

ORIGINAL INVESTIGATION

Socioeconomic Status and the Reward Value of Smoking Following Tobacco Abstinence: A Laboratory Study

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ABSTRACT

Introduction: Socioeconomic status (SES) indicators are robustly associated with smoking behaviors. Yet, the psychological mechanisms underlying relations are unclear. This study merged the socioecological construct of SES with laboratory psychological science to investigate how income, education, and employment status predicted the reward value of smoking following tobacco abstinence among a diverse sample of adult daily smokers. We hypothesized that participants with lower SES (i.e., less education, lower income, and unemployed) would experience greater abstinence-induced enhancement of the reward value of smoking.

Methods: Adult smokers ($N = 240$; 68.7% male; 51.7% Black, 33.8% White, 7.1% Latino, and 7.5% other) attended 2 laboratory sessions (1 nonabstinent and 1 following 16-hr tobacco abstinence) involving behavioral assessment of (a) latency to smoking when delaying smoking was monetarily rewarded and (b) purchasing individual cigarettes. Generalized estimating equations were used to test the interaction between each SES variable (education, income, and employment) and abstinence state to illustrate whether participants with certain SES characteristics were more sensitive to the abstinence-induced enhancement of the relative reward value of smoking.

Results: Participants who never attended college (vs. college attendees) exhibited greater abstinence-induced enhancement of the reward value of smoking, which was indicated by reduced willingness to delay smoking for money ($ps = .03$). Income and employment status did not moderate abstinence effects.

Conclusions: Less-educated smokers were particularly motivated to smoke during acute abstinence. Observed educational disparities in smoking behaviors and smoking cessation might reflect a biased valuation of immediate drug-related (over less immediate alternative) rewards. Future research should explore potential mediators of this association.

INTRODUCTION

Socioeconomic status (SES) is one of the most prominent predictors of cigarette smoking (Barbeau, Krieger, & Soobader, 2004), with income, educational level, and employment status demonstrating strong associations with smoking prevalence (CDC, 2011a), quit rates (CDC, 2009), and cessation during a specific quit attempt (Businelle et al., 2010; Kendzor et al., 2012). Much attention has been paid to the measurement of SES and how environmental, sociological, and interpersonal factors might link SES to smoking. However, applications of psychological science to shed light on the intrapersonal processes linking SES to smoking are scant.

Behavioral economic perspectives are useful psychological accounts of addiction motivation. These models purport that compulsive drug use reflects a tendency to place a

disproportionately high reward value on drug seeking and consumption in comparison to alternative nondrug reinforcers (Audrain-McGovern et al., 2004; Higgins, Heil, & Lussier, 2004). The result of this reward imbalance is that motivated behavior becomes biased toward pursuing drug reinforcers that provide immediate pharmacological reward and away from nondrug reinforcers that provide less immediate nonpharmacological reward. In the case of tobacco addiction, previous cross-sectional research among smokers enrolled in a cessation study found that lower education was associated with a greater discounting of delayed financial rewards (Jaroni, Wright, Lerman, & Epstein, 2004). Another study found that greater delay discounting of financial rewards predicted poorer cessation outcomes within a sample of low SES smokers (Sheffer et al., 2012). While these findings provide initial evidence that SES may be linked with a preference toward immediate (vs.

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Socioeconomic status and the reward value of smoking

delayed) rewards in smokers, several critical aspects of the relation between SES and the reward value of smoking are unclear.

First, it is unclear whether a smoker with low SES might assign disproportional value to *drug* rewards, a process that may fluctuate within the context of addiction in a different fashion than financial rewards. This is an important gap in knowledge as the reward value of smoking in particular may wax and wane dependent on the recency of smoking (i.e., drug satiety). For instance, if one has been abstinent from smoking for several hours, the relative reward value of smoking versus alternative rewards (i.e., money) may be enhanced, which might promote a strong motivation to reinstate smoking behavior (McKee, Weinberger, Shi, Tetrault, & Coppola, 2012). Reward valuation changes induced by cigarette abstinence might explain the maintenance of tobacco addiction among smokers not wishing to quit (e.g., motivation to smoke following overnight abstinence, temporary smoking restrictions at work) as well as risk of lapsing when making a self-imposed quit attempt. Hence, individuals who experience greater abstinence-induced increases in the relative reward value of smoking may be those most at risk of smoking lapse and relapse during a quit attempt. Importantly, such processes may also maintain addiction among those not wishing to quit.

Second, it is unclear whether different SES indicators may exhibit disparate relations to assignments of the reward value of smoking (vs. alternate rewards). There has been at least one study demonstrating the independent relations of income, education, and occupation to smoking prevalence when all were considered jointly in a multivariate model that adjusted for the association among these three SES indicators (Barbeau et al., 2004). Further, another study in Black smokers found that only unemployment was a significant predictor of smoking relapse when income and education were included in the same predictor model (Kendzor et al., 2012). These empirical studies support the potential for unique effects of the SES variables in their associations with smoking behaviors, as suggested by theory.

This laboratory study tested the hypothesis that lower SES would predict disproportionate enhancement in the relative reward value of a drug reward (i.e., smoking) versus nondrug reinforcer (i.e., money) following acute tobacco abstinence. This hypothesis was based on prior research linking low SES to preference for immediate financial rewards (e.g., Jaroni et al., 2004) and on the notion that disadvantaged individuals may have histories of reduced access to alternative reinforcers (e.g., fewer material goods, less satisfaction from educational and career goals) yet equivalent (or enhanced) access to smoking and other immediate reinforcers, which ultimately could bias valuation of smoking relative to alternative nonsmoking rewards within the context of tobacco addiction. Due to the paucity of prior literature and theory on SES markers and the reward value of smoking following cigarette abstinence, however, we did not have hypotheses about potential differential effects by SES indicator.

METHODS

Participants

This report reflects a secondary analysis of data collected as part of a parent study of individual differences in cigarette withdrawal (Leventhal et al., in press). Participants were required to be ≥ 18 years old, regular smokers for ≥ 2 years (≥ 10 cigarettes/day),

and English speaking. Although 350 participants were enrolled, only 286 received SES questions due to a late introduction of these items. The analyzable sample was further reduced to 240 due to drop out prior to study completion ($n = 44$) and inability to meet abstinence criteria in the abstinence session ($n = 2$). There were no significant differences between participants who received versus did not receive SES questions or between study completers and noncompleters on baseline demographic or smoking variables. All procedures were approved by the University of Southern California Institutional Review Board.

Procedures

Participants attended a baseline visit at which questionnaire measures were administered. Subsequently, participants attended two counterbalanced experimental session visits that included a behavioral economic-based smoking lapse analog task: (a) abstinence session (16 hr of smoking abstinence; breath carbon monoxide [CO] ≤ 9 ppm required) and (b) nonabstinent session (*ad libitum* smoking prior to arrival and smoke a cigarette of their preferred brand at the beginning of that session in the laboratory). Both experimental sessions began at noon and the *M* (*SD*) time between the two experimental sessions was 11.6 (7.0) days. Following a 50-min period of initial assessments and procedures, participants underwent the lapse analog task consisting of a delay period (50 min), a self-administration period (60 min), and a rest period (ending 2 hr and 50 min after the start of the delay period; McKee, Krishnan-Sarin, Shi, Mase, & O'Malley, 2006). During the task, participants received a tray containing 8 cigarettes, a lighter, and an ashtray. At the outset of the delay period, participants were instructed they could commence smoking at any point over the next 50 min, but they would earn \$0.20 for each 5 min they delayed smoking. Thus, participants could earn a maximum of \$2 for delaying smoking. The delay period ended when the participant indicated they wanted to smoke or after 50 min elapsed if the participant chose not to smoke. During the self-administration period, participants were instructed that they could smoke as much or little as they wanted for 60 min, but they had a \$1.60 credit and each cigarette smoked would cost \$0.20. Participants were told at the beginning of the self-administration period that they would not have another opportunity to smoke again until the end of the rest period.

Variables of Interest

Socioeconomic Status

Socioeconomic status variables collected at baseline were last year's pretax household income, educational attainment, and employment status.

Cigarette Dependence

Cigarette dependence severity was assessed with the Fagerström Test of Cigarette Dependence (FTCD) (Fagerström, 2012; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) at baseline.

Cigarette Withdrawal

Cigarette withdrawal was assessed to evaluate the robustness of the abstinence manipulation using an 11-item variant of the Minnesota Nicotine Withdrawal Scale (MNWS) (Hughes & Hatsukami, 1986) that asked participants to report withdrawal symptoms experienced "so far today" on 6-point Likert scales, with higher scores indicating greater symptomatology.

Abstinence Status

A breath CO test was also used during the experimental sessions to assess the robustness of the abstinence manipulation and to verify compliance with smoking instructions.

Smoking Task Performance

Performance on the lapse analog task was the outcome of interest, which consisted of (a) latency to smoking initiation during the delay period (range 0–50 min), which is inversely proportional to the relative reward value of initiating smoking versus delaying smoking for money, and (b) the number of cigarettes smoked during the self-administration period (possible range 0–8), which reflects the reward value of smoking once given the opportunity. Because these continuous variables were not normally distributed, we created two additional binary outcome variables of interest via recoding: (c) latency to smoking initiation during the delay period (delay all 50 min vs. delay <50 min) and (d) the number of cigarettes smoked during the self-administration period (≥ 1 cigarette/s vs. 0 cigarettes smoked).

Data Analyses

Preliminary analyses involved reporting sample descriptive statistics and examining the relations of SES indicators to demographics, cigarette dependence, and each other. As a check of our experimental abstinence manipulation, we conducted paired sample *t* tests to illustrate the robustness of the effects of abstinence on MNWS and CO scores. The main analyses involved testing the relation of SES variables and abstinence to lapse analog task outcomes using generalized estimating equations (GEE) (Zeger & Liang, 1986), which allow both categorical and continuous independent and dependent variables and the inclusion of within-participant effects.

The first set of GEE models included the within-participant abstinence variable (abstinent vs. nonabstinent) as the sole predictor. Then, for each SES indicator, we tested separate sets of GEE models that in the first step included only the main effects of abstinence and the single SES variable as simultaneous predictors. The second step added the interaction between abstinence and the SES variable to illustrate whether participants with certain SES characteristics were more sensitive to the effects of abstinence on performance on the lapse analog task. Separate GEE models were tested for each outcome.

As noted in Results section, some of the SES indicators were significantly associated with age, cigarette dependence, and each other, leaving unclear whether the findings from the main analyses reflected unique incremental relations over and above age, cigarette dependence, and the other SES indicators. Therefore, for each main analysis yielding a significant SES effect, we retested the model after controlling for age, cigarette dependence, and the other SES indicators.

RESULTS

Preliminary Analyses

Participant Characteristics

Participants were predominately male (68.7%), were 44.5 ($SD = 10.3$) years old on average, and were racially/ethnically diverse (51.7% Black, 33.8% White, 4.2% multiracial,

7.1% Latino, and 3.3% Asian, American Indian, or refused to answer). Approximately 52% reported single marital status. On average, the sample had moderate to high levels of cigarette dependence (FTCD score = 5.29 [$SD = 1.92$]) and smoked 16.7 ($SD = 4.77$) cigarettes per day. The sample's annual income distribution was <\$15,000 (57.9%), \$15,000–\$29,999 (24.6%), \$30,000–\$44,999 (10.4%), and \geq \$45,000 (7.1%). With regard to education, 9.6% did not complete high school or earn a General Educational Development certificate or credential (GED), 35.4% completed high school or attained their GED, 40.8% completed some college or were currently enrolled, and 14.2% completed their college degree. Overall, 132 participants (55.0%) were unemployed and 108 (45.0%) were employed in some form. Due to the nonnormal distribution, SES variables were coded as binary variables for analyses: income <\$15,000/year (vs. \geq \$15,000/year), never attended college (vs. attended college), and unemployed (vs. employed).

Variable Interrelations

The prevalence and intercorrelations of each binary SES indicator are presented in Table 1. None were significantly associated with other demographic variables or cigarette dependence with two exceptions: unemployed participants were significantly younger than employed participants ($F = 4.91, p = .046$) and participants who never attended college had significantly greater cigarette dependence than those who attended college ($F = 8.38, p = .004$).

Manipulation Check Variables

Abstinence significantly increased cigarette withdrawal symptom levels per MNWS total scores (nonabstinent $M [SD] = 1.09 [0.95]$ vs. abstinent $M [SD] = 1.89 [1.08]$; $t = 11.0, p < .0001$, Cohen's $d = 0.71$) and reduced CO levels (nonabstinent $M [SD] = 28.0 [12.0]$ vs. abstinent $M [SD] = 5.6 [2.1]$; $t = 27.2, p < .0001$, Cohen's $d = -1.76$), as expected.

Main Analyses

Main Effects of Abstinence

In the initial step of the GEE models, abstinence significantly predicted faster smoking during the delay period and higher levels of smoking during the self-administration period (Table 2).

Income

Neither the main effect of income nor the income \times abstinence interaction term significantly predicted any lapse analog task outcome ($ps \geq .19$).

Table 1. Descriptive Statistics and Intercorrelation of Socioeconomic Status Indicators

		Correlations (ϕ coefficient)		
		1.	2.	3.
1.	Never attended college	108 (45%)	–	
2.	Annual income <\$15,000	139 (57.9%)	.25*	–
3.	Unemployed	132 (55%)	.09	.22* –

Note. $N = 240$.

* $p \leq .0001$.

Socioeconomic status and the reward value of smoking

Education

Education did not have a significant main effect on any lapse analog task outcome ($ps \geq .21$). However, the education \times abstinence interaction term significantly predicted number of minutes delayed (standardized estimate B [95% CI] = -6.54 [$-2.39, -0.69$], $p = .03$) and odds of delaying all 50 min (B [95% CI] = -0.64 [$-1.24, -0.05$], $p = .03$) before smoking. In each case, the interaction signified that the extent to which abstinence enhanced the reward value of smoking was stronger among individuals who never attended college than those who had attended college (Table 3 and Figure 1, panels A and B). Moreover, the education \times abstinence interaction effects were not substantially altered after controlling for income, employment, age, and cigarette dependence (minutes delayed: B [95% CI] = -6.54 [$-12.40, -0.69$], $p = .03$; delay all 50 min: B [95% CI] = -0.66 [$-1.27, -1.05$], $p = .03$). The education \times abstinence interaction term, however, did not meet the threshold for statistical significance of $p \leq .05$ in the prediction of the odds of smoking at least one cigarette during the self-administration period (B [95% CI] = 1.18 [$-0.02, 2.38$], $p = .053$; Table 3 and Figure 1, panel C) or the number of cigarettes smoked during the self-administration period ($p > .06$).

Employment

The main effect of employment on performance during the delay period as measured by the number of minutes delayed did not surpass the threshold for statistical significance (B [95% CI] = 3.57 [$-0.68, 7.83$], $p = .053$; Figure 2, panel A). However, there was a main effect of employment on performance during

the delay period, such that unemployed participants were significantly more likely to delay all 50 min (odds ratio [OR] [95% CI] = 1.62 [$1.04, 2.54$], $p = .03$) than employed participants (Figure 2, panel B). These main effects of employment were not substantially altered after controlling for income, education, age, and cigarette dependence (delay all 50 min: OR [95% CI] = 1.60 [$1.01, 2.53$], $p = .04$). Employment did not significantly predict cigarettes purchased during the self-administration period. There were no significant employment \times abstinence interactions.

Supplemental Analyses

Reanalysis With Nonbinary SES Indicators

Additional analyses using either multilevel categorical or continuous SES variables indicators based on raw survey data yielded results consistent with those reported above.

Analysis of Order Effects

Additional analyses controlling for the main effect of the experimental session order did not alter the primary findings nor were there any significant interactions between SES variables and order in predicting any of the outcomes.

Abstinence-Induced Withdrawal Differences

Given the education \times abstinence effects found, we conducted additional analyses to explore whether these findings could be explained by the possibility that smokers who never attended college (vs. college attendees) experienced greater abstinence-induced changes in nicotine withdrawal symptoms, which in

Table 2. Main Effects of Abstinence on Lapse Analog Task Outcomes

Variable	Nonabstinent	Abstinent	Abstinence effect	
	M (SD) or %	M (SD) or %	B or OR (95% CI)	p value
Delay time (min)	38.7 (18.0)	21.8 (22.7)	-16.9 ($-19.8, -13.93$)	<.0001
Delay all 50 min (yes/no)	65.0%	35.0%	0.29 (0.22, 0.39)	<.0001
Postdelay number of cigarettes smoked	1.30 (0.90)	1.58 (0.93)	.29 (0.17, 0.41)	<.0001
Postdelay smoked ≥ 1 cigarette (yes/no)	83.8%	92.5%	2.39 (1.43, 3.99)	<.0001

Note. B = standardized estimate; $N = 240$; OR = odds ratio; CI = confidence interval. Results from generalized estimating equations of the within-participant abstinent (vs. nonabstinent) contrast predicting each outcome.

Table 3. Effects of Abstinence on Lapse Analog Task Outcomes Stratified by Educational Status

Predictor	Outcome							
	Delay procedure				Postdelay self-administration procedure			
	Delay time (min)		Willing to delay all 50 min (yes/no)		Number of cigarettes smoked		Smoked ≥ 1 cigarette (yes/no)	
	B (95% CI)	p value	OR (95% CI)	p value	B (95% CI)	p value	OR (95% CI)	p value
Abstinence effect (by education)								
Never attended college ($n = 108$)	-20.5 ($-24.9, -16.0$)	<.0001	0.20 (0.13, 0.32)	<.0001	0.31 (0.16, 0.47)	<.0001	5.20 (1.84, 14.67)	.002
Attended college ($n = 132$)	-13.9 ($-17.6, -10.1$)	<.0001	0.38 (0.26, 0.56)	<.0001	0.26 (0.09, 0.44)	.003	1.59 (0.88, 2.90)	.12

Note. B = standardized estimate; $N = 240$; OR = odds ratio; CI = confidence interval. Results from generalized estimating equations of the within-participant abstinent (vs. nonabstinent) contrast predicting each outcome.

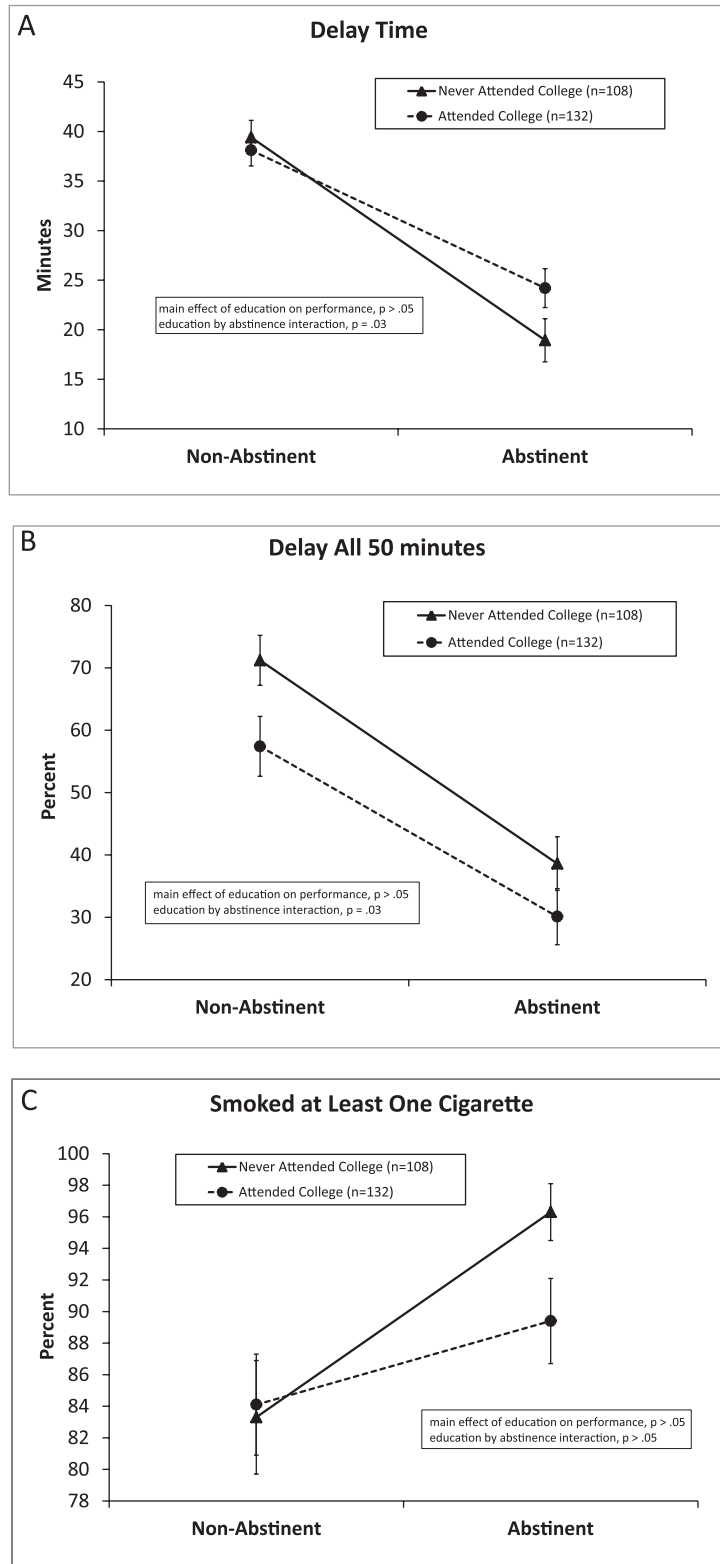


Figure 1. Results from generalized estimating equations models for education \times abstinence interaction effects on the mean ($\pm SE$) latency to smoking initiation in minutes (range: 0–50) during the delay period (A), the percent ($\pm SE$) of participants who delayed all 50 min without initiating smoking during the delay period (B), and the percent ($\pm SE$) of participants who smoked at least one cigarette during the self-administration period (C).

turn influenced choices on the lapse analog task. These results showed that the education \times abstinence term did not significantly predict MNWS scores (B [95% CI] = 0.15 [–0.13,

0.43], $p = .29$), suggesting that withdrawal symptoms did not account for education \times abstinence on lapse analog task performance.

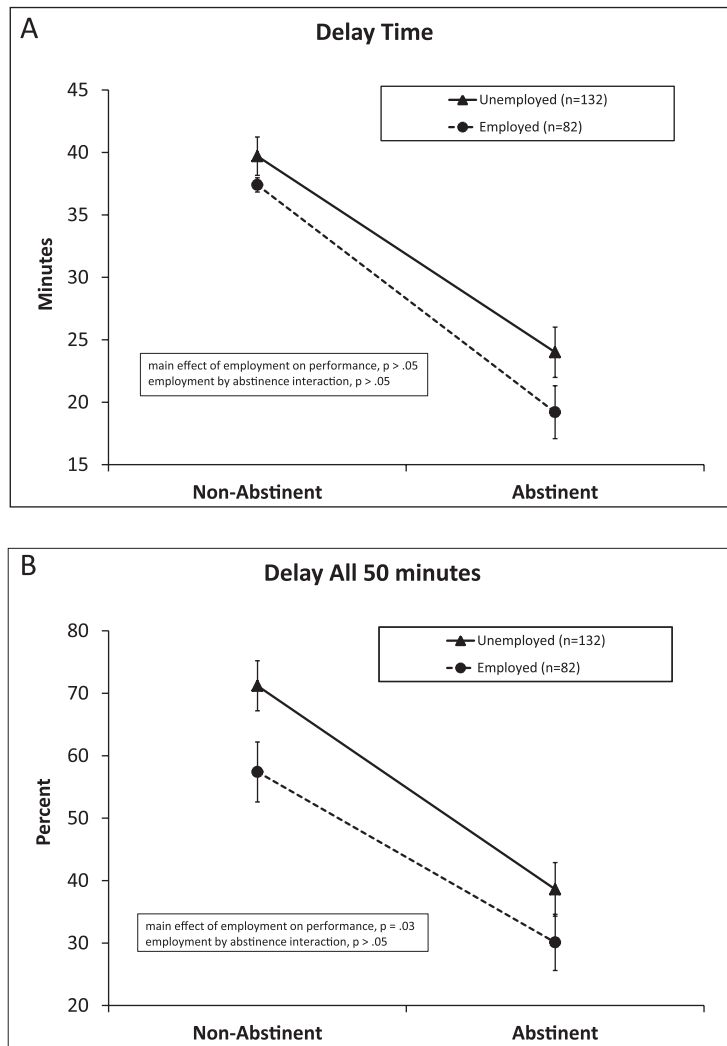


Figure 2. Results from generalized estimating equations models for employment \times abstinence interaction effects on the mean ($\pm SE$) latency to smoking initiation in minutes (range: 0–50) during the delay period (A), and the percent ($\pm SE$) of participants who delayed all 50min without initiating smoking during the delay period (B).

DISCUSSION

The results from this study indicated that educational level was the only SES indicator that significantly moderated how acute abstinence affected participants’ willingness to forgo financial gain in exchange for the ability to smoke sooner. Specifically, the extent to which abstinence enhanced the reward value of smoking was stronger among individuals who never attended college than those who attended college, even when controlling for other SES indicators and cigarette dependence. Moreover, these effects were not attributable to the experience of greater abstinence-induced changes in nicotine withdrawal symptoms among the less educated. Together, these results suggest that less educated smokers may place a particularly high incentive value on resuming smoking during acute cigarette abstinence, which could be integrated with prior results linking lower education to smoking lapse risk (Businelle et al., 2010; CDC, 2011b) and reflect a possible mechanism that maintains daily smoking behavior among less educated smokers.

This study reflects a meaningful integration with and advancement of prior work documenting a relation between low

education and a preference for immediate versus delayed financial rewards in treatment-seeking smokers (e.g., Jaroni et al., 2004). Importantly, the two rewards that participants could choose between in the current study differed on two different dimensions: (a) pharmacological activity (pharmacological vs. nonpharmacological) and (b) immediacy (smoking now vs. money to be spent later). Hence, we cannot determine the extent to which the results may reflect a preference for smoking due to its pharmacological nature, immediacy, or some combination of the two. Yet, the interaction between education and experimentally manipulated abstinence suggest that it is unlikely that results could be explained by baseline (or trait-like) relations between education and discounting of all delayed rewards. Future work might include comparison groups of nonsmokers and former smokers and include parallel tasks contrasting different types of rewards in order to better address the generalizability and specificity of these findings and add broad knowledge relevant across the fields of decision-making science, impulsivity and individual differences, and reward motivation.

Although the focus of this work was on SES by abstinence interactions, results also indicated a main effect of

employment, such that relative to employed smokers, unemployed smokers were more likely to delay smoking entirely to obtain a financial reward, when averaged across both abstinent and nonabstinent sessions. This is not unexpected given that the value of money would likely be enhanced among the unemployed, who may be experiencing financial instability pursuant to employment loss (Galobardes, Shaw, Lawlor, Lynch, & Davey Smith, 2006). That a similar effect was not demonstrated among those of low income might reflect that it is not income level that is most important but rather the experience of financial strain pursuant to unemployment that enhances the salience of financial gain in the face of more immediate pharmacological rewards (smoking). Furthermore, the divergent effects across income, employment, and education are consistent with prior research indicating that these three SES indicators may play unique roles in smoking, other behaviors, and health (Adler, 2009; Adler & Newman, 2002; Braveman et al., 2005; Diemer, Mistry, Wadsworth, Lopez, & Reimers, 2013).

Limitations of this study include that participants were current smokers not interested in quitting smoking and the laboratory setting, which may limit generalizability. Because the current sample was largely of low SES, we may have experienced attenuated power to detect effects that might have been more apparent if a sample with greater variability in SES were included. Further, the use of money as the alternative nondrug reward to smoking has implications. Although money has a universal objective value, its subjective value might vary in important ways across individuals, and the current assessment of income did not account for the number of persons supported or income-to-needs ratios. Indeed, the main effect of employment in this study may perhaps reflect the differential proportional value of money for individuals who sorely in need of financial resources. In addition, future studies might include more nuanced indicators of SES and attempt to assess educational quality.

This study represents one of the first attempts to merge broad sociological constructs of SES with basic laboratory psychological science employing behavioral pharmacology paradigms. These results highlight the possible importance of offsetting the acute enhancement in the incentive value of smoking (vs. other rewards) that may occur during acute abstinence and possibly increase risk of lapse early in a cessation attempt. Pending replication and extension of these results to clinical populations, the current findings raise the possibility that treatments that diminish the reward value of smoking and heighten the reward value of alternative reinforcers (e.g., varenicline; Igari et al., 2014) may be a fruitful strategy for aiding cessation in certain low SES smokers, such as those with low education.

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DECLARATION OF INTERESTS

None declared.

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Socioeconomic status and the reward value of smoking

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