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Contingency Management Improves Smoking Cessation Treatment Outcomes among Highly Impulsive Adolescent Smokers Relative to Cognitive Behavioral Therapy

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Contributors

Drs. Krishnan-Sarin and Cavallo designed the study protocol. Drs. Krishnan-Sarin, Cavallo, Kong, Krishnan-Sarin, and Carroll conceptualized the study. Dr. Morean conducted the literature search and conducted the statistical analyses with assistance from Dr. Kong and Mr. Pittman. Dr. Morean wrote the first draft of the manuscript, and all authors contributed to and have approved the final version of the manuscript.

Conflict of Interest

Drs. Morean, Kong, Camenga, Cavallo, Carroll, Krishnan-Sarin and Mr. Pittman declare that they have no actual or potential conflict of interest.

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Abstract

Background—Impulsive adolescents have difficulty quitting smoking. We examined if treatments that provide behavioral incentives for abstinence improve treatment outcomes among impulsive adolescent smokers, who have been shown to be highly sensitive to reward.

Methods—We ran secondary data analyses on 64 teen smokers (mean age = 16.36 [1.44]; cigarettes/day = 13.97 [6.61]; 53.1% female; 90.6% Caucasian) who completed a four-week smoking cessation trial to determine whether impulsive adolescents differentially benefit from receiving cognitive behavioral therapy (CBT), contingency management (CM), or the combination of the two (CM/CBT). Indices of treatment efficacy included self-report percent days abstinent and end of treatment biochemically-confirmed 7-day point prevalence abstinence (EOT abstinence). We assessed self-reported impulsivity using the Brief Barratt Impulsiveness Scale. We used univariate Generalized Linear Modeling to examine main effects and interactions of impulsivity and treatment condition as predictors of self-reported abstinence, and exact logistic regression to examine EOT abstinence.

Results—CM/CBT and CM were comparably effective in promoting abstinence, so analyses were conducted comparing the efficacy of CBT to treatments with a CM component (i.e., CM and CM/CBT). CBT and deficient self-regulation predicted lower self-reported abstinence rates within the total analytic sample. Treatments containing CM were more effective than CBT in predicting 1) self-reported abstinence among behaviorally impulsive adolescents (% days abstinent: CM 77%; CM/CBT 81%; CBT 30%) and 2) EOT point prevalence abstinence among behaviorally impulsive adolescents and adolescents with significant deficits in self-regulation.

Conclusion—CM-based interventions may improve the low smoking cessation rates previously observed among impulsive adolescent smokers.

Keywords

adolescent; impulsivity; smoking cessation; cognitive behavioral therapy; contingency management

1.0 Introduction

Although several smoking cessation interventions are available for adolescents, quit rates remain low (Karpinski et al., 2010). A growing body of research indicates that impulsivity, which is characterized by difficulty delaying gratification (Doran et al., 2007) and by “a predisposition toward rapid, unplanned action...with diminished regard to negative consequences” (Moeller et al., 2001), may play an important role in adolescent smoking behaviors. Impulsive adolescents are more likely to initiate smoking than their less impulsive counterparts (e.g., Audrain-McGovern et al., 2006, O’Loughlin et al., 2014) and disproportionately struggle to quit (Krishnan-Sarin et al., 2007). Highlighting a possible mechanism of action, impulsive youth experience stronger positively reinforcing (e.g., pleasure) and negatively reinforcing (e.g., dampened negative affect) smoking-related

rewards than their less impulsive counterparts, which makes smoking more appealing and quitting more daunting (Doran et al., 2007). When considering these findings alongside evidence that adolescent health behaviors, broadly defined, are more strongly motivated by external changes (e.g., raising prices) than by intrinsic motivation (Steinberg, 2007), it is plausible that impulsive adolescents may benefit differentially from smoking cessation interventions that provide contingency management (CM), a behavioral intervention that reinforces abstinence with immediate, tangible rewards (e.g., cash).

Research indicates that CM is an efficacious smoking cessation intervention for adolescents when offered alone (Corby et al., 2000, Roll, 2005) or in conjunction with pharmacotherapies (e.g., bupropion, Gray et al., 2011) or psychosocial treatments (e.g., cognitive behavioral therapy; Cavallo et al., 2007, Krishnan-Sarin et al., 2006). Krishnan-Sarin and colleagues (2013) recently compared the efficacy of CM, CBT, and the combination of CM/CBT for smoking cessation. CM and CM/CBT were superior to CBT in predicting EOT abstinence but did not differ from one another, suggesting that favorable adolescent treatment outcomes largely were driven by CM. However, no study has examined whether CM may improve cessation rates among impulsive smokers.

To this end, we conducted a secondary analysis of Krishnan-Sarin's (2013) data to determine if impulsive adolescents' ability to quit smoking depended on the treatment they received (i.e., CBT, CM, or CM/CBT). Self-reported impulsivity was assessed based on prior research demonstrating strong associations with youth smoking (e.g., Tercyak and Audrain-McGovern, 2003). We predicted that impulsivity would be inversely related to self-reported abstinence over the course of treatment and biochemically-confirmed EOT abstinence. However, we anticipated that impulsive adolescents would respond better to treatments providing CM (i.e., either CM alone or CM/CBT) relative to CBT alone. Although CM appeared to drive biochemically-confirmed treatment efficacy within the total sample, it was unclear whether CM/CBT would be superior to CM for impulsive adolescents; if CM were reinforcing irrespective of impulsivity, comparable treatment outcomes for CM and CM/CBT would be expected. However, CBT skills (e.g., assertiveness, coping skills, relapse prevention) may have had an incremental benefit for impulsive adolescents beyond CM's financial motivation for abstinence.

2.0 Materials and Method

We briefly review key aspects of the Krishnan-Sarin et al. (2013) study design below.

2.1 Participants

Our analytic sample comprised 64 high school smokers (mean age 16.36 [1.43]; mean cigarettes/day = 13.97 [6.61]; 53.1% female; 90.6% Caucasian) who had non-missing data on the study variables. Original eligibility criteria included: 1) smoking ≥ 5 cigarettes daily 2) urine cotinine levels ≥ 350 ng/ml, 3) parental consent (< 18 years), 4) student assent/consent, and 5) the absence of major depression and/or panic disorder. The analytic sample did not differ significantly from the parent sample ($N = 72$) on the study variables (results not depicted).

2.2 Procedure

Treatment conditions (CBT [$n = 22$], CM [$n = 19$], or CM/CBT [$n = 23$]) were balanced by gender and race. The CBT condition comprised four weekly meetings (30-minutes) with a counselor during which CBT skills were taught (e.g., coping with withdrawal/craving). The CM condition comprised daily weekday appointments (5-minutes) with a research assistant during which students provided a urine sample and received progressive daily monetary reinforcers for achieving/maintaining abstinence. Research assistants were trained to provide no smoking cessation advice/counseling. The CM/CBT condition comprised both treatments.

2.3 Measures

2.3.1 Impulsivity—Students completed the 30-item Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995). Consistent with recent research in adult and adolescent samples (Morean, et al., 2014a; Morean et al., 2014b), an evaluation of the latent structure of the BIS-11 in this sample (results not depicted) confirmed two four-item subscales reflecting Behavioral Impulsivity (e.g., “I do things without thinking”) and Impaired Self-Regulation (e.g., “I am a careful thinker” [reverse coded]). Both subscales were normally distributed and internally consistent (Behavioral Impulsivity: mean 9.64(2.69), $\alpha = .79$; Impaired Self-Regulation mean 9.42(2.44), $\alpha = .72$) and evidenced moderate overlap ($r = .38$).

2.3.2 Treatment Efficacy Outcomes—First, we considered seven-day point prevalence EOT abstinence confirmed by urine cotinine levels ≤ 50 ng/ml. The parent study indicated that no CBT participants achieved EOT abstinence (i.e., CBT 0%; CM 36.3%; CM/CBT 36.7%), so we also examined self-reported abstinence (% days over the course of treatment), which was assessed weekly via Time Line Follow Back (Lewis-Esquerre et al., 2005).

2.4 Data Analytic Plan

2.4.1 Baseline and Preliminary Analyses—We used analysis of variance (ANOVA) to evaluate differences in baseline impulsivity across treatment conditions. We then evaluated whether providing CM/CBT to impulsive adolescents relative to CM alone significantly improved EOT abstinence (logistic regression) or percent days abstinent (univariate general linear model). For each model, main effects and interactions of impulsivity and treatment condition were examined. If CM and CM/CBT were comparably efficacious, both conditions would be combined (i.e., any CM) in subsequent analyses to maximize statistical power and parsimony.

2.4.2 Primary Analyses: Treatment Efficacy Outcomes—We ran a univariate GLM model examining main effects and two-way interactions between treatment condition and impulsivity (i.e., behavioral impulsivity and impaired self-regulation) in predicting self-reported abstinence. Within the total analytic sample, we then ran an exact logistic regression model examining main effects of treatment condition, behavioral impulsivity, and impaired self-regulation on EOT abstinence. Interactions between treatment condition and impulsivity were not examined given the lack of variance in the CBT condition. As a proxy, we examined main effects of treatment condition separately for individuals deemed high/low

in impulsivity based on median split (median Behavioral Impulsivity = 10.0; Impaired Self-Regulation = 9.50).

3.0 Results

3.1 Baseline and Preliminary Analyses

No differences in baseline impulsivity were observed by treatment condition (Behavioral Impulsivity: $p = .61$; Impaired Self-Regulation: $p = .83$), reducing concerns that treatment effects were driven by differences in impulsivity. Demonstrating the CM and CM/CBT were comparably efficacious, neither the main effect of treatment condition nor the interactions between treatment condition and impulsivity significantly predicted either self-reported abstinence (main effect [$p = .637$]; Treatment x Behavioral Impulsivity [$p = .166$]; Treatment x Impaired Self-Regulation [$p = .881$]) or EOT abstinence (block 1 [main effects]: $p = .42$; block 2 [treatment condition x impulsivity interactions]: $p = .38$). As such, CM and CM/CBT were combined into a single group (i.e., receiving any CM) for all remaining analyses.

3.2 Primary Analyses: Treatment Efficacy Outcomes

The GLM model comparing the efficacy of CBT ($n = 22$) to any CM ($n = 42$) accounted for 31.4 % of the variance in self-reported abstinence (Table 1). Students receiving any CM ($p < .001$) reported abstinence on more days than students receiving CBT. Students with higher levels of impaired self-regulation ($p = .004$) reported abstinence on fewer days than their counterparts. Among highly behaviorally impulsive adolescents, CM was significantly more effective than CBT in encouraging abstinence ($p = .003$; Figure 1).

The main effects of the exact logistic regression model indicated that CM participants were 16.4 times more likely to achieve EOT abstinence than CBT participants ($p = .001$; Table 1). Main effects for behavioral impulsivity failed to reach significance although the direction of the effect was consistent with that observed for self-reported abstinence. After splitting the sample by behavioral impulsivity, highly behaviorally impulsive adolescents receiving CM were 11.3 times more likely to achieve abstinence ($p = .014$) than those receiving CBT. After splitting the sample by self-regulation, adolescents with considerable self-regulation deficits who received CM were 8.3 times more likely to achieve EOT abstinence ($p = .038$) compared to those receiving CBT. Treatment condition did not significantly predict abstinence among adolescents low in behavioral impulsivity (exact OR = 4.45, $p > .05$) or with modest impairments in self-regulation (exact OR = 4.45; $p > .05$).

4.0 Discussion

The current study suggests that impulsive adolescents may experience differential success in quitting smoking based on the type of treatment they receive. Of central importance, CM was disproportionately effective for impulsive adolescents relative to CBT; adolescents who were more behaviorally impulsive and who received CM were 11.3 times more likely to achieve EOT abstinence than those who received CBT. Similarly, adolescents with significant deficits in self-regulation who received CM were 8.3 times more likely to achieve EOT abstinence than those who received CBT. Consistent with the results for EOT

abstinence, adolescents who were behaviorally impulsive and received CM self-reported abstinence on significantly more days than those who received CBT (any CM [83%]; CBT alone [39%]), although a parallel effect was not observed among adolescents with deficits in self-regulation. The differential observed pattern of findings could be driven by the fact that self-reported and biochemically-confirmed abstinence represent fundamentally different ways of conceptualizing treatment efficacy (i.e., a snapshot of abstinence at EOT versus abstinence over the course of treatment), as well as to both the increased variability in % days abstinent across the treatment conditions (% abstinent: any CM 81%; CBT 53%) relative to EOT abstinence (% abstinent: any CM 64%; CBT 0%) and the dichotomization of impulsivity when predicting EOT abstinence. When considering the biochemically-confirmed and self-reported findings together, the benefits of CM may be disproportionately large among adolescent smokers whose impulsivity is characterized by impulsive action (e.g., doing things without thinking) rather than deficits in self-regulation and planning (e.g., difficulty concentrating/planning). Additional research may help to clarify the observed patterns of results.

Although the mechanism of action driving the observed findings is not known, the immediate, consistent nature of a monetary reward may help bolster behavioral control and, to a lesser extent, self-regulation when impulsive teens experience triggers and cravings to smoke. While impulsive adolescents may find the effects of smoking especially rewarding (Doran et al., 2007), the prospect of earning money appears to be equally or more reinforcing, at least in the short term. The comparable efficacy of CM and CM/CBT suggests that impulsive adolescents may find it easier to focus on a simple contingency (i.e., no smoking = \$\$\$) than to call upon the complex repertoire of CBT skills when faced with an immediate decision to smoke. These findings are in concordance with research indicating that adolescent smokers who discount longterm rewards do poorly in smoking cessation treatment (Krishnan-Sarin et al., 2007).

While this study provides encouraging preliminary evidence supporting the use of CM for impulsive adolescent smokers, several limitations merit note. The study was limited by its small sample size ($N = 64$), and high attrition rates prohibited meaningful examinations of the extent to which the observed pattern of results held up at the 3-month study follow-up. Further, the study included self-report data, which were limited by participants' level of insight into their impulsivity and their willingness to report accurately about their smoking. Although prior research generally supports the validity of adolescents' self-reported substance use (e.g., Winters et al., 1990), adolescents may be prone to overestimation or underestimation of their smoking behavior. However, the assessment of biochemically-confirmed EOT abstinence and the fact that the study explicitly was designed to maximize adolescents' willingness to report honestly (e.g., parental consent was not required for participation, data were not shared with the schools) help to mitigate this concern.

Study results also could be influenced by differences in the frequency of contact across treatment conditions (weekly CBT vs daily CM appointments), although research assistants were trained to provide no feedback to participants regarding their smoking behavior to help ensure that money (not contact) was serving as the reinforcer in the CM condition.

Finally, although the observed benefit of CM for impulsive adolescents was considerable during and at the end of treatment, it was not possible to evaluate the extent to which the benefit of receiving CM persisted long-term, in the absence of the monetary reinforcer. However, prior research, including a large meta-analysis examining the effectiveness of CM for adolescents and adults who received substance abuse treatment, provides encouraging evidence that participants who receive CM may continue to benefit following active treatment (e.g., Predergast et al., 2006). Among adult substance users, CM is associated with longer periods of abstinence during treatment, which, in turn, is a strong predictor of long-term abstinence (Petty, 2010). Future studies in adolescents could use CM to not only reinforce abstinence, but also to reinforce other positive behaviors, which may serve as alternatives to smoking (e.g. exercise, healthy eating, sport participation and also may protect against relapse and help to extend the benefits of CM beyond active treatment.

In spite of these limitations, the current study provides initial support for the utility of CM as a smoking cessation intervention for impulsive adolescent smokers, a population that historically has been very difficult to treat (e.g., Krishnan-Sarin et al., 2007). Effectively assessing adolescent smokers' impulsivity prior to enrollment in a smoking cessation program may help determine a maximally effective course of action. If the current pattern of results is replicated in future trials, efforts focused on optimizing methods for funding and disseminating CM-based smoking cessation interventions for youth will be critical.

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Highlights

- Treatments containing CM were more effective than CBT for impulsive teen smokers
- Behaviorally impulsive teens who got CM self-reported abstinence on more days (77%)
- Behaviorally impulsive teens who got CM were 11.3x as likely to be abstinent at EOT
- Teens with poor self-regulation who got CM were 8.3x as likely to be abstinent at EOT

Figure 1.
Treatment Containing a Contingency Management Component is Superior to Cognitive Behavioral Therapy for Individuals who are Behaviorally Impulsive

Table 1

Treatment Condition, Behavioral Impulsivity, and Impaired Self-Regulation as Predictors of Self-Reported Percent Days Abstinent during Treatment and Biochemically-Confirmed Abstinence at the End of Treatment

Total Analytic Sample	Self-Reported % Days Abstinent ^a		Biochemically-Confirmed EOT Abstinence ^b
	F	η^2	Exact Odds Ratio
Treatment Condition (any CM vs. CBT)	13.74	.19***	16.47***
Behavioral Impulsivity	3.45	.06	3.14
Impaired Self-Regulation	8.89	.13**	0.52
Treatment Condition $\times$ Behavioral Impulsivity	9.45	.14**	--
Treatment Condition $\times$ Impaired Self-Regulation	0.15	.00	--
<u>Sample Split by Behavioral Impulsivity</u>			
Low Behavioral Impulsivity (any CM vs. CBT)	--	--	4.45
High Behavioral Impulsivity (any CM vs. CBT)	--	--	11.25*
<u>Sample Split by Impaired Self-Regulation</u>			
Low Impaired Self-Regulation (any CM vs. CBT)	--	--	6.76
High Impaired Self-Regulation (any CM vs. CBT)	--	--	8.31*

Note.

 $p < .001$

**
 $p < .01$

*
 $p < .05$

^a denotes that analyses were conducted using univariate general linear modeling;

^b denotes that analyses were run using exact logistic regression; -- denotes analyses that were not run/were not applicable

Abbreviations are EOT (end of treatment), CM (contingency management), CBT (cognitive behavioral therapy); The reference group for treatment effects was CBT