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Extending Animal Models to Explore Social Rewards Associated With Designated Smoking Areas on College Campuses

Stephanie L. Lochbihler, BA; Daniel A. Miller, PhD; Paul E. Etcheverry, PhD

Abstract. Objective: Animal studies have shown that when nicotine is administered in the presence of other animals (as compared with alone), it is more rewarding. As a human analogue to these studies, rewards associated with designated smoking areas on university campuses were examined, since these areas promote using nicotine in the presence of others. Participants: Participants were 118 (Sample 1, collected November 2011) and 94 (Sample 2, collected April 2012) student smokers at a midwestern university. Method: Data were collected via an Internet survey. Results: Social interaction while smoking on campus (as compared with smoking alone) significantly increased the perceived reward of smoking, looking forward to spending time in the campus smoking areas, and how many times the campus smoking areas were visited. Conclusions: Although designated smoking areas may protect nonsmoking students from the dangers of secondhand smoke, these areas may increase the rewards associated with nicotine for the smokers who use them.

Keywords: conditioned place preference, nicotine, smoking, social reward, tobacco

M any college campuses have instituted policies that allow smoking only in designated areas to discourage smoking by making it inconvenient and also to protect nonsmokers from secondhand smoke. As a result of these policies, smokers on campuses with designated smoking areas are concentrated into select areas and therefore more likely to smoke in the presence of others. Results of animal studies have shown that that social interaction is a very rewarding property (ie, a reinforcer), in that the probability of a response or behavior is increased due to the possibility of social interaction, and these rewards are enhanced by the reinforcement properties of nicotine. In animal studies, reward typically refers to a stimulus that elicits approach behavior and reinforcement typically refers to the strengthening of behavior in response to a stimulus (reinforcer). This definition is also relevant to human studies; however, with humans, reward can also refer to the positive value or emotional stimulation (ie, cognitions or perceptions of enjoyment, comfort, pleasure, etc) an individual assigns to a stimulus. In an effort to provide a human analogue to these animal studies, we propose that rather than discouraging tobacco use, the social interaction experienced at designated smoking areas may actually encourage tobacco use by making the experience more rewarding.

Social Interaction Is Rewarding

Many animal studies using various learning paradigms have demonstrated that social interaction is very rewarding. For example, in a study by Humphreys and Einon, rats learned to traverse a T-shaped maze when the reward of social contact with another rat was at the end of the maze. Additionally, in a study by Evans et al., rats were trained to press a lever in order to gain access to another rat, and this social contact was shown to be an effective reinforcer, similar to food reinforcement under the same conditions. Furthermore, it has been shown that the neurotransmitter systems that mediate the hedonic properties of food and drugs rewards also moderate social play in rats.

In humans, there is substantial evidence demonstrating that seeking of social interaction is innate; for example, many
developmental studies show that infants exhibit social competency and social interaction-seeking behavior from birth. In addition, functional magnetic resonance imaging studies have shown that the parts of the brain that are rich in dopamine receptors and process primary rewards, such as food, sex, and drugs that produce euphoria, also process social reward information. Thus, for both animals and humans, social interaction appears to be necessary for healthy development and survival, and acts as a natural and powerful reinforcer similar to feeding, drinking, and sexual behavior.

**Nicotine Is Rewarding?**

There is a paradox regarding the rewarding aspects of nicotine, the major component of tobacco that reinforces smoking behavior. The potential for abuse, frequency of consumption, and rate of relapse for cigarette smoking is equal to or greater than other drugs of abuse, and the intake of nicotine leads to dependence and addiction through chronic usage. However, despite nicotine’s apparently highly addictive nature in humans, the self-administration paradigm in rats and mice (operant responses such as lever presses to obtain drug infusions) has shown that nicotine’s reinforcement property is relatively weak in comparison with other addictive drugs of abuse. Additionally, the success rates for smoking cessation efforts that specifically target the pharmacological property of nicotine are low, suggesting that there are nonnicotine properties that factor into smoking behavior and relapse. Subsequently, it has been repeatedly demonstrated that nicotine enhances the reinforcement effects of nonnicotine reinforcers. That is, when nicotine is paired with nonnicotine reinforcers (such as social play), there is an increase in operant responses to the reinforcement properties of the nonnicotine stimuli. For example, in a study by Palmatier et al, it was found that nicotine increased rats’ lever-pressing behavior for sucrose reward. Furthermore, this increase was shown to be synergistic and not just the result of the combined effect of 2 weak reinforcers.

Additionally, both human and animal studies show evidence that environmental cues influence nicotine consumption. Human studies have shown that a neutral stimulus paired with the availability of smoking can become a conditioned stimulus that triggers smoking behavior and cravings. For example, if a person always smokes when they are on the telephone, then the ringing of a phone (an originally neutral stimulus) can trigger cravings. In an animal study, Caggiula et al, paired nicotine self-administration and visual stimuli (such as operant chamber light cues) and found that the visual cues were important in maintaining high operant response rates to self-administration of nicotine in rats, suggesting that environmental cues associated with the consumption of a drug may become conditioned reinforcers that are influential in smoking behaviors. One of these environmental cues may be the social context in which nicotine is consumed. As described below, recent studies using the conditioned place preference paradigm have demonstrated the importance of social interaction in nicotine dependence.

**Conditioned Place Preference and Nicotine**

The conditioned place preference (CPP) paradigm involves 3 experimental steps: pairing a distinct environment with a stimulus, equal exposure to a second distinct environment without the stimulus, and then a choice test is given to measure the number of times the animal approaches the area conditioned with the stimulus as well as the amount of time spent there. An increase in either approach or time spent in the conditioned area suggests that the stimulus is rewarding. Similar to the studies involving operant conditioning described above, experiments using the CPP paradigm have had mixed results. For example, some studies report that nicotine is effective in inducing CPP whereas others have found that nicotine is not effective in producing CPP and some studies even a show conditioned place aversion effect at high dosages. Thus, as with the work with operant paradigms, there seems to be a disconnect between the addictive properties of nicotine in humans and its reinforcement value in rats and mice.

However, a recent study demonstrated that a robust CPP was shown when nicotine and social interaction were experienced at the same time (the experimental rat group were conditioned in an area that paired nicotine and another rat), but not when each stimulus was experienced individually. Similar to the operant paradigms described above, a synergistic interaction was observed even at the lowest dose of nicotine given. They also determined that the interaction was not merely the additive effect of 2 individual weak rewards; by pairing nicotine with both sides of the apparatus (negating the rewarding effects of nicotine) and pairing social reward on one side, they found that the social reward–nicotine pairing resulted in a robust CPP in comparison with controls that received saline on both sides of the apparatus, suggesting that the rewards of nicotine and social reward interact synergistically.

Therefore, both the self-administrative and conditioned place preference design demonstrate that nicotine, when administered in a social setting, is a more powerful reinforcer than when administered alone. The apparent disconnect between the abuse potential, relapse liability, and the psychological reinforcing effects of nicotine may be explained by nicotine’s interaction with other reinforcing stimuli. It could be that it is not just the nicotine itself that makes cessation so difficult and abuse to be so prevalent, but possibly the contexts in which the drug is consumed (ie, the social interaction that accompanies use, particularly through the policy of designated smoking areas).

With the numerous studies that examine the behavioral responses to nicotine and social reward using nonhuman subjects, we hope to compliment and corroborate the evidence using a human analogue. In order to investigate this, we surveyed smokers on a campus that allowed smoking in designated smoking areas (smoking huts) and in parking lots...
and personal vehicles. With this policy, smokers either consume nicotine whilst in the presence of others when using designated smoking areas, or alone when smoking in parking lots or personal vehicles. This allows us to determine the relationship between social interaction and nicotine similar to the study by Thiel et al.\textsuperscript{36} using human subjects in a correlational manner. Based on the animal literature, we formulated the following hypotheses:

1. Participants who interact with others while smoking on campus will find smoking on campus more rewarding than those who do not interact with others.
2. Participants who interact with others while smoking on campus will visit the area more often (CCP), as well as report positive feelings toward their preferred area (looking forward to spending time in their preferred designated smoking area).

METHODS

Below are the methods for 2 separate samples of participants. Sample 1 was collected in November 2011. In April 2012, a second sample of participants was collected and additional measures were added in order to replicate previous findings and to rule out alternative explanations. Unless otherwise noted, the measures and procedures for both samples were the same. Data collection for both samples received human subjects approval from the university-wide Human Subjects Committee.

Participants

Participants from a mid-sized US midwestern university with designated smoking areas were recruited for participation via their university assigned e-mail. Sixty-five percent of college smokers are considered occasional smokers, or “social” smokers, but most students do not consider themselves to be “smokers” unless they smoke daily. Due to this proclivity to underestimate smoking status, students were considered “smokers” if they smoked within the last 30 days. Only students who had smoked within the last 30 days and who were aged 18 and over were included in analyses. For Sample 1, there were 118 participants with an average age of 29 ($SD = 8.4$); there were 44 men (37.3%) and 74 women (62.7%). For Sample 2, there were 94 participants with an average age 29 ($SD = 9.6$); there were 57 men (39.4%) and 37 women (60.6%).

Procedure

Participants were contacted via their university e-mail and asked to complete a Web survey via an encrypted Web site. The survey contained basic demographic questions as well as questions about smoking behavior, perceived smoking rewards, and how much they visited their preferred smoking area.

Animal Models of Social Rewards of Designated Smoking Areas

Social Interaction

The university’s smoking policy allows smokers to either smoke in designated smoking areas, parking lots, or in personal vehicles. Wherever smokers choose to smoke, they may have the option to interact with others while smoking. Therefore, we measured social interaction while smoking by asking participants to think about their preferred smoking area (ie, a single place on campus where they smoked most) and then asked them to answer the following question, “Do you interact with others while in your preferred area to smoke?” Those who indicated “yes” were coded as the numerical value of “1” and “no” was coded as “0.” It was assumed in Sample 1 that the majority of smokers who interacted with others were primarily smoking in the university provided smoking areas, and the majority of smokers who were smoking alone were doing so in personal vehicles or parking lots. In Sample 2, we directly measured the location of participants’ preferred area to smoke and participants were asked to select their preferred smoking area from a list of locations provided. This list included all university-approved smoking locations, including designated smoking areas (smoking huts), parking lots, and personal vehicles. In addition, participants could select unapproved smoking locations such as directly outside of buildings and walking to and from classes.

For Sample 2, a crosstab analysis was done between the variables of social interaction and location of preferred area. The crosstab analysis revealed that 94% of participants whose preferred smoking location was a designated smoking area (smoking hut) interacted with others, whereas only 13% of participants whose preferred smoking location was in their cars or parking lots interacted with others. However, a good deal of participants did not follow the university’s smoking policy (29%) and instead smoked in nonapproved areas such as directly outside of campus buildings and en route to and from classes. These participants were split almost evenly, with 53% of the noncompliant smokers reporting interacting with others while smoking. Due to the strong overlap between preferred smoking location and social interaction while smoking in that location, the social interaction variable was maintained as the independent variable.

Cognitive Measure of Reward

To measure the cognitions associated with how rewarding smoking was to the participants, we used questions derived from Rimal and Real.\textsuperscript{38} Participants are asked to indicate how rewarding smoking was to the participants, we used questions derived from animal models (smoking huts) interacted with others, whereas only 13% of participants who indicated “no” were coded as “0.” It was assumed in Sample 1 that the majority of smokers who interacted with others were primarily smoking in the university provided smoking areas, and the majority of smokers who were smoking alone were doing so in personal vehicles or parking lots. In Sample 2, we directly measured the location of participants’ preferred area to smoke and participants were asked to select their preferred smoking area from a list of locations provided. This list included all university-approved smoking locations, including designated smoking areas (smoking huts), parking lots, and personal vehicles. In addition, participants could select unapproved smoking locations such as directly outside of buildings and walking to and from classes.

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Cognitive Measure of Reward

To measure the cognitions associated with how rewarding smoking was to the participants, we used questions derived from Rimal and Real.\textsuperscript{38} Participants are asked to indicate how strongly they agreed with statements (using a 7-point Likert scale) such as “Smoking on campus is enjoyable,” “Smoking on campus is relaxing,” and “Smoking on campus is fun.” A composite score for reward was calculated by averaging the scores of the 6 statements ($\alpha = .92$).

Conditioned Place Preference

In animal studies, conditioned place preference is measured in terms of how many times a rat approaches and spends time in an area that is associated with nicotine.
Because smoking areas are fixed areas on campus (either a smoking hut or a personal vehicle in the parking lot), we measured the behavioral component of CPP by asking “How often do you visit your preferred area to smoke?” and participants chose between the 6 responses ranging from “Never” (coded as a 0) and “More than 3 times daily” (coded as 5). Additionally, in order to assess the cognitive component of CPP, we asked if they exhibit positive feelings towards that area by having them rate their agreement to the statement “I look forward to spending time in my preferred area to smoke?” on a 5-point Likert scale.

**Big Five Inventory.** Participants in Sample 2 also completed the 44-item Big Five Inventory (BFI). The subscales showed good internal consistency: extroversion ($\alpha = .83$), neuroticism ($\alpha = .83$), conscientiousness ($\alpha = .82$), openness ($\alpha = .78$), and agreeableness ($\alpha = .81$). A 1-way analysis of variance (ANOVA) was conducted to determine which of the Big Five personality dimensions to use as covariates. The results indicated that there were significant effects of social interaction on extroversion, $F(1, 78) = 6.37$, $p = .014$, and openness, $F(1, 78) = 10.45$, $p = .002$. In particular, those participants who engaged in social interaction were more extraverted ($M = 3.59$ vs $M = 3.19$) and higher in openness ($M = 3.91$ vs $M = 3.56$). There were no other significant effects of social interaction on the other Big Five personality dimensions. Based on these results extroversion and openness were used as additional covariates in Sample 2.

**Amount of smoking.** Also in Sample 2, how much participants smoked in general was assessed with “How many cigarettes do you usually smoke?” and ranked on a scale from 1 to 7 with the following anchors: 1 = less than a pack monthly, 2 = a pack monthly, 3 = less than a pack weekly, 4 = a pack weekly, 5 = less than a pack daily, 6 = a pack day, and 7 = more than a pack a day ($M = 3.62$, $SD = 2.03$).

**RESULTS**

Standardized beta coefficients were computed through SPSS using the linear regression method of calculation (SPSS, Chicago, Illinois). In the regression equation, social interaction was the predictor variable (0 = no interaction, and 1 = interaction) and the following variables were included as covariates: age, gender (0 = male, and 1 = female), and other familial influences outside of campus-related smoking (ie, one or both parents who smoke; 0 = no parental smokers, and 1 = at least 1 parental smoker) and sibling smokers (0 = no sibling smokers, and 1 = at least 1 sibling smoker). Parent and sibling smokers were used as covariates because previous human studies have shown that familial influences are an important factor in smoking behavior. Due to an unfortunate omission, whether or not participants had sibling smokers was not assessed in Sample 2.

The standardized betas and $p$ values for Sample 1 are presented in Table 1. As hypothesized, social interaction while smoking in preferred area on campus significantly increased the perceived reward of smoking on campus ($\beta = .30$, $p = .004$). Social interaction was also significantly related to how much smokers looked forward to spending time in the preferred area ($\beta = .30$, $p = .003$) and how many times they visited their preferred area to smoke ($\beta = .51$, $p = .000$).

Presented in Table 2 are the standardized betas and $p$ values for Sample 2. One question from Sample 1 was whether people who interacted with others while smoking are somehow different than those who do not interact with others, and this difference is what produced the variances in perceived reward. The results from the BFI indicated that these 2 groups were in fact different in terms of extraversion and openness. Thus, these variables were added as additional covariates in order to rule out the possibility that the effects observed in Sample 1 were due to the personality differences between the social and nonsocial smokers. The results from Sample 2 replicated the results from Sample 1. Social interaction while smoking in preferred area on campus again significantly increased the perceived reward of smoking on campus ($\beta = .38$, $p = .002$); social interaction was again significantly related to how much smokers looked forward to spending time in the preferred area ($\beta = .45$, $p = .000$) and how many times they visited their preferred area to smoke ($\beta = .48$, $p = .000$). In addition, we measured amount of smoking in Sample 2 (not measured in Sample 1); however, social interaction was not a significant predictor of amount of smoking, $\beta = .16$, $p = .18$.

Mediational analyses were done to test the mediational relationship with perceived rewards as the mediator between social interaction and the dependent variables in both Sample 1 and Sample 2.

**Mediational Analysis for Looking Forward to Spending Time**

As the above regression revealed, there were significant total effects of social interaction on looking forward to spending time in the preferred smoking area ($\beta = .30$, $p = .003$). Furthermore, participants who socially interacted with others while in their preferred smoking area were more likely...
TABLE 2. Regression Analysis for Sample 2 (N = 94)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Perceived reward β</th>
<th>Looking forward to spending time in PSA β</th>
<th>How many times visit the PSA β</th>
<th>Amount of smoking β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social interaction</td>
<td>.38**</td>
<td>.45***</td>
<td>.48***</td>
<td>.16</td>
</tr>
<tr>
<td>Extroversion</td>
<td>.03</td>
<td>-.02</td>
<td>.09</td>
<td>.01</td>
</tr>
<tr>
<td>Openness</td>
<td>.02</td>
<td>.02</td>
<td>-.18</td>
<td>.10</td>
</tr>
<tr>
<td>Age</td>
<td>.11</td>
<td>.17</td>
<td>.08</td>
<td>.25*</td>
</tr>
<tr>
<td>Gender</td>
<td>-.01</td>
<td>.01</td>
<td>.10</td>
<td>-.02</td>
</tr>
<tr>
<td>Parent smokers</td>
<td>-.06</td>
<td>-.07</td>
<td>.26</td>
<td>.10</td>
</tr>
<tr>
<td>R²</td>
<td>.20</td>
<td>.26</td>
<td>.26</td>
<td>.16</td>
</tr>
</tbody>
</table>

Note. PSA = preferred smoking area.
*p < .05; **p < .01; ***p < .001.

Mediational Analysis for Number of Times Smoking Area Visited

Following the same mediational process, there was a significant total effect of social interaction on number of times smoking areas visited (β = .51, p = .000). Furthermore, participants who interacted with others while in their preferred smoking area perceived smoking on campus as more rewarding (β = .30, p = .003) than those who did not have social interaction. Finally, when social interaction and perceived reward were simultaneously entered as predictors of the dependent variable, perceived rewards was a significant predictor of number of times smoking area was visited (β = .22, p = .016), and the direct effect of social interaction on number of times visited was reduced (β = .45, p = .000), suggesting partial mediation of the effect of social interaction by perceived reward. The results of the bootstrapping analysis indicated that perceived reward (bias-corrected 95% CI [.0067, .1464]) was a statistically significant mediator (see Figure 1). A second bootstrapping analysis indicated that this mediational relationship was replicated in Sample 2, even when differences in extroversion and openness between the social and nonsocial smokers were controlled (bias-corrected 95% CI [.1021, .4353]). See Figure 2 for beta weights from Sample 2.
mediational relationship was replicated in Sample 2, even when differences in extroversion and openness between the social and nonsocial smokers were controlled (bias-corrected 95% CI [.0417, .3164]). See Figure 2 for beta weights from Sample 2.

Indirect Effect of Social Interaction on Amount of Smoking

Although there was no significant total effect of social interaction on amount of smoking in Sample 2, that does not mean there is not a significant indirect effect of social interaction on amount of smoking via rewards. As indicated in previous analyses in Sample 2, social interaction has a significant effect on perceived rewards ($\beta = .38, p = .002$). Furthermore, perceived rewards has a significant effect on amount of smoking ($\beta = .25, p = .036$). To test the indirect effect, we used Preacher and Hayes’ bootstrapping technique\(^44\) (including age, gender, extroversion, openness, and familial influences as covariates). Social interaction has a significant indirect effect on amount of smoking via perceived reward (bias-corrected 95% CI [.0304, .9357]).

COMMENT

Our results supported our hypotheses: Those who interact with others in the smoking areas find smoking on campus more rewarding than those who smoke alone, they look forward to smoking in their preferred smoking area more, and they visit the preferred smoking area more often. Thus, designated smoking areas on campus are not without unintended consequences. By forcing smokers to congregate together, smokers may develop a conditioned preference to an area that provides the reward of social interaction and nicotine, increasing the reinforcement value. Therefore, although these areas may protect nonsmokers from secondhand smoke, they may also be encouraging smoking behaviors in the students that are using them. The results suggest that a more prudent way to protect nonsmokers may be entirely smoke-free campuses.

The results from Sample 2 ruled out personality differences between participants who self-select into the smoking areas as an explanation for our results, and replicated the findings from Sample 1. Additionally, the crosstab analysis from Sample 2 indicated that designated smoking areas were indeed associated with greater social interaction, compared with smoking in parking lots and cars. Almost all smokers who used the designated smoking areas (94%) engaged in social interaction while smoking, whereas only 13% of those who smoked in their cars or in parking lots engaged in social interaction.

Sample 2 helps rule out social interaction as a proxy variable for amount of smoking. Both the total effect and the direct effect of social interaction on amount of smoking were nonsignificant. Interestingly, the significant indirect effect of social interaction on amount of smoking via rewards indicates that because social interaction makes smoking more rewarding, it also has an indirect tendency to increase the amount of smoking. However, the lack of a significant total effect points to the possibility that there are other variables related to social interaction that work to decrease amount of smoking. That is, there must be unidentified negative indirect effects of social interaction on amount of smoking (suppressor variables). One possibility could be that when people engage in social interaction on campus, they smoke at a slower pace; ie, because they are conversing, they are unable to smoke as rapidly, and thus consume fewer cigarettes. Further research is needed to understand the complex relationship between social interaction and smoking, especially identifying these potential suppressor variables.

Our study corroborates animal models using Pavlovian and operant paradigms that show a synergistic interaction between social reward and nicotine. In these animal studies, cognitive factors cannot be determined; therefore, it is debated whether reward is truly the underlying mechanism, or if there are confounding influences such as novelty-seeking and state-dependent learning\(^45,46\). It is also questioned whether the results from these animal studies will extend to human subjects.\(^45\) Our results help confirm results from animal models that perceived reward is the mediator between social interaction and how many times the preferred area is visited. It also demonstrates how these animal studies may generalize to humans.

Limitations and Conclusions

One of the limitations of these studies is the correlational design. As with any correlational design, it is difficult to rule out the possibility of alternative explanations. However, we believe that the addition of the second sample helped to rule out several alternative explanations, increasing the internal validity of our study. Furthermore, our results replicate several well-controlled animal experiments—allowing us to have confidence in our conclusions.

Our findings, in combination with animal studies, show the influence of the social context on experiences with nicotine. Although designated smoking areas on campuses are decreasing, our findings could extend to designated smoking areas in other public places, including areas designated for smoking at the workplace. Future research could examine changing policies regarding employee smoke breaks to allow employees to smoke only one at a time, thus avoiding the social reward interaction.

When considering the social context, it is important to consider the selection effect or the finding that smokers select whom to associate with based on smoking status.\(^47\) The conditioned place preference effect adds an addition to the common selection finding, as it suggests that with whom and where people smoke may be influenced by a synergistic effect of smoking and social interaction on rewards. Research has also found evidence for a socialization effect in which the smoking behaviors of others can influence one’s own smoking.\(^48\) The synergistic effects of nicotine and social interaction on rewards might lead to a strengthening of socialization effects through concurrent receipt of reward. This idea is speculative, but suggests interesting avenues for future research.
In conclusion, our findings reveal a need to further examine the effects of social reward on nicotine consumption, and investigate the consequences of designated smoking areas. Furthermore, these results emphasize the importance of taking into consideration the social cues when treating nicotine addiction, as well as confirm the need for empirical evidence to be used in regards to the implementation of public policies.

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CONFLICT OF INTEREST DISCLOSURE

The authors have no conflicts of interest to report. The authors confirm that the research presented in this article met the ethical guidelines, including adherence to the legal requirements, of the United States and received approval from the Institutional Review Board of Purdue University.

NOTE

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