

Automatic Affective Responses to Smoking Cues

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The authors examined automatic emotional reactions to smoking cues among 35 smokers and 25 nonsmokers (32 women and 28 men), using a novel implicit measure, the Affect Misattribution Procedure. Associative-learning theories of addiction suggest that smokers develop positive responses to cues linked to the rewarding effects of nicotine. Prior research, however, has yielded mixed evidence for whether smokers have favorable or unfavorable automatic responses to smoking cues. These findings may depend on the methods used to measure implicit responses. Using the Affect Misattribution Procedure, the authors found that nonsmokers responded to smoking cues with clear negative affect, whereas smokers' responses depended on individual differences in current smoking withdrawal. Smokers having withdrawal symptoms and those most motivated to smoke showed favorable emotional responses to smoking cues, but those with no withdrawal or low motivation to smoke showed negative responses. These results help integrate previous studies finding that smokers have negative automatic responses to cigarettes with those studies finding that smokers' responses were relatively positive. The results are important for theories that emphasize the role of cue conditioning in maintaining addiction because these theories assume, consistent with the current findings, that smoking cues can take on positive reward value.

Keywords: drug cues, automatic, implicit attitude, smoking behavior, nicotine addiction

As smokers come to associate cues, such as ashtrays and burning cigarettes, with the rewarding effects of nicotine, those cues may themselves come to reinforce, and thus perpetuate, smoking behavior (Kaplan, Meyer, & Stroebel, 1983; Ludwig, Wikler, & Stark, 1974; Shiffman, 1986; Tiffany, 1990). Consistent with this notion, studies have shown that when people addicted to a drug are shown drug-related cues, their heart rate and skin conductivity increase, and they report craving for the drug (Carter & Tiffany, 1999). Exposure to drug cues can also elicit affective responses (e.g., Tiffany, Cox, & Elash, 2000). Thus, because nonpharmacological, conditioned aspects of smoking likely play a role in the maintenance of smoking behavior (Caggiula et al. 2001; Rose & Behm, 2004; for a review, see Rose, 2006), studying emotional reactions to drug cues may help understand how cues in the environment maintain smoking behavior.

Emotional responses and craving are typically measured with self-reports, but self-reports of drug and drug-cue responses pose the same problems as self-reports in any other domain. If self-reports are to provide useful data, research participants must have subjective access to the information. They must also be willing to express their responses, free from social desirability bias. When it comes to drug use, both of these factors pose a serious threat to the validity of self-report measures (Nisbett & Wilson, 1977; Sayette et al., 2000). Smokers may not be aware of the underlying processes leading them to smoke, and even when they are aware, they may be reluctant to report about them (Stacy, 1997; Wright, Aquilino, & Supple, 1998). These problems make it important to go beyond self-report to develop a fuller understanding of psychological reactions to drug cues.

In this article, we used a recently developed implicit attitude measure to assess automatic affective responses to smoking cues. Implicit attitudes are spontaneous evaluative responses. They may be evoked without intention and without awareness that a person is being influenced. Implicit attitude measures are useful whenever there is concern over the veracity of self-reports because they do not rely on introspection and they are designed to resist self-presentation strategies.

Do smokers have more positive automatic responses to smoking cues than nonsmokers do? Research on associative learning in drug addiction strongly suggests that they would. Drugs of abuse, such as nicotine, act as primary reinforcers, stimulating the same reward pathways as other unconditioned reinforcers, such as food and sex (Koob & Le Moal, 1997). The rewarding properties of drugs become

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easily associated with other cues, such as the look, taste, and smell of cigarettes (McClemon, Hiott, Huettel, & Rose, 2005; Rose & Levin, 1991). These cues may therefore elicit positive emotional reactions themselves, thus motivating drug use. At the same time, studies measuring implicit responses to smoking cues have observed cue-elicited increases in negative affect (Tiffany, Cox, & Elash, 2000). To better understand smokers' reactions, we compared smokers' and nonsmokers' implicit responses to smoking cues, and we assessed the relationships among implicit responses, nicotine withdrawal, and nicotine dependence.

Several studies have examined implicit evaluations of smoking cues, yielding a complex pattern of results. Some of the studies have suggested that smokers have negative implicit responses to smoking cues, whereas other studies have suggested the opposite. After reviewing those studies, we describe a new procedure, used here, that may circumvent some of the interpretation problems arising in previous studies. On the basis of previous cue-exposure research and the rewarding effects of nicotine, we predicted that smokers would have more positive implicit responses than nonsmokers. On the basis of previous cue-reactivity studies, we also expected these responses to be moderated by smoking withdrawal and motivational states (T. J. Payne, Smith, Sturges, & Holleran, 1996; Sherman, Rose, Koch, Presson, & Chassin, 2003; Waters, Shiffman, Bradley, & Mogg, 2003). Specifically, we expected responses to be most favorable among smokers experiencing withdrawal symptoms and among those with the greatest desire to smoke.

Implicit Cognition and Smoking

There is good evidence that drug cues elicit implicit cognition. For example, smokers show attentional biases toward smoking-related words (Gross, Jarvik, & Rosenblatt, 1993; Johnsen, Laberg, Cox, Vaksdal, & Hugdahl 1994; McCusker & Gettings, 1997). Attentional biases toward drug cues appear automatic, operating in spite of and interfering with intentional behavior. Other studies show that drug cues activate selective kinds of implicit memory—effects of past experience on performance without conscious recollection (Leung & McCusker, 1999; see also Stacy, Ames, Sussman, & Dent, 1996).

Although these studies show that smoking cues reliably evoke semantic associations and attract attention, the evidence on automatic emotional responses is much less consistent. In one study, Swanson, Rudman, and Greenwald (2001) used the implicit association test (IAT; Greenwald, McGhee, & Schwartz, 1998) to examine implicit evaluations of smoking, and they found that in two out of three experiments, both smokers and nonsmokers showed equally negative implicit evaluations of smoking cues. In the third experiment, smokers showed less negative responses than nonsmokers, although both groups showed negative responses. In a second study with the IAT, Sherman et al. (2003, Study 2) found that light smokers showed negative responses, whereas heavy smokers showed significantly less negative responses, although neither group showed favor-

able evaluations of smoking. Similar results were reported by Huijding, de Jong, Wiers, and Verkooijen (2005, Study 1), who found relatively negative evaluations among both smokers and nonsmokers, with smokers significantly less negative than nonsmokers. Finally, Bassett and Dabbs (2005) used a related measure, the go/no-go association task (Nosek & Banaji, 2001), and found that smokers showed negative associations with smoking on the go/no-go association task, although their associations were less negative than those of nonsmokers. Findings of negative implicit reactions to smoking cues among smokers are difficult to reconcile with the idea that automatic positive responses mediate smoking behavior. These studies suggest instead that smokers smoke despite their automatic affective responses, not because of them. Such a conclusion would have important implications because it would mean that automatic emotional responses to cues could not be a major factor in maintaining smoking behavior, as is posited by some theories (e.g., Rose & Levin, 1991; Tiffany, 1990).

Not all studies, however, show negative responses among smokers. In a recent study with the IAT, smokers showed neutral attitudes toward cigarettes, whereas nonsmokers showed relatively negative attitudes (De Houwer, Custers, & De Clercq, in press, Study 1). Sherman et al. (2003, Study 1) used an evaluative-priming procedure (Fazio, Sanbonmatsu, Powell, & Kardes, 1986). They found positive responses among smokers, but only to smoking cues that represented sensory aspects of smoking. Together these studies make it difficult to draw a firm conclusion about smokers' automatic responses to smoking cues.

The diversity of findings with different implicit tests suggests that method factors may be important. Most of the studies showing negative implicit responses among smokers used the IAT or closely related methods. Because the IAT measures relative evaluations, the interpretation of IAT scores always depends on comparison with a contrast category. Some authors have argued that a score of zero on the IAT reflects a meaningful zero, in the sense that it reflects no difference in the strength of associations between the two pairs of items (Greenwald, Nosek, & Sriram, 2006). By this interpretation, participants who respond with equal speed on compatible and incompatible blocks have no preference for one category or the other. If an IAT score of zero reflects neutrality, then the findings of negative IAT scores among smokers can be interpreted as negative attitudes toward smoking. Other researchers, however, have argued that a zero IAT score is unlikely to reflect true neutrality (Blanton & Jaccard, 2006). Because response times on compatible and incompatible blocks are influenced by multiple factors, including two separate attitudes, the extremity of pleasant and unpleasant items, and general processing speed, these researchers have urged caution in interpreting zero scores to reflect neutrality. Moreover, the choice of contrast category has been shown to determine whether smoking attitudes appear relatively favorable or unfavorable (Robinson, Meier, Zetocha, & McCaul, 2005). When the categories were smoking and nonsmoking, nonsmokers responded faster when smoking was paired with negative words, but

smokers showed no difference between pairings. In contrast, when the categories were smoking and stealing, both smokers and nonsmokers responded faster when smoking was paired with positive words and stealing was paired with negative words. That is, in comparison with stealing, both smokers and nonsmokers responded to smoking relatively favorably. These results illustrate that caution is needed in interpreting IAT results in absolute terms because conclusions depend not only on attitudes toward smoking, but also on other task features.

The IAT has also been criticized for being sensitive to cultural associations that may mask the participant's own evaluation (Karpinski & Hilton, 2001; Olson & Fazio, 2004). For example, cultural norms that disapprove of smoking may produce negative IAT scores even for a person who likes cigarettes. The personalized IAT is a variant of the IAT that aims to reduce the effect of cultural associations (Olson & Fazio, 2004). Consistent with this explanation, the only study to use the personalized IAT to investigate smoking found that smokers had a relatively positive attitude toward cigarettes (De Houwer et al., in press, Study 2). These findings make it difficult to know whether the traditional IAT findings should be interpreted as reflecting smokers' affective reactions to smoking cues.

Other methodological concerns include the reliability and predictive validity of many implicit measures. Reliability for reaction-time priming tasks tends to be very low (Bosson, Swann & Pennebaker, 2000; Cunningham, Preacher, & Banaji, 2001; Kawakami & Dovidio, 2001). Reliability estimates for the IAT are usually better, but range widely (Banse, Seise, & Zerbes, 2001; Bosson, Swann, & Pennebaker, 2000; Cunningham et al., 2001). When IAT scores are reliable, they nonetheless tend to show weak relationships with behavior. These psychometric issues make it difficult to know what to conclude about the automatic reactions of smokers to smoking cues in previous research. Additional methods that avoid these difficulties in interpretation should be used to find more evidence.

The Affect Misattribution Procedure

In light of these methodological issues, B. K. Payne, Cheng, Govorun, and Stewart (2005) recently developed the Affect Misattribution Procedure (AMP) as an implicit measure of affective responses. In the AMP, prime pictures are flashed briefly but visibly on a computer screen. For the present research, prime pictures were smoking-related cues (e.g., a burning cigarette) and neutral control pictures. Following the prime picture, a Chinese pictograph is flashed, also briefly but visibly. Participants' task is to rate the pictograph as pleasant or unpleasant. Because this judgment is ambiguous, participants have little basis for their decision and tend to rely on spontaneous affective responses initiated by the prime pictures.

Participants are warned that the prime pictures might influence their judgments, and they are instructed to avoid any influence. The motivation for this warning is to set intentional strategies in opposition to automatic influences

of the primes. This approach is similar to the use of exclusion instructions in memory research, in which participants are instructed to complete word stem cues (e.g., *pick*___) with words that they have not studied or to reject words that arise from a particular study episode (Jacoby, 1991; Jacoby, Kelley, Brown, & Jasechko, 1989). Under these exclusion instructions, the to-be-excluded study items nonetheless often evoke incorrect endorsements above the baseline rate for new items. This in turn is taken to reflect the positive influence of item fluency or familiarity operating in the absence of explicit recollection of studying the words. That is, because these influences persist despite the participant's intention to the contrary, they are characterized as relatively automatic or uncontrolled. Similarly, in the AMP procedure, if participants were aware of the origin of their emotional reactions, the warning instructions would enable them to effectively isolate or exclude these responses from their ratings of the pictographs.

The effectiveness of this approach has been tested in several validation studies. Across six studies, this warning was found to have no detectible effect, in comparison with an unwarned control group (B. K. Payne et al., 2005). This suggests, first, that the effect of the primes on evaluations is difficult to control. The pattern also suggests that the warning does not ironically inflate the priming effect as is sometimes found in research on thought suppressions (Wegner, 1994; Wegner, Schneider, Carter, & White, 1987). This is not surprising because ironic rebound effects typically occur only after participants have stopped attempting to suppress or when their cognitive capacity is taxed by a secondary task, neither of which applies in the AMP (Wegner & Erber, 1992). The influence of the primes therefore appears independent of intentions to avoid their influence. Subjective perceptions of the influence of primes on target judgments have been shown to be unrelated to actual bias in judgments, suggesting that participants are not able to effectively monitor the influence of the primes on responses (B. K. Payne et al., 2005). The warning is thus included in standard versions of the task because it ensures that measured differences are unlikely to be based on intentional judgments of the primes.

Converging evidence for the implicit or automatic nature of AMP effects comes from studies examining motivations to control or distort responses. In one study, individual differences in motivation to control prejudice were significantly correlated with self-reported racial attitudes, but not with racial attitudes as measured by the AMP (B. K. Payne et al., 2005). Another study manipulated social pressure to appear unbiased and found that social pressure influenced self-reported racial attitudes but not AMP responses (B. K. Payne, Burkley, & Stokes, 2007). Finally, a study manipulating social pressure to underreport liking for alcohol found similar effects (B. K. Payne, Govorun, & Arbuckle, 2007). Self-reported drinking dropped by 45% under social pressure, and self-reported attitudes toward alcohol became significantly less favorable. AMP responses, however, were not affected by social pressure. AMP responses are implicit, not in the sense that the primes or affective reactions to them are necessarily unconscious, but in the sense that

participants are unable to monitor and control the influence of the primes on their responses.

Unlike many implicit methods, the variable of interest in the AMP is not reaction times, but evaluations of the pictographs. Using ratings rather than response times has the advantage of avoiding the high variability that can introduce noise into response time methods. The proportion of pleasant judgments for each prime type serves as an index of participants' spontaneous affective reactions to the primes. Previous studies with the AMP have shown that it has several important measurement properties. It is reliable, with internal consistencies usually above .80 (B. K. Payne et al., 2005). Perhaps most important, AMP scores have correlated strongly with relevant behavioral measures. For example, AMP responses to alcoholic drinks correlated strongly with the amount participants reported drinking per week (B. K. Payne, Govorun, & Arbuckle, 2007). These psychometric strengths make the AMP well suited to investigate implicit responses to nicotine cues. We expected that smokers would have more pleasant responses to smoking cues than nonsmokers would and that these responses would differ as a function of nicotine withdrawal and dependence.

Method

Participants

Participants were 35 smokers (23 men and 12 women) and 25 nonsmokers (5 men and 20 women) recruited from an undergraduate population (mean age = 20 years, $SD = 5$ years). The criteria for nonsmoking participants were that they had smoked fewer than 100 cigarettes in their lifetimes and had smoked none in the past 30 days. Of the 25 nonsmokers, 20 reported never having smoked cigarettes. The criteria for smoking participants were that they smoked at least 2 days per week and smoked at least one cigarette per smoking day. The smoking group smoked a mean of 6.19 cigarettes per day ($SD = 5.85$), with a range from less than 1 to 20 cigarettes per day.

Materials

AMP. Stimuli for the AMP were drawn from previous studies of smoking cue reactivity (McClernon et al. 2005). The smoking cues were 60 digital photographs of smoking-related objects (e.g., cigarettes, lighters) and people smoking cigarettes. Control cues were 60 matched photos of everyday objects (e.g., stapler, keys) and people holding objects unrelated to smoking. Judges familiar with the aims of the study verified that the smoking and control images were neutral in affect and were balanced in terms of composition, gender, race depicted, and complexity. The effectiveness of these cues in eliciting craving responses among smokers was validated in a previous neuroimaging study (McClernon et al., 2005). The smoking and control cues served as primes in the AMP. The targets to be evaluated were 120 Chinese pictographs that have been used in previous AMP designs (B. K. Payne et al., 2005).

Each trial of the AMP began with the presentation of a smoking or control cue as a prime (see Figure 1). The prime was presented for 75 ms, followed by a blank screen for 125 ms, followed by a target pictograph. The target was presented for 100 ms and was followed by a black-and-white visual mask that remained on the screen until a response was made. The purpose of the mask was to disrupt after-images, thereby limiting perceptual processing and maximizing ambiguity of the target items. Participants were instructed to judge the pleasantness of the Chinese pictographs. They were asked to decide whether each pictograph was more or less pleasant than the average pictograph and to press one of two keys labeled *pleasant* and *unpleasant*. One practice trial was provided so that participants could be familiarized with a trial sequence and with the appearance of a pictograph. One practice trial was deemed sufficient because participants made only one simple judgment on each trial. In this and previous studies, no participants reported having any trouble making these judgments.

The instructions included a warning to avoid being influenced by the primes. The warning read as follows:

It is important to note that the photographs flashed before each Chinese pictograph might influence your judgment of pleasantness. If you find the photo pleasant, you might judge the character more pleasant than you otherwise would. If you find the photo unpleasant, you might judge the character as less pleasant. *Please try your absolute best to avoid being influenced by the photos.* Your task is to evaluate the Chinese characters without any influence from the photos.

Participants completed 120 trials, which required 5–7 min.

Questionnaires. Two questionnaires were completed to measure withdrawal and dependence. The Shiffman/Jarvik Withdrawal Questionnaire (SWQ) is a 32-item scale that measures nicotine withdrawal symptoms on the basis of how participants feel at the moment (Shiffman & Jarvik, 1976). The SWQ includes six subscales: (a) Craving (urge to smoke), (b) Negative Affect (feelings of tension, irritability), (c) Appetite (current hunger), (d) Arousal (feeling awake vs. sleepy), (e) Habit Withdrawal (missing having

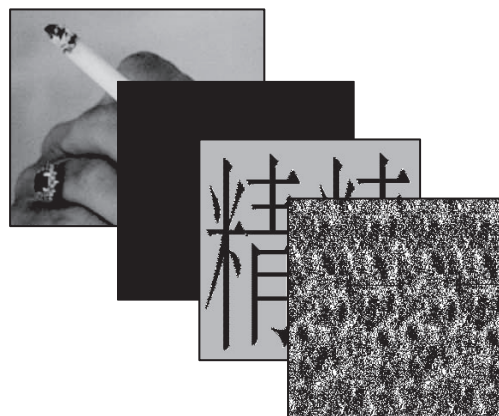


Figure 1. Representative stimuli for a trial of the Affect Misattribution Procedure.

cigarettes in hand or mouth), and (f) Somatic Symptoms (i.e., headache, tightness in chest, dizziness, etc.). Each question was answered on a 7-point scale from 1 (*not at all*) to 7 (*extremely*).

The Wisconsin Inventory of Smoking Dependence Motives (WISDM) is a 68-item measure of nicotine dependence (Piper et al., 2004). Unlike the SWQ, which measures current symptoms, the WISDM assesses chronic motivations for smoking dependence. The scale includes 13 subscales: (a) Affiliative Attachment (emotional attachment to smoking), (b) Automaticity (smoking without awareness of intention), (c) Behavioral Choice-Melioration (smoking despite constraints or negative consequences), (d) Cognitive Enhancement (smoking to improve attention and cognition), (e) Craving (smoking because of urges), (f) Cue Exposure (smoking in response to associated cues), (g) Loss of Control (belief that one cannot control smoking), (h) Negative Reinforcement (smoking to relieve unpleasant states), (i) Positive Reinforcement (smoking to achieve pleasant states), (j) Social-Environmental Goads (smoking because of social context), (k) Taste and Sensory Properties (smoking for taste or other sensory qualities), (l) Tolerance (smoking more to achieve the same rewards), and (m) Weight Control (smoking to control weight). Participants responded to each question with a 7-point scale from 1 (*not true of me at all*) to 7 (*extremely true of me*). Both groups were asked to complete the scales because differences in these symptoms could be potentially interesting. Participants were instructed that even if they did not smoke, some of the questions would relate to smoking habits and that, where appropriate, they could answer the questions meaningfully by selecting answers such as *not at all true of me*.

Procedure

Smoking participants were not instructed to refrain from smoking before the session because doing so might have created pressure to distort reports of smoking behavior. Instead, we measured naturally occurring individual differences in withdrawal, craving, and smoking frequency to examine how these factors related to implicit responses. Participants completed the study at individual cubicles with all tasks and questionnaires in a computer-based format. After providing informed consent, participants completed the AMP, followed by the questionnaires. After the questionnaires, participants indicated how many cigarettes they smoked per day, answered several questions about their smoking history, and provided demographic information. The order of measures was determined by several considerations. Because the AMP was intended to measure spontaneous affective responses to smoking cues, it was delivered before the other tasks so that thinking extensively about smoking habits would not change participants' spontaneous responses. The withdrawal and craving questionnaires were delivered next because we were interested in momentary states and their relation to AMP performance. Questions about smoking habits and demographics were deemed less likely to be influenced by previous measures.

Participants were fully debriefed and provided with information about smoking cessation treatments on campus.

Results

Implicit Responses for Smokers and Nonsmokers

AMP responses were scored by computing the proportion of *pleasant* responses to pictographs on trials with smoking cues and trials with control cues. These proportions were analyzed with a 2 (prime type: smoking, control) \times 2 (smoking group: smokers, nonsmokers) analysis of variance. This analysis showed a significant main effect of prime type, $F(1, 58) = 27.01, p < .001, \eta^2 = .32$, and a significant Prime Type \times Smoking Group interaction, $F(1, 58) = 11.98, p < .001, \eta^2 = .17$. Figure 2 displays the means. Simple effects tests showed that nonsmokers had significantly more negative responses following smoking cues than control cues, $F(1, 24) = 31.98, p < .001, \eta^2 = .57$. In contrast, smokers showed no significant differences in response to smoking cues versus control cues, $F(1, 34) = 1.82, p = .19, \eta^2 = .05$. Cross-group comparisons showed that smokers showed more positive responses to smoking cues than nonsmokers, $F(1, 58) = 6.91, p < .02, \eta^2 = .11$, and showed more negative responses to control cues than nonsmokers, $F(1, 58) = 5.59, p < .05, \eta^2 = .09$.

These results suggest that nonsmokers' implicit responses to smoking cues were relatively negative, whereas smokers' responses were similar to their responses to control items. Responses varied widely, however. The difference between responses on smoking trials and control trials among smokers ranged from $-.85$ to $.68$ and among nonsmokers ranged from $-.85$ to $.05$ (the possible range was -1 to 1). In the following analyses, we examine individual difference correlations to explore the sources of systematic variability among smokers.

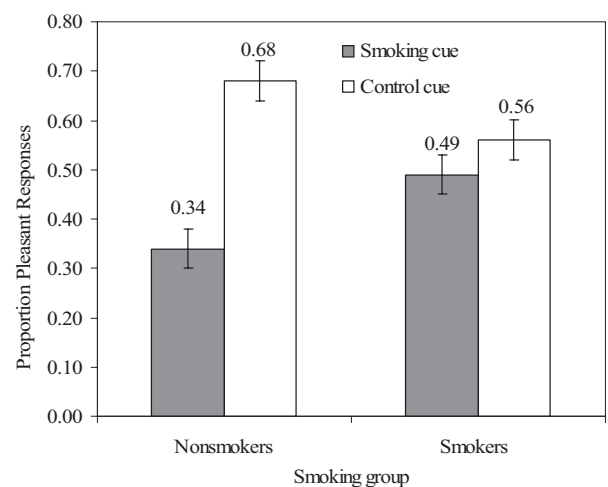


Figure 2. Mean proportion of *pleasant* responses as a function of prime type and smoking group. Error bars represent one standard error.

Individual Differences

AMP responses were scored as a difference score by subtracting the proportion of pleasant responses on control trials from pleasant responses on smoking trials. This produced a score for each participant, with higher values reflecting more positive responses to smoking cues relative to control cues. The AMP score showed high internal consistency ($\alpha = .94$).¹

Cigarettes per day. The number of cigarettes smoked per day was log-transformed because the raw values were heavily skewed. Among smokers, AMP responses were positively correlated with number of cigarettes per day ($r = .28$), but this relationship was not significant ($p = .11$).

Withdrawal. The top of Table 1 displays the correlations between the SWQ and AMP responses among smokers. Withdrawal was scored both as a full-scale composite, averaging across all items ($M_{\text{nonsmokers}} = 1.82$, $SD = 0.23$; $M_{\text{smokers}} = 2.35$, $SD = 0.47$) and as individual subscales. The composite measure was strongly related to AMP scores, showing that participants who were experiencing withdrawal symptoms responded more favorably to smoking cues. The relationship was driven primarily by the Habit Withdrawal, Somatic Symptoms, and Craving subscales.² Although smokers showed neutral implicit responses on average, the subset of smokers who were experiencing withdrawal symptoms responded favorably to smoking cues, whereas those smokers who were not experiencing withdrawal responded negatively, as shown in Figure 3.

Table 1
Correlations Between AMP Scores and Measures of Withdrawal and Dependence Among Smokers ($N = 35$)

Measure	AMP
Shiffman/Jarvik Withdrawal Questionnaire	
Full-scale composite	.49**
Habit Withdrawal	.45**
Somatic Symptoms	.42*
Craving	.35*
Negative Affect	.11
Appetite	.10
Arousal	-.04
WISDM dependence scales	
Full-scale composite	.31
Taste and Sensory Properties	.47**
Positive Reinforcement	.38*
Negative Reinforcement	.36*
Cognitive Enhancement	.34*
Cue Exposure	.20
Affiliative Attachment	.20
Craving	.19
Weight Control	.15
Loss of Control	.14
Behavioral Choice-Melioration	.12
Automaticity	.11
Tolerance	.07
Social-Environmental Goals	-.02

Note. AMP = Affect Misattribution Procedure; WISDM = Wisconsin Inventory of Smoking Dependence Motives.

* $p < .05$. ** $p < .01$.

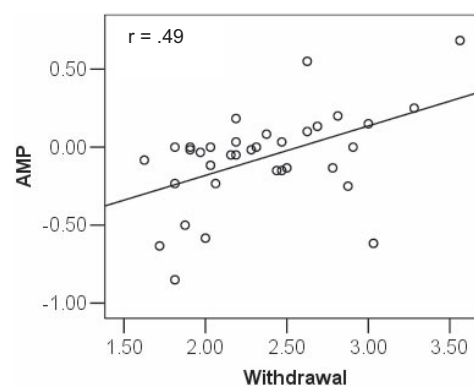


Figure 3. Scatter plot depicting the relationship between withdrawal (composite index) and Affect Misattribution Procedure (AMP) responses among smokers. AMP scores greater than zero reflect positive responses to smoking cues, relative to control cues. Possible scores for AMP range from -1.0 to 1.0 ; possible scores for withdrawal range from 1 to 7.

A series of regression analyses were run to examine whether the differences between smokers and nonsmokers in AMP responses remained when controlling for individual differences in withdrawal symptoms. Ignoring withdrawal scores, the relationship between smoking status (dummy coded) and AMP difference scores was significant, $\beta = .41$, $t(57) = 3.46$, $p < .001$. When the composite measure of withdrawal was controlled, the effect of smoking status was eliminated, $\beta = .14$, $t(57) = 1.08$, $p = .28$. The same was found for individual indexes of habit withdrawal, $\beta = .20$, $t(57) = 1.49$, $p = .14$, and craving, $\beta = .18$, $t(57) = 1.18$, $p = .24$. When somatic symptoms were controlled, however, the effect of smoking status remained significant, $\beta = .29$, $t(57) = 2.43$, $p < .05$. These analyses suggest that the differences between smokers and nonsmokers could be explained, in part, by differences in habit withdrawal and craving.

Smoking motivation. Whereas the withdrawal scales measured momentary experiences of symptoms and craving, the dependence scales measured chronic motivations

¹ Internal consistency was computed by randomly selecting one smoking trial and one control trial and subtracting them, then selecting another pair (without replacement), and so on until all trials were used. This created 60 difference scores for each person. Those difference scores were treated as individual items in a reliability analysis with Cronbach's alpha. For more details on this procedure, see B. K. Payne et al. (2005).

² Although it may at first seem surprising that the composite scale was more strongly related to AMP responses than the average correlation between the AMP and the subscales, it is important to note that the variance (215.99) and reliability ($\alpha = .85$) of the composite scale were greater than the average variance (22.90) and reliability ($\alpha = .68$) of the subscales. Because restricted variance and low reliabilities can attenuate correlations, the greater variance and reliability of the composite provide greater power to detect correlations (Cohen & Cohen, 1983, pp. 67–71).

for smoking. The bottom of Table 1 displays the correlations between the WISDM (composite $M_{\text{nonsmokers}} = 1.08$, $SD = 0.15$; $M_{\text{smokers}} = 2.86$, $SD = 0.89$) and AMP responses among smokers. The full-scale dependence composite was correlated in the expected direction but was not significant ($p = .11$). Of the subscales, four were significantly related to AMP responses. The strongest relationship was with the Taste and Sensory Properties subscale. This motivation is relevant to the rewarding properties of smoking, because most beginning smokers do not enjoy the taste and sensations of smoking, but they develop positive associations over time. The next strongest correlations were with the Positive Reinforcement and Negative Reinforcement subscales, which again is clearly related to reward processes. Finally, Cognitive Enhancement was significantly related to AMP responses.

The role of these smoking dependence motivations in differentiating smokers and nonsmokers was tested with a series of regression analyses. When the composite dependence index was controlled, the effect of smoking status was eliminated, $\beta = .11$, $t(57) = 0.56$, $p = .58$. The effect of smoking status was eliminated by controlling for each of the subscales, including Taste, $\beta = -.06$, $t(57) = 0.33$, $p = .74$; Positive Reinforcement, $\beta = .06$, $t(57) = 0.31$, $p = .76$; Negative Reinforcement, $\beta = .09$, $t(57) = 0.50$, $p = .62$, and Cognitive Enhancement, $\beta = .21$, $t(57) = 1.33$, $p = .19$. These analyses suggest that, as with the withdrawal scales, the differences between smokers and nonsmokers can be explained, in part, by differences in smoking motivation.

Discussion

We found that smokers and nonsmokers had very different automatic reactions to smoking cues. The reactions of nonsmokers were strongly and uniformly negative. Smokers, however, were neutral toward smoking cues on average. Their reactions depended on the nature of their motivations for smoking and on their current withdrawal state. In fact, these psychological variables had a larger impact than smoking behavior characteristics (e.g., the number of cigarettes smoked per day) and largely explained the differences in implicit affective responses between smokers and nonsmokers.

These results shed light on the ways that drug cues may help sustain addictions. Nonsmokers, unlike smokers, reacted to smoking cues with immediate dislike. For those smokers who were craving a cigarette, who missed the habitual behaviors of smoking, or who felt somatic symptoms of withdrawal, the smoking cues sparked pleasant reactions. Reactions were pleasant also for smokers who most liked the taste of cigarettes, for those who found smoking reinforcing, and for those who smoked to help boost attention and concentration. These patterns suggest that in addition to habitual nicotine levels, motivational factors may influence the automatic emotional impact of smoking cues.

Relation to Previous Research

The importance of smoking motivations and withdrawal states may help resolve some of the inconsistencies in prior studies. Some studies found relatively negative implicit responses to smoking cues among smokers, although their responses were less negative than those of nonsmokers (e.g., Bassett & Dabbs, 2005; Huijding et al., 2005; Sherman et al., 2003, Study 2; Swanson et al., 2001, Study 3). Other studies showed equally negative responses between both groups (Swanson et al., 2001, Studies 1 and 2). Still other studies showed relatively positive responses among smokers but not nonsmokers (De Houwer et al., in press, Study 2; Sherman et al., 2003, Study 1). All of the studies found negative responses to smoking cues among nonsmokers, with the differences only in the smokers' responses. One reason for the inconsistency may be that most of these studies did not take motivation and withdrawal into account. If some of the smoker samples had stronger smoking motivations or greater withdrawal symptoms than others, these unmeasured differences could lead to different conclusions about smokers' implicit responses. A key exception was the study of Sherman et al. (2003, Study 1) in which nicotine-deprived smokers showed relatively favorable responses to smoking cues on a priming task. Our finding of positive responses among smokers experiencing withdrawal symptoms converges nicely with this finding. The current results may contribute to bridging two patterns seen in previous research. At the mean level, smokers appeared neutral toward smoking cues. However, when withdrawal was taken into account, the apparent neutrality of smokers revealed a fairly positive response among smokers experiencing withdrawal and a negative response among smokers who were not. Thus, both patterns seen in previous research were found, under different motivational conditions.

Individual differences in motivation and withdrawal, however, are not the only differences between our study and prior ones. There are important differences in the ways that implicit responses were measured. Many of the studies finding negative responses among smokers used the IAT or closely related methods to measure implicit attitudes. If the IAT is sensitive not only to individual attitudes, but also to cultural norms, as has been argued (Olson & Fazio, 2004), then negative responses among smokers may partly reflect societal disapproval of smoking rather than dislike of smoking cues. The AMP differs in interesting ways from these other tests. The AMP measured affective responses that were elicited by the smoking cues but that were not experienced as such. Instead, the subjective experience was that a Chinese pictograph was pleasant or unpleasant (B. K. Payne et al., 2005). Participants were instructed to avoid expressing any influence of the primes, and if they thought a reaction was caused by the prime, they could easily have corrected it by simply pressing the other key. Yet they did not. The AMP captured emotional reactions that participants did not recognize as reactions to the smoking cues. This kind of unrecognized emotional response may have

important consequences, because it is difficult to regulate an emotional response to a smoking cue that is not recognized as such.

Our findings suggest that people's responses to smoking cues are easily misattributed to other sources. These kinds of misattributions may limit a person's insight into the effects of environmental cues on his or her behavior. For example, research on cue reactivity suggests that if a person who is trying to quit smoking walks into a room where a cigarette is burning in an ashtray, he or she may feel a sudden desire to smoke (Kaplan, Meyer, & Stroebe, 1983; Ludwig, Wikler, & Stark, 1974; Shiffman, 1986; Tiffany, 1990). If the person knows that the source of the craving is the burning cigarette, he or she might be able control the urge by leaving the room and thereby avoiding temptation, one effective component of smoking cessation (Fisher, Lichtenstein, Haire-Joshu, Morgan, & Rehberg, 1993). However, if the source of the craving goes unacknowledged, the person's options for self-regulation are more limited. A novel contribution of the present study was to capture these misattributed reactions with the AMP.

Unanswered Questions and Future Directions

The correlations we found linking automatic affect to smoking motivation and withdrawal beg the question of causal direction. On the one hand, it seems plausible that the desire to smoke rendered smoking cues more attractive. On the other hand, presenting smoking cues might have created craving and withdrawal symptoms for some smokers (especially those who found the cues most pleasant), thus influencing the ways participants responded on the surveys. Future studies might manipulate motivation by manipulating whether participants smoke or abstain from smoking before the study. Future research might also manipulate the order of the AMP and questionnaire measures so that the potential effects of one task on the other can be gauged.

The smoking frequency in this sample was relatively low. It would clearly be useful to examine the relation between implicit attitudes and smoking over a greater range of daily cigarette consumption. A study that included heavier smokers might be expected to show stronger relationships with implicit attitudes because heavier smokers can be expected to experience greater potential cravings and withdrawal. It is also possible, however, that heavier smokers might show a more complex pattern in which greater smoking experience might produce more negative affect toward cigarettes because of negative experiences associated with heavier smoking. These possibilities await future research. The observed smoking frequency was consistent with other college-aged samples (Rigotti, Lee, & Wechsler, 2000). Moreover, because a substantial number of college students start smoking regularly after entering college (Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998), understanding the affective processes related to smoking in this age group is important in itself.

Finally, previous studies with functional neuroimaging have found that self-reported states, such as craving and

withdrawal, were correlated with activity in regions linked both to emotion and to attention and cognitive control (e.g., Grant, London, & Newlin, 1996; McClernon et al., 2005). No studies have yet examined neural correlates of implicit responses to drug cues. Comparisons between neural correlates of self-reported versus implicit responses may reveal important dissociations, shedding light on the processes that distinguish implicit and explicit responses to drug cues. The associations among automatic affective responses, smoking behavior, and motivations fill an important gap in understanding psychological responses to smoking cues. In contrast to the results of early research, studies that use a variety of methods converge to suggest that smokers' automatic responses to smoking cues differ from the responses of nonsmokers and depend on motivational states, such as craving and withdrawal. Although preliminary, these findings fit well with theories arguing that conditioned cue associations help maintain addictions. Rather than smokers smoking despite an automatic aversion, automatic emotional responses to cues may help keep smokers smoking.

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