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Behavioral Impulsivity Predicts Treatment Outcome in a Smoking Cessation Program for Adolescent Smokers

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Abstract

Objective—To examine the relationship between impulsivity and smoking cessation treatment response among adolescents.

Methods—Thirty adolescent smokers participated in a high school based smoking cessation program combining contingency management and cognitive behavioral therapy. Self-report (Barratt Impulsiveness Scale (BIS—11); Kirby Delay Discounting Measure (DDM)) and behavioral (Experiential Discounting Task (EDT); Continuous Performance Task (CPT)) measures of impulsivity were assessed at treatment onset.

Results—Sixteen participants (53%) were abstinent from smoking at completion of the four-week study. Compared to abstinent adolescents, those not achieving abstinence discounted monetary rewards more on the EDT and committed more commission errors on the CPT. Group differences were not observed on the BIS-11 or DDM.

Conclusions—These preliminary results suggest that specific behavioral measures of impulsivity may be associated with the ability to initiate and/or maintain abstinence from smoking among adolescent smokers.

Keywords

Tobacco; Adolescents; Impulsivity; Delay Discounting; Smoking Cessation

1. Introduction

Tobacco use is an epidemic problem among adolescents. Approximately 2000 adolescents initiate smoking daily; of these, 61% report wanting to quit smoking cigarettes, and 59% report a quit attempt in the past year (MMWR, 2001). Given that most adult smokers begin smoking in adolescence, the identification of factors predicting treatment outcomes for adolescent smokers has significant public health implications for both adolescent and adult smokers.

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Impulsivity, an important factor influencing the risk for addiction, encompasses several clinically relevant components including a diminished ability to inhibit inappropriate behaviors, tendency to act without forethought, and relative insensitivity to behavioral consequences (Kreek et al., 2005, Moeller et al., 2001). Although impulsivity is associated with smoking in adults (e.g. Bickel et al., 1999; Mitchell, 1999), this relationship remains ambiguous in adolescents (Audrain-McGovern et al., 2004; Reynolds et al., 2003). For example, using a behavioral impulsivity measure of delayed discounting (which measured the relative value of immediate versus delayed rewards), Reynolds and colleagues (2003) found that while adolescent smokers did not differ from never smokers, those adolescents who had tried cigarettes but had not progressed to regular smoking discounted delayed rewards more compared with never/current smokers, suggesting a role for impulsive processes in smoking initiation. In contrast, Audrain-McGovern and colleagues (2004) demonstrated that impulsivity, assessed using a self-report delay discounting measure, was higher in adolescent smokers compared with never smokers and that its influence on smoking progression was mediated through other complementary reinforcers like peer smoking. Furthermore, although impulsivity has been associated with relapse in adult smokers (Doran et al., 2004), its relationship to cessation outcome in adolescents has not been systematically examined.

The current study explored the utility of behavioral and self-report measures of impulsivity in predicting behavioral treatment outcome in a high-school adolescent smoking cessation program based on our earlier work (Krishnan-Sarin et al., 2006). Additionally, since emerging evidence suggests that behavioral and self-report measures of impulsivity may be measuring different and potentially unrelated processes (e.g., Reynolds et al., 2006) we evaluated interrelationships between the measures. We hypothesized that impulsivity at treatment onset would be associated inversely with tobacco abstinence at end of treatment.

2. Methods

Treatment-seeking adolescent smokers, 14–18 years old and smoking ≥ 10 cigarettes/day, with quantitative urine cotinine levels > 350 ng/ml (Graham Massey Analytical Labs, Shelton, CT) were recruited during open recruitment sessions held during lunch breaks in participating high schools in New Haven County. Waiver of parental permission was approved by the Yale Human Investigation Committee and participating schools. Information sheets about the treatment program were mailed to parents two weeks prior to the recruitment sessions in which they were given the option of calling the school if they did not want their child to participate in the program. Adolescents who expressed an interest in quitting smoking during the recruitment sessions were scheduled for an initial appointment held at the local high school or at our clinic. At this appointment, signed assent from 14–17 year olds and consent from 18 year olds was obtained. Standardized clinical assessments or an evaluation by a clinical psychologist was used to assess attention deficit hyperactivity disorder (AD/HD) and exclude those meeting the Diagnostic and Statistical Manual of Mental Disorders–IV (DSM-IV) criteria for current psychiatric conditions or other substance dependence. Nicotine dependence and intellectual functioning were assessed as in our previous study (see Krishnan-Sarin et al., 2006).

2.1. Smoking Cessation Procedures

Based on procedures established in our previous study (Krishnan-Sarin et al., 2006), thirty newly recruited adolescents participated in a four-week, school-based smoking cessation program in which they received reinforcement on an escalating magnitude schedule contingent on smoking abstinence (with a reset contingency for non-abstinence) and individual weekly smoking cessation cognitive behavioral therapy. Abstinence rates at the end of treatment were determined using self-reports confirmed by quantitative urine cotinine levels < 50ng/ml.

2.2. Impulsivity measures

Impulsivity measures were completed 3–10 days prior to the quit day when participants were still actively smoking, and time since last cigarette and breath CO levels were determined to assess level of nicotine deprivation.

2.2.1. Barratt Impulsiveness Scale-11 (BIS-11; Patton et al., 1995)—This 30-item self-report measures trait impulsivity and yields four scales/subscales: total and nonplanning, cognitive, and motor impulsivity scores.

2.2.2. Kirby Delay Discounting Measure (DDM; Kirby et al., 1999)—This 27-item questionnaire assesses discounting of hypothetical monetary amounts across three different delayed-reward magnitudes ($25, $55, and $85). *k*-values, indexing the extent to which respondents choose smaller immediate amounts over larger delayed ones, are determined for each monetary value.

2.2.3. Experiential Discounting Task (EDT; Reynolds and Schiffbauer, 2004)—This computerized task assesses real-time delay discounting across four delay choice blocks (0, 7, 15, and 30 s). In each block, participants choose between an immediate adjusting amount (e.g., $0.15) and a delayed, standard amount ($0.30). During the task, respondents receive money from an attached coin dispenser. “Indifference points,” or monetary amounts at which two choice options are treated as subjectively equal, are determined for each block and plotted to form discount functions. Previous research with the EDT has used a hyperbolic-decay function to characterize the pattern of indifference points over increasing delays (Reynolds, 2006; Reynolds & Schiffbauer, 2004). However, an increasingly-common alternative method for analyzing delay-discounting data is to calculate area-under-the-curve (AUC) directly from indifference-point values (Myerson et al., 2001). The AUC method avoids certain systematic errors in characterizing delay-discounting data that occur when fitting these data to a hyperbolic-decay function. For this reason, the AUC method was used to analyze the EDT data of this study, with smaller AUC values indicating greater delay discounting and impulsivity.

2.2.4. Conners’ Continuous Performance Test – II (CPT; Connors, 2000)—In this computerized task, participants are instructed to respond as quickly as possible to a target stimuli and refrain from responding to more rarely occurring nontarget stimuli. Inattention is indicated by high numbers of omissions and long reaction times. Impulsivity is indicated by high numbers of commissions and short reaction times.

3. Data Analyses

Data were inspected for normality of distribution using a Shapiro-Wilk test, and when criteria were not satisfied (for EDT and DDM), the data were transformed using a logarithmic function. Abstinent and non-abstinent participants were compared via analyses of variance. Relationships between the different measures of impulsivity were examined using Pearson correlation coefficients tests.

4. Results

Participants (n=30) smoked on average 14.35 (SD=2.5) cigs/day for 2.63 (SD=1.6) years and had average baseline urine cotinine levels of 1064.2 (SD=405) ng/ml and had average modified Fagerstrom Tolerance Questionnaire (mFTQ) scores of 2.88 (SD=0.81) indicating a moderate level of dependence. Sixteen participants (53%) were abstinent at the end of treatment. No significant differences were observed between abstinent (A) and non-abstinent (NA) smokers on demographics [age in years: A=16.7 (SD=0.24), NA=16.4 (SD=0.25); gender: A=7M, 9F,

NA=7M, 7F], tobacco use [mFTQ: A=2.8 (SD=0.2), NA=3.1 (SD=0.3), cigs/day: A=16.3 (SD=1.9), NA=15.2 (SD=2.1) and years smoked: A=2.7 (SD=0.3), NA=2.6 (SD=0.6)], intelligence [Kauffman Brief Intelligence Test scores: A=99.63 (SD=1.9), NA=96.85 (SD=3.1)], AD/HD diagnosis [A=2 participants, NA=2 participants], or number of days in the past 30 that alcohol [A=2.9 (SD=5.4), NA=0.5 (SD=0.8)] or marijuana [A=2.8 (SD=5.3), NA=5.2 (SD=9.7)] was used. Prior to impulsivity assessment, the groups did not differ on cigarette deprivation measures [time since last cigarette in minutes: A=69 (SD=15), NA=70 (SD=13) or breath CO in ppm: A=15 (SD=1.5), NA=17.1 (SD=2.1)].

Non-abstinent participants as compared to abstinent ones discounted more significantly on the EDT ($p<0.05$) and had higher commission-error scores on the CPT ($p<0.05$; Table 1). No significant differences were observed on other impulsivity measures. Significant correlations were observed between commission errors on the CPT and the DDM (average and medium-size values) as well as BIS-11 total scores.

5. Discussion

To our knowledge, this is the first study to suggest that adolescent smokers who are unable to achieve smoking abstinence are significantly more impulsive at treatment onset than those who attain abstinence. Compared with abstinent participants, non-abstinent ones discounted monetary rewards more on the EDT and made more commission errors on the CPT. Importantly, the differences on the CPT likely reflect distinctions in behavioral disinhibition and not attentional processing since differences were not observed on the attentional measure of non-responses to targets. These findings suggest that several domains of impulsivity (rapid discounting of rewards, disinhibition of prepotent responses) are clinically relevant in predicting behavioral treatment response in adolescent smokers.

Behavioral measures, and not self-reports, were significantly related to treatment outcome, consistent with earlier reports suggesting that behavioral and self-report assessments of impulsivity assessments may represent different levels of analyses, from detailing specific behavioral processes to more general trait-like impulsive tendencies (Lejuez et al., 2003, Reynolds et al., 2006). However, given the small sample size, the differences between self-report and behavioral measures in predicting treatment outcome should be interpreted with caution. While the abstinent and non-abstinent groups were not significantly different in responses on self-report measures like the BIS-II or the Kirby DDM, the group means for these measures were numerically in the direction of greater impulsivity in the group that did not achieve abstinence. Interestingly, we also found significant correlations between CPT scores and certain scores on the BIS-11 and DDM, which suggests some levels of association between these measures. It is possible that measures like the BIS-11, one that focuses more on trait impulsiveness, and the Kirby DDM, may lack sensitivity to identify differences within small samples. Future studies with larger samples are needed to confirm these results.

Another limitation of this study is that impulsivity assessments were only obtained at treatment onset. Future studies should use multiple assessments of impulsivity (e.g., pre/post-treatment) to determine if this construct changes with time or after acute and chronic tobacco abstinence. Importantly, research is needed to examine whether the present findings extend to other behavioral and pharmacological interventions for adolescent smokers. Our program used contingency management techniques which motivated abstinence by offering adolescents alternative monetary reinforcers, a strategy that might be particularly sensitive to tasks that assess the relative salience of immediate versus delayed monetary rewards.

The present finding that impulsive adolescents appear less likely to quit smoking suggests that treatments targeting impulsivity and enhancing motivations to quit smoking warrant

examination in adolescents. Options include the development of skills programs focused on improving behavioral inhibitory processes, adaptation and optimization of behavioral therapies (e.g., contingency management or motivational enhancement) procedures to target impulsive decision-making, or use of medications that reduce impulsive behaviors. Finally, further investigation into the biological determinants of impulsivity and the influence of impulsivity on specific stages of smoking behaviors (initiation, maintenance) would help direct prevention and treatment strategies for tobacco smoking in adolescents and adults.

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Table 1

Responses on and correlations between self-reports and behavioral tasks measuring impulsivity

Responses on measures [Average (SE)]			MEASURES	Correlations between measures										
				BIS-11				DDM				CPT		
Abstinent	Non Abstinent	Statistics		Tot.	Non-plan.	Motor	Cog.	Ave	Small	Med	Large	Omiss.	Commiss.	RT
−0.24(0.02)	−0.34 (0.05)	**F=2.67, p<.05**	**EDT Total AUC**	.14	−.07	.24	.13	−.24	−.35	−.01	.12	.13	−.21	.05
68.44 (1.8)	71.62 (2.6)	F=1.1, p=0.3	**BIS-11**					.23	.07	.33	.21	.17	**.44***	.04
27.75 (0.8)	28.85 (0.9)	F=0.77,p=0.4	**Total**					.21	.15	.20	−.04	.01	.35	−.06
22.94 (0.6)	24.54 (1.4)	F=1.2, p=0.3	**Non-planning**					.20	.01	.35	.27	.17	.32	.11
17.88 (0.9)	18.23 (0.9)	F=0.7, p=0.8	**Motor Cognitive**					.10	.002	.18	.22	.19	.30	.05
0.04 (0.02)	0.02 (0.04)	F=0.3, p=0.6	**DDM**									−.09	**.41***	−.01
0.07 (0.02)	0.07 (0.02)	F=0.00, p=0.9	**Average**									−.23	.21	−.15
0.05 (0.02)	0.03 (0.01)	F=1.0, p=0.3	**Small**									.08	**.44***	.09
0.03 (0.01)	0.008 (0.008)	F=1.89, p=0.2	**Medium Large**									.04	.18	.06
69.9 (19.9)	82.4(30.1)	F=0.13, p=0.7	**CPT**											
51.8 (3.4)	61.5 (2.5)	**F=4.48, p<.05**	**Omissions**											
52.9 (7.5)	46.1 (2.5)	F=0.93, p=0.3	**Commissions RT**											

Note: * **two-tailed tests significant at p<0.05.**

The EDT and DDM data were not normally distributed and were therefore log transformed.

*Median values presented for DDM measures.