Published in final edited form as:

Subst Abus. 2013 ; 34(3): 256–262. doi:10.1080/08897077.2012.763082.

Cigarette smoking and measures of impulsivity in a college sample

Emily C. Balevich, M.A.,

Department of Psychology, Queens College and The Graduate Center of the City University of New York

Naftali D. Wein, B.A., and

Department of Psychology, Queens College

Janine D. Flory, Ph.D.

Department of Psychiatry Mount Sinai School of Medicine/James J Peters Bronx VAMC

Abstract

An association between impulsivity and smoking has been consistently reported in the literature, but few studies have examined how distinct dimensions of impulsivity may relate differentially to smoking initiation versus persistent smoking. The aim of the current study was to examine the relationship between self-report and behavioral measures of impulsivity and smoking status in college students. Participants ($n=243$) completed a self-report history of tobacco use, two self-report measures of impulsivity (the Barratt Impulsiveness Scale and Zuckerman Sensation-Seeking Scale) and two behavioral measures (the Delay Discounting Task and Iowa Gambling Task). All participants were classified as never-smokers, triers, or smokers based on their smoking history, and between-group differences on the four measures were examined. On the self-report measures, all three groups differed on sensation seeking with the never-smokers reporting the lowest levels and the smokers reporting the highest. Furthermore, the smokers reported significantly higher disinhibitory impulsivity than the triers and never-smokers. The groups did not differ on the behavioral measures. Our results indicate that distinct dimensions of impulsivity characterize different smoking phenotypes. In particular, sensation seeking is associated with the initiation of smoking whereas disinhibitory impulsivity is associated with the transition to more persistent and regular use of cigarettes.

Keywords

delay discounting; disinhibition; impulsivity; reward seeking; tobacco use

1. Introduction

Cigarette smoking is the leading preventable cause of death in the United States¹. As many as 90% of adult smokers began smoking before or at the age of 18, and nearly one fourth of all high school students and young adults are current smokers^{2,3}. As such, the development of effective smoking prevention and cessation strategies for young people is an important public health issue. Identifying characteristics associated with smoking initiation and persistent smoking in this population is critical for the development of such strategies.

Impulsivity is widely recognized as a multidimensional trait that is associated with substance use problems, including initiation of use and addiction to tobacco⁴⁻⁷.

The association between impulsivity and cigarette smoking has been consistently demonstrated in research utilizing self-report scales. Cross-sectional studies have shown that adolescent and adult smokers report greater disinhibitory impulsivity⁸⁻¹⁰ and sensation-seeking^{8,11} than their non-smoking counterparts. For the most part, this research compares smokers and non-smokers, but does not examine whether different aspects of impulsivity are related to distinct smoking phenotypes, e.g., initiation versus persistence of use. Impulsivity is presumed to be a multidimensional construct, and recent factor analyses have supported the notion that the construct has two underlying dimensions: reward sensitivity and rash impulsiveness¹². A two-step model of addiction has been proposed which states that individual differences in reward sensitivity mediate initial use whereas differences in rash impulsiveness mediate persistent abuse of substances¹². Our previous findings revealed that the Barratt Impulsiveness Scale, Zuckerman Sensation Seeking Scale, and the Novelty-Seeking scale of the Temperament and Character Inventory loaded onto two factors labeled Disinhibition and Reward Seeking¹³. Disinhibition included items that indicate a lack of reflection or inability to constrain an impulse; Reward Seeking included items that indicate novelty and sensation seeking and reflect an approach orientation. We found that Disinhibition was associated with tobacco dependence and a younger age of initiation of tobacco use while Reward Seeking was not. Both factors of impulsivity were related to smoking initiation. These results are consistent with a two-step model of addiction as proposed by Dawe et al.¹².

Research examining the association between cigarette smoking and behavioral measures of impulsivity, however, has yielded less consistent results. Smokers have been shown to perform more impulsively on a delay discounting task (DDT) compared to non-smokers in adult^{14,15} and adolescent⁹ samples. However, Reynolds, Karraker, Horn, & Richards¹⁶ failed to find such an effect in a sample of adolescent smokers, and Bickel et al.¹⁴ found no differences on DDT performance between non-smokers and ex-smokers. Sweitzer et al.¹⁵ examined different aspects of tobacco use in an attempt to resolve inconsistencies in the literature and found that while total tobacco exposure was not related to delay discounting, people reporting heavy tobacco dependence discounted more steeply than people with fewer signs of tobacco dependence; early morning smoking, in particular, was related to delay discounting. These results are consistent with data reported by Field, Santarcangelo, Sumnall, Goudie, & Cole¹⁷ who found that daily smokers performed more impulsively after an at least 13 hour period of smoking abstinence compared to when they smoked as usual. Inconsistent results from these cross-sectional observations raise the question of whether performance on the DDT is a stable trait which may differentiate smokers from non-smokers or varies as a function of cigarette use.

The Iowa Gambling Task (IGT) is understood to measure decision-making impairments thought to be reflective of impaired functioning of the prefrontal cortex¹⁸. Performance on the IGT has been shown to be impaired in a variety of substance abusers¹⁹⁻²² suggesting that addiction may be associated with prefrontal dysfunction that manifests in the inability to inhibit impulsive behavior¹². Thus, according to the two-step model of addiction, performance on the IGT may be related to an individual's propensity to transition to persistent use of a substance. However, few studies have examined performance on the IGT in smokers, and those which did failed to find any differences between smokers and non-smokers^{23,24} or between dependent and non-dependent smokers²⁵.

The aim of the current study was to evaluate the association of commonly used self-report and behavioral measures of impulsivity and decision-making with cigarette smoking in

young adults. We set out to replicate the results reported previously in a middle aged sample, i.e., to determine whether sensation seeking and disinhibitory impulsivity were associated with initiation versus persistent cigarette smoking. We also evaluated whether behavioral measures of impulsivity and decision-making would be associated with smoking phenotype.

2. Methods

2.1. Participants

Study participants included undergraduate students enrolled in an introductory psychology course ($n=243$) who received course credit for participation. The study sample had a mean age of 19.4 years (± 1.4) and included 113 males and 130 females. According to their answers on a self-report history of tobacco use, participants were classified into one of three groups: never-smokers ($n=102$), triers ($n=91$), and smokers ($n=50$). Those who had never smoked a cigarette were included in the never group; those who had tried smoking but smoked less than 100 cigarettes in their lifetime were included in the trier group; and those who had smoked at least 100 cigarettes in their lifetime were included in the smoker group. In addition to cigarette use, participants were asked to report their use of alcohol, marijuana and waterpipe for comparison purposes.

2.2. Measures

Table 1 presents a summary of the self-report and behavioral measures of impulsivity used in the analysis. The Barratt Impulsiveness Scale (BIS-11A) is a 30-item self-rated scale that measures the tendency to control thoughts and behaviors (e.g., acts without thinking, decides “on the spur of the moment,” does not plan ahead)^{26,27}. This version of the scale has three subscales: Nonplanning, Cognitive Impulsiveness, and Motor Impulsiveness. Items are rated on a scale of 1 to 4, ranging from rarely/never to almost always/always. In an independent sample of thirty students, retest reliability statistics obtained over a period of four to six weeks revealed strong retest reliability ($r=0.78$) for the BIS-11A.

The Zuckerman Sensation Seeking Scale (SSS-V) is a 40 item scale that measures an individual's preference to seek novel and complex experiences²⁸. Items present two opposing statements and respondents are asked to choose the one that most closely matches their “likes or feelings”. The scale has four subscales: Thrill and Adventure Seeking, Experience Seeking, Boredom Susceptibility and Disinhibited Behavior. Retest reliability statistics obtained over a period of four to six weeks showed strong retest reliability for the SSS-V ($r=0.87$).

The Delay Discounting Task (DDT) is a computerized reward choice task that asks respondents to make hypothetical choices about receiving money¹⁵. Two versions of this task, a fixed-sequence and titrating sequence version, were presented to subjects in counterbalanced order to evaluate the comparability of the alternate forms. In the fixed-sequence version, participants were presented with 161 choices in randomized order on a computer screen. They had to decide between receiving an amount of money, ranging from \$0.10 to \$105, that they could receive immediately (today) versus an alternative fixed amount (\$100) that they could receive after a delay, which ranged from 0 to 1825 days. All combinations of delays and immediate rewards were presented in randomized order, and indifference points were calculated for each delay interval using the procedure described by Mitchell⁸. In the second version, the computer program presented the lowest amount to be received immediately and calculated indifference points during task administration, i.e., subsequent choices were titrated according to the indifference points of an individual. Additionally, in the second version of the task, the delay ranged from 1 to 1825 days.

Indifference points for both versions were calculated using the procedure described by Mitchell⁸. A hyperbolic function was then fitted to these seven indifference points using Mazur's equation²⁹: $V=A/(1+kD)$, where k is the free parameter describing the steepness of the discounting curve, and larger k values indicate steeper discounting^{8,30,31}. A log transformation was used to normalize the distribution of k values, and R^2 values were calculated for each participant to measure goodness of fit of the hyperbolic function. Although not all participants were administered the same version of the task, prior research has demonstrated that the discounting function is comparable across alternate formats of presentation³², including fixed-sequence versus titrating sequence procedures³³. Additionally, the two versions were presented to the independent sample of 30 students in counterbalanced order to evaluate the comparability of the alternate forms and results showed that the two versions of the task were comparable ($r=0.75$).

The Iowa Gambling Task (IGT) is also a reward choice task in which the goal is to maximize the amount of hypothetical money earned by choosing a card from one of four decks^{18,34}. Two of the decks (A, B) are associated with bigger wins (\$100) and two decks (C, D) are associated with smaller wins (\$50). Although decks A and B are associated with bigger wins, choosing from these decks also results in bigger losses over time (punishment) and it is more advantageous (i.e., less impulsive) to choose from decks C and D. The dependent measure used in the current analyses was the difference between good choices (C and D) and bad choices (A and B) on the final set of 20 trials. The score ranges from -100 to 100, and lower values represent riskier choices. Notably, performance on this task was not comparable over time in the independent sample of students ($r=0.27$).

2.3. Procedure

Upon arriving at the laboratory, participants were given a brief overview of the study. Following written informed consent procedures, participants completed the two self-report measures via an online survey program. Next, participants were presented with the two behavioral tasks: the DDT and the IGT. Of the 243 total participants, 135 completed version 1 of the DDT as described above, and 108 completed version 2 of the task. Data for 9 participants are missing for the fixed-sequence version of the tasks because participants responded inconsistently to the choices, rendering the program unable to calculate a discount curve. Data from 12 participants were excluded from the analysis because their R^2 was less than .51, indicating a poor fit of the hyperbolic function, resulting in a sample size of 222 for this task. The protocol was approved by the Institutional Review Board at Queens College.

2.4. Statistical Analyses

A series of one-way analyses of variance (ANOVAs) was conducted to examine differences across smoking groups on the two self-report total scores and the two behavioral measures. The Bonferroni method was used to correct for multiple comparisons ($\alpha=0.05/4=0.01$). All significant ANOVAs were followed up with Tukey's post-hoc tests.

3. Results

Table 2 presents demographic data on the participants by smoking group. The groups did not differ by age, but smokers were more likely to be male relative to never-smokers and triers. The groups differed in terms of race; the majority of never-smokers were Caucasian and Asian, the majority of triers were Caucasian and Latino/Hispanic, and the majority of smokers were Caucasian. The groups did not differ on parents' level of education. Smokers were the most likely to have tried alcohol, marijuana, and waterpipe, followed by the triers. The never-smokers were least likely to have tried any of the three.

Table 3 summarizes how the three smoking status groups differed on the self-report and behavioral measures of impulsivity. The results revealed that regular smokers reported significantly higher (i.e., more impulsive) total scores on the BIS-11A relative to those people who had never smoked or who had only tried smoking. Because the total score revealed a significant group difference ($p < 0.001$), subscale analyses were conducted and showed that scores on the Motor Impulsiveness subscale followed this same pattern. On the Cognitive Impulsiveness subscale, never smokers reported lower impulsivity than the smokers, but neither subgroup differed from the trier subgroup.

With respect to the SSS-V scale, results indicated that the smoking groups all differed from each other on the total score, with regular smokers reporting the highest level of sensation seeking and nonsmokers reporting the lowest level. Again, because this group difference was significant ($p < 0.001$), subscale analyses were conducted and showed that this pattern was repeated in the Disinhibition subscale. Never smokers reported a lower tendency toward Experience Seeking, relative to the triers and the smokers.

Analyses did not reveal any group differences on either DDT or IGT performance.

4. Discussion

The present study evaluated how two self-report measures and two behavioral tasks of impulsivity relate to smoking status. Smokers were differentiated from never smokers and triers by higher disinhibitory impulsivity (i.e., higher total and motor subscale scores on the BIS-11A). The smokers also reported higher Cognitive Impulsiveness than the never-smokers. Previously we reported that the three BIS-11A subscale scores loaded onto a latent factor that was associated with tobacco dependence and a lower age of first use of tobacco among middle-aged adults¹³. The results reported here are consistent with those findings and suggest that the impulsivity traits measured by the BIS-11A may mediate the transition from casual, occasional smoking to more regular smoking. In contrast, never smokers were distinguished from people who reported ever smoking, including casual and regular smokers, by lower reports of Experience Seeking and Disinhibition. Here again, the results are consistent with our prior results showing that smoking initiation is associated with higher sensation seeking and suggest that sensation seeking may distinguish between people who do and do not experiment with cigarettes.

The results reported here are notable in that they were observed in a young adult sample, suggesting that the prior dissociation observed between smoking phenotypes and trait measures of impulsivity and sensation seeking in a middle-aged sample does not simply reflect the consequences of long term tobacco use. Because many of the so-called regular users in the current sample have not yet begun to smoke heavily, it appears that casual and more regular smokers are dissimilar with respect to these trait measures even at the beginning stages of tobacco use. This pattern of results could be interpreted as evidence for models of substance dependence that propose that addiction represents a loss of effortful control after repeated use, but that initiation of such use is influenced by a variety of factors, including availability and the rewarding properties of its use, and that these two processes may have different underlying neurobiological correlates³⁵. It is thought that the loss of effortful control that characterizes addiction is a consequence of regular use, but an alternative view is that the inability to constrain or inhibit drug use represents an individual difference factor that predates the initiation of drug use¹². Animal data indicate that these constructs may be orthogonal³⁶. Interestingly, Ersche, Turton, Pradhan, Bullmore, & Robbins³⁷ administered these same two questionnaires in a family study of chronic stimulant users and showed that siblings of addicted users reported higher levels of BIS-11A impulsivity relative to control volunteers, but they did not differ from controls on SSS-V

scores. These results suggest that the BIS-11A scale may tap an endophenotype (e.g., disinhibitory impulsivity or low effortful control) for drug addiction.

Consistent with prior research, performance on the IGT did not differ among the three smoking groups^{24,25}. One possible explanation for our lack of findings is that impaired IGT performance typically seen in other types of substance abusers may actually be the result of, rather than a precipitating factor for, substance use. The lack of an association between smoking status and DDT performance was somewhat surprising in light of the abundant evidence that smokers do perform more impulsively on this task, and in particular that tobacco dependence is associated with steeper discounting¹⁵. As such, we did expect that smokers would perform more impulsively on this measure; however, it is possible that we did not find this effect because our smokers are relatively new to smoking and may not yet be addicted. As Reynolds, Ortengren, Richards, & de Wit³⁸ have noted, the question of whether performance on the DDT reflects a consequence or a predisposing factor for tobacco use (and dependence) has not been resolved. However, results consistent with the latter view come from two sources. First, Audrain-McGovern and colleagues³⁹ identified three distinct smoking trajectories in a prospective longitudinal cohort that spanned the years from 15 to 21, including nonsmokers, early/fast smoking adopters and slow smoking progressors and found that baseline delay discounting was associated with the acquisition of tobacco use. Additionally, results from a family study of maternal smoking showed that the 12-13 year old children of mothers who were smokers discounted more than children of non-smoking mothers⁴⁰. Notably, none of the children had yet initiated tobacco use.

A few limitations of the current study should be noted. First, the generalizability of the results is limited by the use of a college student sample which is restricted on a number of factors such as level of education and socioeconomic status. Future research should address this issue by replicating these results in a more representative sample. Secondly, the use of a cross-sectional research design limits our ability to determine directionality of the results. An alternative hypothesis is that the prolonged cigarette use leads to neurological changes that underlie increased levels of impulsive behavior. Furthermore, because the smokers in our sample are relatively new to smoking, it is uncertain whether they will transition to regular smoking in the long-term and become truly addicted. Thus, future research should address these issues with the use of a longitudinal study which follows subjects over long periods of time, from the initiation of use to long-term, persistent use of cigarettes. The question of whether self-reported and behavioral measures of impulsivity show change when long term smokers stop using tobacco is also unanswered. The use of neuroimaging techniques to relate self-report and behavioral tasks to neural circuitry and to examine how this neural circuitry may change as a function of smoking initiation, persistent smoking, and smoking termination following long-term smoking would help further our understanding of the relationship between impulsivity and smoking.

To conclude, we observed that disinhibitory impulsiveness, as measured by the BIS-11A, is associated with regular smoking among new smokers but that sensation seeking was associated with a propensity to try smoking.

Acknowledgments

This research was supported by National Institutes of Health grants MH K01-069979 (JDF).

References

1. CDC. Smoking-attributable mortality, years of potential life lost, and productivity losses, United States, 2000-2004. *Morbidity and Mortality Weekly Report*. 2008; 57:3.

2. CDC. Smoking and Tobacco Use: National Youth Tobacco Survey. NYTS Data and Documentation; 2006. 2006
3. CDC. Cigarette Smoking Among Adults and Trends in Smoking Cessation -- United States 2008. Morbidity and Mortality Weekly Report. 2009; 58:6.
4. de Wit H, Richards JB. Dual determinants of drug use in humans: reward and impulsivity. *Nebr Symp Motiv.* 2004; 50:19–55. [PubMed: 15160637]
5. Lejuez CW, Magidson JF, Mitchell SH, Sinha R, Stevens MC, de Wit H. Behavioral and biological indicators of impulsivity in the development of alcohol use, problems, and disorders. *Alcohol Clin Exp Res.* Aug; 2010 34(8):1334–1345. [PubMed: 20491733]
6. Mitchell SH. Measuring impulsivity and modeling its association with cigarette smoking. *Behav Cogn Neurosci Rev.* Dec; 2004 3(4):261–275. [PubMed: 15812110]
7. Rogers RD, Moeller FG, Swann AC, Clark L. Recent research on impulsivity in individuals with drug use and mental health disorders: implications for alcoholism. *Alcohol Clin Exp Res.* Aug; 2010 34(8):1319–1333. [PubMed: 20528825]
8. Mitchell SH. Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology (Berl).* Oct; 1999 146(4):455–464. [PubMed: 10550496]
9. 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.* Jun; 2007 15(3):264–271. [PubMed: 17563213]
10. Skinner MD, Aubin HJ, Berlin I. Impulsivity in smoking, nonsmoking, and ex-smoking alcoholics. *Addict Behav.* Jul; 2004 29(5):973–978. [PubMed: 15219344]
11. Lejuez CW, Aclin W, Bornovalova M, Moolchan ET. Differences in risk-taking propensity across inner-city adolescent ever- and never-smokers. *Nicotine Tob Res.* Feb; 2005 7(1):71–79. [PubMed: 15804679]
12. Dawe S, Gullo MJ, Loxton NJ. Reward drive and rash impulsiveness as dimensions of impulsivity: implications for substance misuse. *Addict Behav.* Sep; 2004 29(7):1389–1405. [PubMed: 15345272]
13. Flory JD, Manuck SB. Impulsiveness and cigarette smoking. *Psychosom Med.* May; 2009 71(4): 431–437. [PubMed: 19251874]
14. Bickel WK, Odum AL, Madden GJ. Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology (Berl).* Oct; 1999 146(4):447–454. [PubMed: 10550495]
15. Sweitzer MM, Donny EC, Dierker LC, Flory JD, Manuck SB. Delay discounting and smoking: association with the Fagerstrom Test for Nicotine Dependence but not cigarettes smoked per day. *Nicotine Tob Res.* Oct; 2008 10(10):1571–1575. [PubMed: 18946776]
16. Reynolds B, Karraker K, Horn K, Richards JB. Delay and probability discounting as related to different stages of adolescent smoking and non-smoking. *Behav Processes.* Oct 31; 2003 64(3): 333–344. [PubMed: 14580702]
17. Field M, Santarcangelo M, Sumnall H, Goudie A, Cole J. Delay discounting and the behavioural economics of cigarette purchases in smokers: the effects of nicotine deprivation. *Psychopharmacology (Berl).* Jun; 2006 186(2):255–263. [PubMed: 16609902]
18. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition.* Apr-Jun; 1994 50(1-3):7–15. [PubMed: 8039375]
19. Barry D, Petry NM. Predictors of decision-making on the Iowa Gambling Task: independent effects of lifetime history of substance use disorders and performance on the Trail Making Test. *Brain Cogn.* Apr; 2008 66(3):243–252. [PubMed: 17942206]
20. Bechara A, Damasio H. Decision-making and addiction (part I): impaired activation of somatic states in substance dependent individuals when pondering decisions with negative future consequences. *Neuropsychologia.* 2002; 40(10):1675–1689. [PubMed: 11992656]
21. Hermann D, Lemenager T, Gelbke J, Welzel H, Skopp G, Mann K. Decision making of heavy cannabis users on the Iowa Gambling Task: stronger association with THC of hair analysis than with personality traits of the Tridimensional Personality Questionnaire. *Eur Addict Res.* 2009; 15(2):94–98. [PubMed: 19142009]

22. Kjome KL, Lane SD, Schmitz JM, et al. Relationship between impulsivity and decision making in cocaine dependence. *Psychiatry Res.* Jul 30; 2010 178(2):299–304. [PubMed: 20478631]
23. Businelle MS, Apperson MR, Kendzor DE, Terlecki MA, Copeland AL. The relative impact of nicotine dependence, other substance dependence, and gender on Bechara Gambling Task performance. *Exp Clin Psychopharmacol.* Dec; 2008 16(6):513–520. [PubMed: 19086772]
24. Lejuez CW, Aklin WM, Jones HA, et al. The Balloon Analogue Risk Task (BART) differentiates smokers and nonsmokers. *Exp Clin Psychopharmacol.* Feb; 2003 11(1):26–33. [PubMed: 12622341]
25. Harmsen H, Bischof G, Brooks A, Hohagen F, Rumpf HJ. The relationship between impaired decision-making, sensation seeking and readiness to change in cigarette smokers. *Addict Behav.* Apr; 2006 31(4):581–592. [PubMed: 15982828]
26. Barratt, ES. Impulsiveness and Aggression. In: Monahan, J.; Steadman, HJ., editors. *Violence and mental disorder: developments in risk assessment.* University of Chicago Press; Chicago: 1994. p. 61-79.
27. Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. *J Clin Psychol.* Nov; 1995 51(6):768–774. [PubMed: 8778124]
28. Zuckerman, M. *Sensation Seeking: Beyond the Optimal Level of Arousal.* Lawrence Erlbaum Associates, Inc.; Hillsdale, NJ: 1979.
29. Mazur, JE. An adjusting procedure for studying delayed reinforcement. In: Commons, ML.; Mazur, JE.; Nevin, JA.; Rachlin, H., editors. *The Effect of Delay and Intervening Events on Reinforcement Value.* Vol. 5. Lawrence Erlbaum Associates, Inc.; Hillsdale, N.J.: 1987. p. 55-73.
30. de Wit H, Flory JD, Acheson A, McCloskey M, Manuck SB. IQ and nonplanning impulsivity are independently associated with delay discounting in middle-aged adults. *Personality and Individual Differences.* 2007; 42(1):111–121.
31. Richards JB, Zhang L, Mitchell SH, de Wit H. Delay or probability discounting in a model of impulsive behavior: effect of alcohol. *J Exp Anal Behav.* Mar; 1999 71(2):121–143. [PubMed: 10220927]
32. Epstein LH, Richards JB, Saad FG, Paluch RA, Roemmich JN, Lerman C. Comparison between two measures of delay discounting in smokers. *Exp Clin Psychopharmacol.* May; 2003 11(2):131–138. [PubMed: 12755457]
33. Rodzon K, Berry MS, Odum AL. Within-subject comparison of degree of delay discounting using titrating and fixed sequence procedures. *Behav Processes.* Jan; 2011 86(1):164–167. [PubMed: 20932882]
34. Bechara, A. *Iowa Gambling Task: Professional manual.* Psychological Assessment Resources; Odessa, FL: 2007.
35. Goldstein RZ, Volkow ND. Drug addiction and its underlying neurobiological basis: neuroimaging evidence for the involvement of the frontal cortex. *Am J Psychiatry.* Oct; 2002 159(10):1642–1652. [PubMed: 12359667]
36. Belin D, Mar AC, Dalley JW, Robbins TW, Everitt BJ. High impulsivity predicts the switch to compulsive cocaine-taking. *Science.* Jun 6; 2008 320(5881):1352–1355. [PubMed: 18535246]
37. Ersche KD, Turton AJ, Pradhan S, Bullmore ET, Robbins TW. Drug addiction endophenotypes: impulsive versus sensation-seeking personality traits. *Biol Psychiatry.* Oct 15; 2010 68(8):770–773. [PubMed: 20678754]
38. Reynolds B, Ortengren A, Richards JB, de Wit H. Dimensions of impulsive behavior: Personality and behavioral measures. *Personality and Individual Differences.* 2006; 40(2):305–315.
39. Audrain-McGovern J, Rodriguez D, Epstein LH, Cuevas J, Rodgers K, Wileyto EP. Does delay discounting play an etiological role in smoking or is it a consequence of smoking? *Drug Alcohol Depend.* Aug 1; 2009 103(3):99–106. [PubMed: 19443136]
40. Reynolds B, Leraas K, Collins C, Melanko S. Delay discounting by the children of smokers and nonsmokers. *Drug Alcohol Depend.* Jan 1; 2009 99(1-3):350–353. [PubMed: 18818028]

Table 1
Self-report and behavioral measures of impulsivity

<u>Self-Report Measures</u>		
Scale	Scores	Description
Barratt Impulsiveness Scale (Barratt, 1994; Patton, Stanford, & Barratt, 1995)	Nonplanning	lack of concern for the future
	Motor Impulsiveness	acting without thinking
	Cognitive Impulsiveness	making quick cognitive decisions
	Total	overall lack of control of thoughts and behaviors
Zuckerman Sensation Seeking Scale (Zuckerman, 1979)	Thrill and Adventure Seeking	desire to engage in sports or activities involving speed and danger
	Experience Seeking	desire for experience through the mind and senses, travel and a non-conforming lifestyle
	Disinhibition	desire for social and sexual disinhibition
	Boredom Susceptibility	aversion to repetition, routine and dull people
	Total	overall preference to seek novel and complex experiences
<u>Behavioral Measures</u>		
Task	Scores	Description
Delay Discounting Task (Sweitzer, et al., 2008)	logk	log transformation of k , the free parameter describing the steepness of the discounting curve
Iowa Gambling Task (Bechara et al., 1994)	diff ₅	the difference between good choices (C and D) and bad choices (A and B) on the final set of 20 trials

Table 2

Sample characteristics according to smoking group

Variable	Never-Smokers (n=102)	Triers (n=91)	Smokers (n=50)	F or χ^2	p
Age [X (s.d)]	19.30 (1.34)	19.46 (1.39)	19.70 (1.33)	1.44	0.24
Gender (n%)				7.8	0.02
Male	42/41.1	39/42.9	32/64.0		
Female	60/58.8	52/57.1	18/36.0		
Race (n%)				34.46	<0.001
Caucasian	33/32.3	40/44.0	34/68.0		
African-American	9/8.8	5/5.5	0/0		
Asian	32/31.3	10/11.0	9/18.0		
Latino/Hispanic	18/17.6	25/27.5	2/4.0		
Native American	4/3.9	5/5.5	3/6.0		
Bi/Multiracial	6/5.9	6/6.6	2/4.0		
Other					
Mother's Level of Education [X(s.d.)] ^a	3.94 (2.46)	4.06 (2.41)	4.69 (2.19)	1.72	0.18
Father's Level of Education [X(s.d.)]	3.77 (2.56)	3.85 (2.47)	4.21 (2.35)	0.52	0.60
Ever Tried Alcohol (n%)	62/60.8	83/92.2	48/96.0	39.57	<0.001
Ever Tried Marijuana (n%)	9/8.6	52/57.1	42/84.0	90.62	<0.001
Ever Tried Waterpipe (n%) ^b	15/19.5	43/65.2	30/83.3	50.71	<0.001

^a Parental education was coded on a 8-point scale where 0 indicates no high school diploma, 1 GED, 2 high school diploma, 3 some technical training, 4 some college but no degree, 5 associate's degree, 6 bachelor's degree, 7 master's degree, 8 MD/PhD/ID/PharmD

^b Subset of 179 participants

Table 3

Group Differences for self-report and behavioral measures of impulsivity

Measure	1 Never-Smokers		2 Triers		3 Smokers		F	p	Partial η^2	Significant post hoc comparison
	M	SD	M	SD	M	SD				
Barratt Impulsiveness Scale										
Total	65.31	9.99	67.33	9.48	72.4	9.07	9.03	<0.001	0.07	1,2<3
Nonplanning	25.48	4.72	25.65	4.97	27.42	5.14	2.82	0.06	0.02	
Motor Impulsiveness	20.89	4.35	22.03	4.25	24.22	4.39	9.11	<0.001	0.07	1,2<3
Cognitive Impulsiveness	18.94	3.52	19.65	3.23	20.76	3.20	5.85	0.003	0.05	1<3
Zuckerman Sensation Seeking Scale										
Total	54.46	5.82	58.24	5.91	61.66	4.91	24.69	<0.001	0.17	1<2<3
Thrill and Adventure Seeking	15.62	2.82	16.14	2.85	16.84	2.64	2.44	0.09	0.02	1<3
Experience Seeking	13.51	1.94	14.54	2.06	15.24	1.59	14.67	<0.001	0.11	1<2,3
Disinhibition	13.02	2.38	14.96	2.29	16.14	2.17	32.33	<0.001	0.21	1<2<3
Boredom Susceptibility	12.31	1.82	12.6	1.86	13.44	1.88	3.79	0.02	0.03	1<3
Delay Discounting Task (logk)	-2.00	0.92	-1.98	0.71	-2.07	0.66	0.17	0.84	<0.01	
Iowa Gambling Task	-1.64	8.58	1.47	9.73	-1.12	9.22	2.92	0.06	0.02	