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Adolescent Smokers Rate Delayed Rewards as Less Certain than Adolescent Nonsmokers

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Abstract

This research compared adolescent smokers (n = 45) and nonsmokers (n = 35) on ratings of certainty about receiving delayed rewards during a delay-discounting procedure. Consistent with a previous finding (Patak & Reynolds, 2007) participants generally rated the delayed rewards as increasingly uncertain with longer delays, and ratings of certainty were correlated with delay discounting (r = . 37). Also, the adolescent smokers rated the delayed rewards as significantly less certain than the nonsmokers. These findings indicate that adolescents who smoke cigarettes evaluate delayed outcomes as less certain than adolescents who do not smoke cigarettes.

1. Introduction

Delay discounting refers to observations that outcomes decrease in value, or in their effectiveness to exert control over behavior, when delayed. A more extreme tendency to discount the value of future events is taken to reflect impulsive behavior (e.g., Rachlin, 2000). Consistent with this interpretation, addicted populations often discount more by delay on laboratory assessments of delay discounting than matched, non-addicted control participants [see Reynolds (2006) for a review].

A largely unexplored but potentially important aspect of delay-discounting assessments is the degree to which participants perceive the delayed rewards as also being uncertain (see Green & Myerson, 1996). One study has recently explored participant ratings of uncertainty associated with the delayed rewards of a delay-discounting assessment (Patak & Reynolds, 2007). Participants generally rated the delayed rewards as increasingly uncertain with longer delays to receipt, and the certainty ratings were significantly correlated with how much participants discounted by delay. This finding indicates these delayed rewards are evaluated by participants both in terms of delay and uncertainty. However, no research has yet explored possible differences in certainty estimates between drug users and nonusers.

The current study compared ratings of certainty about delayed rewards between adolescent smokers and nonsmokers from previous work showing that the smokers discounted more by delay than the nonsmokers (Reynolds et al., in press). To increase statistical power, 29 adolescent participants (20 smokers) were added to the original data set for the current analyses. We hypothesized that the adolescent smokers would on average rate the delayed rewards as less certain than the nonsmokers. We also expected that controlling for certainty ratings

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between the smokers and nonsmokers would reduce the effect of smoking status on delay discounting.

2. Methods

2.1. Procedure

All data collection took place in a human-behavior laboratory at Columbus Children's Research Institute (CCRI), Department of Pediatrics, The Ohio State University. CCRI Institutional-Review-Board approved consent and assent forms were reviewed and signed by all participants. Research participation involved the completion of several behavioral tasks and questionnaires [see Reynolds et al. (in press) for further description], only two of which are reported here.

A computerized measure was used to assess delay discounting (Richards et al., 1999). Standard instructions were read to participants, as described previously (Reynolds et al., 2003). The task presented questions for five delays: 1, 2, 30, 180, and 365 days. Participants chose between $10 to be received after one of the delays and a usually smaller amount to be received immediately. The smaller amount was increased or decreased in value (± $0.50) based on previous responses until an indifference value was arrived at for each delay. An indifference value was defined as the smallest amount of money chosen to be received immediately instead of waiting the specified delay to receive the $10 standard. Participants were told before completing the delay-discounting measure that one choice would be randomly selected and honored at the end of the session (see Reynolds et al., 2003).

Immediately following the delay-discounting measure, participants were given a one-page form and asked to rate their certainties for the delayed rewards just presented during the delay-discounting assessment. There was an individual question for each delay assessed, which read as follows:

> If you had chosen the money delayed by 180 days, [the delays were different for each question] were you sure you would actually get that money if it was the randomly selected answer? How sure were you that you would get the money in 180 days if you chose it? (**circle from 1 to 10**)

Participants rated their certainties on a 1 to 10 scale that ranged from “0% certain” to “100% certain.” For future reference, this form will be referred to as a delay-discounting certainty questionnaire (DDCQ).

2.2. Analyses

An area-under-the-curve (AUC) method was used to characterize both the delay-discounting and DDCQ data (see Myerson et al., 2001). From this calculation, the entire area under each discounting and DDCQ curve (see Figure 1 for general examples) was determined, and larger AUC values (ranging from 0 to 1) reflect less discounting by delay or greater certainty about the delayed rewards on the DDCQ. Using SPSS Version 13.0©, tests of normality (Shapiro-Wilk) were performed on AUC values for both delay-discounting and DDCQ data. Neither set of data was normally distributed; therefore they were both log-10 transformed. With these transformed values, a Pearson's correlation test was used to determine degree of association between delay-discounting and DDCQ ratings. Separate between-subjects two-way ANOVAs (smoking status and gender) were performed to compare AUC values for the delay-discounting and DDCQ measures. The delay-discounting comparison for smoking status was repeated with DDCQ ratings entered as a covariate. Partial eta squares (η_p^2) were used to estimate effect sizes.

3. Results

Participant demographic information is presented in Table 1. The smokers had significantly higher breath-carbon-monoxide levels than the nonsmokers, and they also reported more use of alcohol and marijuana.

Delay-discounting data for 11% of the sample (9 participants; 5 smokers) were not included in analyses for failure to meet data-validity criteria (see Dixon et al., 2003;2005). To be retained, a participant's discounting data were required to have indifference points that decreased in monetary value over at least two successive delays and to also *not* have indifference points that increased in monetary value more than once over successive delays.

There were no significant interaction effects between smoking status and gender for delay discounting or ratings on the DDCQ, and there were no main effects of gender for either measure. However, consistent with the previous analyses (Reynolds et al., in press), the smokers still discounted more by delay than the nonsmokers after inclusion of the 29 additional participants [$F(1, 70) = 5.89$, $p = .018$; $\eta_p^2 = .081$] (see Figure 1). Median delay-discounting AUC values for the smokers and nonsmokers were .156 and .323, respectively. The smokers also rated the delayed rewards as less certain than the nonsmokers did [$F(1, 79) = 4.09$, $p = .047$; $\eta_p^2 = .051$] (see Figure 1). Median DDCQ AUC values for the smokers and nonsmokers were .417 and .502, respectively. AUC values for delay discounting and the DDCQ were significantly correlated [$r(70) = .37$, $p = .001$, two-tail test]. Separate correlation analyses for the nonsmokers and smokers showed a significant correlation for the nonsmokers [$r(30) = .52$, $p = .003$, two-tail test] but not for the smokers [$r(39) = .21$, $p = .201$, two-tail test]. When DDCQ ratings were controlled as a covariate in the delay-discounting comparison, the effect of smoking status on delay discounting was reduced, though the difference still approached statistical significance [$F(1, 70) = 3.50$, $p = .066$; $\eta_p^2 = .049$].

4. Discussion

The current findings show that adolescent smokers are less certain about receiving delayed rewards than adolescent nonsmokers. Ratings of uncertainty also were modestly correlated with delay discounting and reduced differences in delay discounting between the smokers and nonsmokers when controlled as a covariate. Future research to explore the sources of these differences in certainty ratings (e.g., different developmental/learning histories related to the predictability of future events) may be important in (a) better characterizing adolescent smokers and in (b) identifying sources of inter-individual variability in delay discounting associated with drug use.

Notably, some results lacked robustness. For example, there was a smaller, non-significant correlation between delay discounting and DDCQ ratings among the smokers. This smaller correlation may have partially resulted from there being less variability in delay discounting for the smokers than for the nonsmokers (standard errors of .057 and .067, respectively). Another possible reason for this inconsistency is that uncertainty about delayed rewards may be less relevant to delay discounting for adolescent smokers. In addition to these correlations, analyses controlling for DDCQ ratings as a covariate reduced differences in delay discounting between the smokers and nonsmokers; however, this group difference still approached statistical significance. With a larger sample, the delay discounting difference between smokers and nonsmokers may have remained statistically significant—even with DDCQ ratings controlled as a covariate.

This study should be replicated to determine the generality of these findings. For instance, the current sample consisted of adolescent participants; and while there may be little reason to expect different findings from adult participants, the present findings should be compared with

adults. Also, it is not clear how these findings will replicate when different types of delay-discounting measures are used. Recent evidence has identified systematic differences in delay discounting based on different variations of discounting procedures (e.g., Kowal et al., 2007;Robles & Vargas, 2007). Similarly, different measures of delay discounting may result in different ratings of certainty.

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References

Dixon MR, Jacobs EA, Sanders S, Guercio JM, Soldner J, Parker-Singler S, Robinson A, Small S, Dillen JE. Impulsivity, self-control, and delay discounting in persons with acquired brain injury. Behav Intervent 2005;20:101–120.

Dixon MR, Marley J, Jacobs EA. Delay discounting in pathological gamblers. J Appl Behav Anal 2003;36:449–458. [PubMed: 14768665]

Green L, Myerson J. Exponential versus hyperbolic discounting of delayed outcomes: Risk and waiting time. Am Zool 1996;36:496–505.

Kowal BP, Yi R, Erisman AC, Bickel WK. A comparison of two algorithms in computerized temporal discounting procedures. Behav Processes. 2007Epub ahead of print

Myerson J, Green L, Warusawitharana M. Area under the curve as a measure of discounting. J Exp Anal Behav 2001;76:235–243. [PubMed: 11599641]

Patak M, Reynolds B. Question-based assessments of delay discounting: Do respondents spontaneously incorporate uncertainty into their valuations for delayed rewards? Addict Behav 2007;32:351–357. [PubMed: 16647214]

Rachlin, H. The science of self control. Cambridge: Harvard University Press; 2000.

Reynolds B. A review of delay-discounting research with humans: relations to drug use and gambling. Behav Pharmacol 2006;17:651–667. [PubMed: 17110792]

Reynolds B, Karraker K, Horn K, Richards JB. Delay and probability discounting as related to different stages of adolescent smoking and non-smoking. Behav Process 2003;64:333–344.

Reynolds B, Patak M, Shroff P, Penfold RB, Melanko S, Duhig AM. Laboratory and self-report assessments of impulsive behavior in adolescent daily smokers and nonsmokers. Exp Clin Psychopharmacol. in press

Richards JB, Zhang L, Mitchell S, de Wit H. Delay and probability discounting in a model of impulsive behavior: Effect of alcohol. J Exp Anal Behav 1999;71:121–143. [PubMed: 10220927]

Robles E, Vargas PA. Functional parameters of delay discounting assessment tasks: Order of presentation. Behav Processes. 2007Epub ahead of print

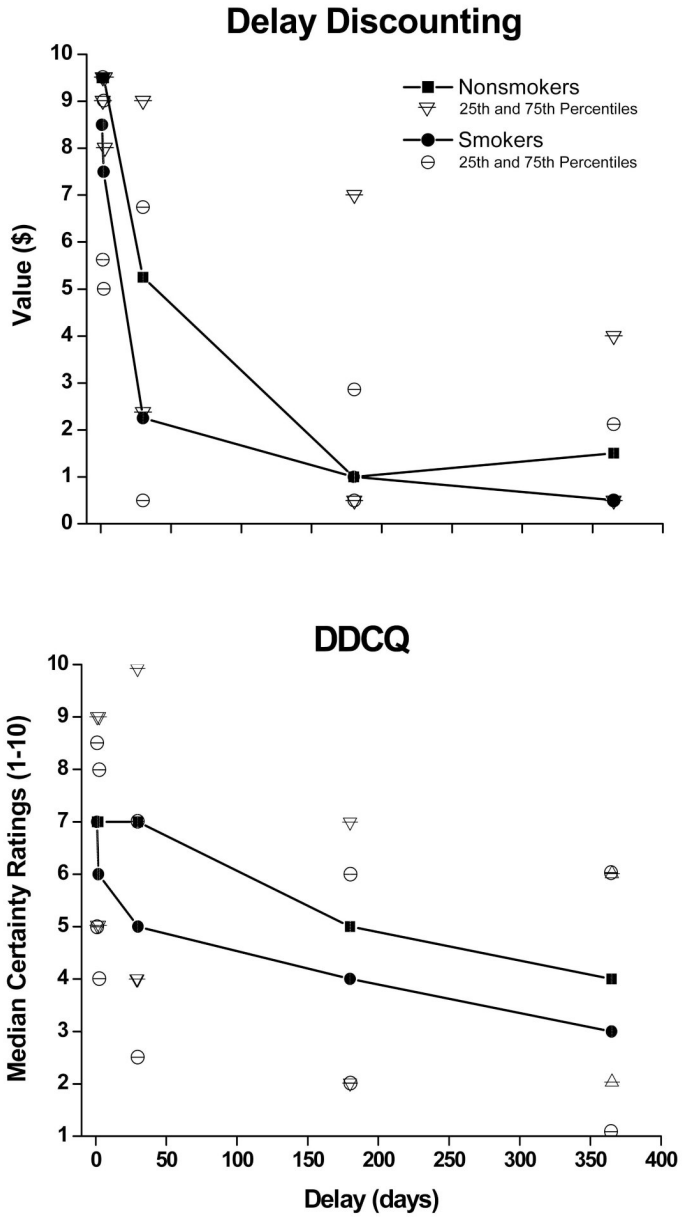

Figure 1.
Top panel: delay-discounting gradients for nonsmokers and smokers for five different delays to a $10 standard. Bottom panel: certainty ratings (1 to 10 scale) for adolescent smokers and nonsmokers based on the five different delays to the $10 delay-discounting standard. The 25th and 75th percentiles are provided for each median indifference point for nonsmokers and smokers.

Table 1

Participant Demographics and drug-use summaries (N = 80)

	Smokers	Nonsmokers
Demographics:		
Sex (*n*; male:female)	21:24	19:16
Age [years; *M* (*SD*)]	15.57 (1.12)	14.80 (0.83)
Race (n; white:black:other)	30:12:03	19:15:01
Carbon monoxide [ppm; *M* (*SD*)]	10.36 (7.10)	1.71 (1.53)**
Annual Household Income ($; Median)[a]	61,572.05	72,531.21
Drug Use [M (SD)][b]		
Cigarettes (number per day)[c]	7.30 (5.17)	0.00 (0.00)**
Alcohol	1.66 (1.05)	0.40 (0.60)*
Marijuana	2.44 (1.67)	0.06 (0.24)**

[a] Annual household income is the median household income from the 2005 adjusted census-tract data.

[b] Except where specified otherwise, drug use was assessed with the following question: 'Thinking about the past six months, how often have you used the following substances?': 0 = Never Tried, 1 = Tried it, 2 = 1-2 times/month, 3 = Once a week, 4 = 2-4 times/week, 5 = 5 or more times/week.

[c] Cigarettes per day were calculated using a timeline followback calendar to determine average number of cigarettes smoked each day over the past 30 days.

* $p < .05$

** $p < .01$ (two-tailed tests)