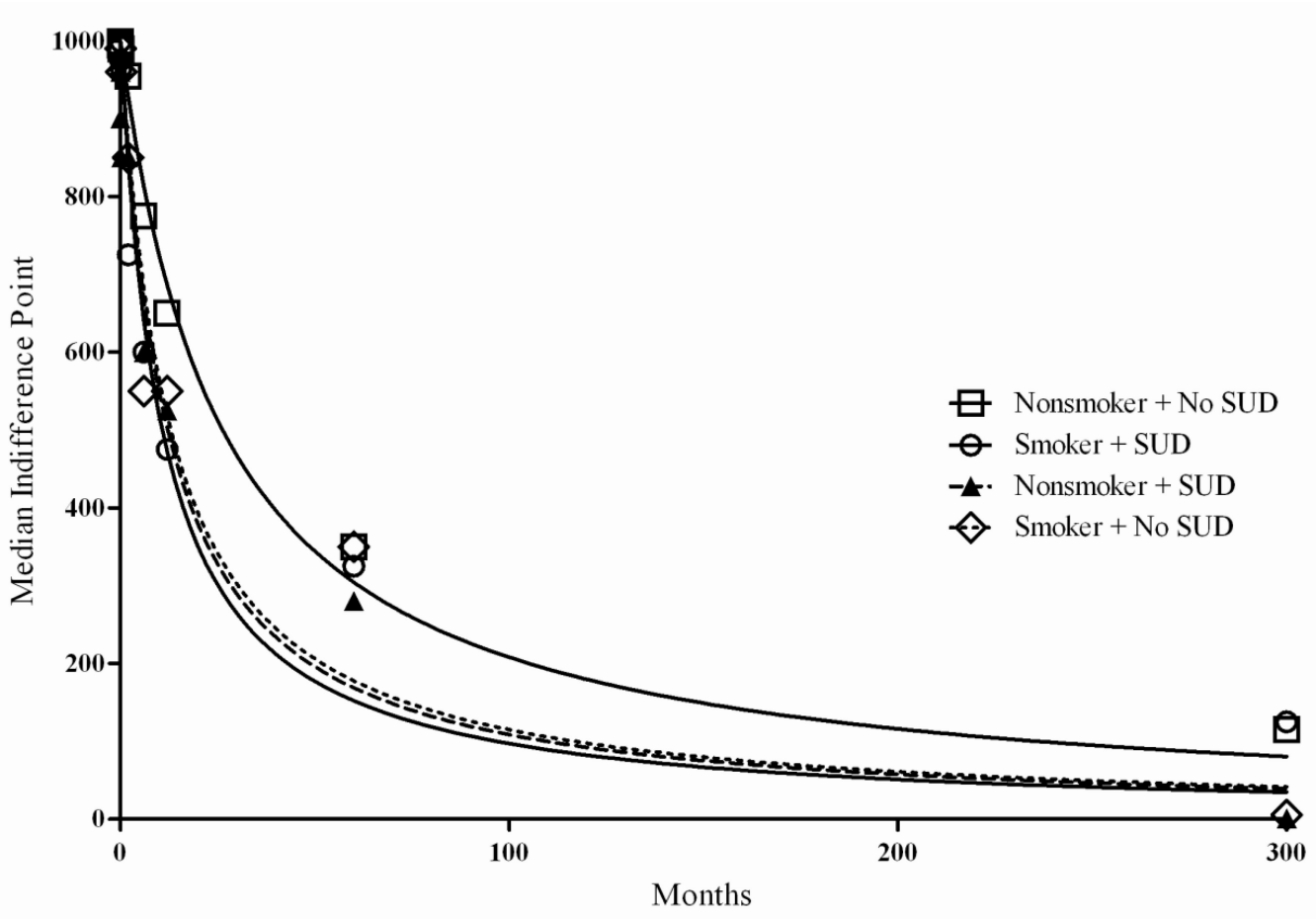

Figure 1.
Median indifference points for each of the four groups. Best fit curves were drawn through these points using Mazur's (1987) hyperbolic decay equation. SUD = Substance Use Disorder.

Table 1

Discounting Rates and R^2s on the Delay Discounting Task by Group

Group	Median *k* value	Mean of log transformed *k*	Standard deviation of log transformed *k*
Nonsmoker + No SUD	0.039	4.411	0.998
Smoker + SUD	0.093	5.103	0.981
Nonsmoker + SUD	0.081	5.031	1.158
Smoker + No SUD	0.077	5.146	0.962

Note. Since delay periods were in month units, *k* values carry the reciprocal of months (i.e., $month^{-1}$) as units. SUD = Substance Use Disorder. Median values are based on the individuals within each group.