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Tobacco Withdrawal and Negative Affect: An Analysis of Initial Emotional Response Intensity and Voluntary Emotion Regulation

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This report used emotion-modulated startle to refine theoretically critical claims about negative affect during tobacco withdrawal. Forty-eight dependent smokers (assigned to either a 24-hr nicotine withdrawal condition or a continued smoking condition) and 48 nonsmokers participated in this study. Participants viewed a series of neutral and unpleasant photographic images and were instructed to *enhance*, *suppress*, or *maintain* their emotional response during specific trials. Participants' startle response was measured before and after this regulation instruction to index 2 components of emotional response: initial negative emotional response intensity and emotion regulation. Compared with the nonwithdrawn groups (continuing smokers and nonsmokers), withdrawal significantly increased self-reported negative affect. However, startle response indicated that emotional response intensity and emotion regulation success were not affected by withdrawal. These results are important because they constrain interpretation of the predominantly self-report literature on the affective consequences of tobacco withdrawal.

Keywords: withdrawal, emotion regulation, smoking

Many theorists argue that negative affect regulation is a primary motive for drug use in general, including tobacco use (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Brandon, 1994; Koob & Le Moal, 2001). In particular, the potent motivational contribution of negative affect during tobacco and other drug withdrawal has been highlighted in recent and longstanding theoretical formulations on drug dependence (Baker et al., 2004; Koob & Le Moal, 2001; Solomon & Corbit, 1974). For example, Baker et al. (2004) suggested that drug users learn that drug administration is exceptionally effective at ameliorating withdrawal-related negative affect. In addition, once this is learned, their drug use is motivated, in part, to avoid or escape this aversive state that results from cessation of use.

Numerous studies have documented that dependent smokers in tobacco withdrawal do indeed report increased negative affect (see Hughes, Higgins, & Bickel, 1994, for review). Sizable correlations are typically noted between self-report measures of withdrawal and mood (Hall, Muñoz, Reus, & Sees, 1993; Piasecki, Fiore, & Baker, 1998). Factor analytic studies indicate that affective items capture much of the reliable variance in withdrawal measures (Welsch et al., 1999). Experimental manipulations of withdrawal in the laboratory document increases in self-reported negative affect (Zinser, Baker, Sherman, & Cannon, 1992). Negative affective symptoms (e.g., anxiety, irritability, frustration or anger, and dysphoria–depressed mood) are also key criteria for nicotine withdrawal in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994).

Thus, it is clear that smokers report difficulty with negative affect when they cease tobacco use. However, the examination of the characteristics of this negative affect has not kept pace with the rapid conceptual and measurement advances in the affective sciences over the past decade. In fact, the majority of the empirical research on affect during tobacco withdrawal has been limited to self-report methods. Clearly, the experiential component of affect that is available to self-report is important and represents a tractable starting point to address theoretical questions about the affective consequences of withdrawal. However, many affective processes are nonconscious and may not be available to self-report methods (LeDoux, 1995). Moreover, self-report methods may not offer the precision necessary to examine important components of overall emotional response (Davidson, Jackson, & Kalin, 2000).

Recent theory and empirical research in the affective sciences have strongly suggested that affect is not a single monolithic construct but instead includes a set of separable component processes such as (a) tonic affective level (i.e., mood), (b) parameters associated with phasic emotional response (e.g., initial emotional response intensity, threshold for response, response rise time), and (c) emotion regulation processes that impact recovery time post-response. Moreover, some but not other of these affective components may be particularly relevant to understanding various forms of psychopathology (Bradley, Cuthbert, & Lang, 1999; Davidson et al., 2000).

As indicated previously, self-report methods have clearly established that dependent smokers experience negative affective problems during tobacco withdrawal, but these measures cannot readily examine the dynamic time course of phasic emotional response. Some components of smokers' affective experience may be more salient and therefore weigh more heavily on their self-report of their affective experience. Thus, it is unclear if report of negative

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affect symptoms during withdrawal indicates generally stable negative mood, increased intensity of response, frequent negative responses, prolonged negative response due to emotion regulation failures, or disruption of some other constituent affective process. Alternatively, self-reported affect may represent an aggregate of these component processes, which might obscure selective withdrawal effects on a subset of affective processes that are critical to understanding drug dependence. Either way, increased precision of measurement is necessary to consider the mechanisms through which withdrawal influences negative affect and subsequently motivates continued drug use and/or relapse.

In contrast to self-report methods, the well-established phenomenon of emotion-modulated startle (EMS; Bradley et al., 1999) provides the high degree of temporal specificity necessary to parse emotional response into its constituents. Numerous studies have shown that the startle response to an abrupt, intense stimulus (e.g., loud noise) is potentiated above baseline when elicited in conditions that produce negative emotional response because this negative emotion primes protective reflexes. Moreover, EMS has been used effectively in basic affective science research to probe the dynamic time course of phasic emotional response to various stressors (Grillon, Ameli, Merikangas, & Woods, 1993; Levenston, Patrick, Bradley, & Lang, 2000).

The primary aim of the present study was to use EMS to substantiate and, perhaps more importantly, refine theoretically critical claims about negative affect during tobacco withdrawal in dependent smokers. This report focuses on two important components of emotional response: *initial negative emotional response intensity* and subsequent *voluntary emotion regulation*.

Emotion regulation has been defined to include processes that are designed to enhance, suppress, or maintain the intensity of an initial emotional response (Davidson et al., 2000; Gross, 1998). These processes can be either conscious and volitional (e.g., distraction, reappraisal, rationalization) or more automatic (e.g., basic biological–homeostatic processes; Davidson et al., 2000; Solomon & Corbit, 1974). Studying negative emotion regulation, in addition to negative emotional response intensity, is important because smokers are more likely than the general population to experience problems that may reflect impaired ability to regulate negative affect, and these problems co-occur with increased severity of withdrawal symptoms and risk for relapse (e.g., depression and anxiety disorders; Black, Zimmernam, & Coryell, 1999; Hall et al., 1993). Preliminary evidence from studies using EMS has suggested that tobacco withdrawal does not alter the intensity of smokers' negative emotional response (Geier, Mucha, & Pauli, 2000; also see V. Mueller, Mucha, & Pauli, 1998, for examination of withdrawal effects on overall and baseline startle and EMS in response to appetitive and/or smoking cues). However, to our knowledge, no study has directly examined tobacco withdrawal's effect on dependent smokers' emotion regulation.

To accomplish these goals, 24-hr tobacco deprived (i.e., withdrawn) smokers, nondeprived (i.e., continuing) smokers, and nonsmokers completed a task designed to index voluntary emotion regulation (Jackson, Malmstadt, Larson, & Davidson, 2000). Participants viewed emotionally evocative unpleasant images and were instructed to regulate (enhance, maintain, or suppress) their negative emotional response at one point during the viewing procedure. EMS was examined both pre- and postregulation instruction to characterize participants' initial negative emotional response intensity and the subsequent success of their voluntary emotion regulation efforts, respectively. Thus, this task can sensitively and selectively test for withdrawal-elicited exacerbation of the intensity of the initial emotional response to stressors or subsequent impaired ability to volitionally regulate that negative emotional response. The inclusion of both nonsmoker and continuing smoker control groups was important to conclude that predicted group differences could be attributed to tobacco withdrawal (Hughes, 1992; Kalman, 2002). Specifically, group differences in designs involving only tobacco deprived versus nondeprived smokers could be caused by active smoking in the nondeprived smokers rather than by withdrawal-related processes in the deprived group. This shortcoming is particularly problematic when studying withdrawal-related emotion because acute nicotine administration may also affect emotion in some situations and individuals, independent of deprivation relief (Gilbert, 1997; Kassel, Stroud, & Paronis, 2003). In contrast, the comparison of tobacco deprived smokers versus nonsmokers provides for an assessment of withdrawal effects that are not complicated by nicotine administration in the control group. However, interpretation of this contrast instead suffers from potential individual differences between smokers and nonsmokers. Therefore, we believed that it was necessary to use two control groups to provide for the clearest interpretation of predicted withdrawal effects.

Method

Participants

Forty-eight daily smokers and 48 nonsmokers were recruited from the University of Madison—Wisconsin and the surrounding community via e-mail, newspaper, and TV advertisements. During an initial phone contact, smokers provided information about their cigarette usage to assess eligibility for participation, and eligible smokers attended an in-person screening session to provide a carbon monoxide (CO) sample to verify study eligibility and to complete detailed self-report measures of smoking history. Inclusion criteria for all participants included age $\geq$18 years, English reading and writing proficiency, and no physical or psychological condition that would contraindicate study participation. Inclusion criteria for smokers included cigarette consumption $\geq$10 cigarettes/day for at least 1 year, screening session CO level $\geq$10 ppm, and no current participation in any smoking cessation program or treatment. Nonsmokers (NS) reported no current or past daily cigarette use and had consumed $<$100 cigarettes total in their lifetime.[1]

Daily smokers meeting the above inclusion criteria were stratified by gender and then randomly assigned in equal numbers to either the withdrawn smoker (WS) group or the continuing smoker (CS) group. Participants in the WS group were instructed to not smoke for 24 hr prior to their laboratory session. Participants in the CS group were instructed to maintain their typical cigarette usage pattern prior to their laboratory session. Equal numbers of male and female participants were included in each of the three groups (CS, WS, and NS).

Experimental Session

On arrival at the laboratory, smokers provided a breath sample for CO assessment. WS participants were required to self-report smoking absti-

[1] Nonsmokers were selected from a larger unpublished study (Curtin & Gulotta, 2004) of individual differences in emotion regulation. For this purpose, we included all participants from that study who met the nonsmoking criteria.

nence and to obtain a CO level of ≤7 ppm to participate. At this point, CS participants smoked a cigarette to forestall symptoms of withdrawal symptoms during the task. Next, participants completed the voluntary emotion regulation task (see Figure 1; Jackson et al., 2000). Participants viewed a series of 120 digitized photographic images (88 unpleasant and 32 neutral images; Center for the Study of Emotion and Attention, 1999). Each image was presented for 8 s with a 12-s interstimulus interval. Four seconds after onset of an unpleasant image, a digitized voice instructed participants to "enhance," "suppress," or "maintain" their current emotional response. For neutral images, the only instruction was to maintain their neutral emotional response. Sixteen seconds after image onset (8 s after image offset), the word *RELAX* appeared, and participants were instructed to terminate their effort at emotion regulation and prepare for the next image.

All participants were reimbursed $10/hr for a total of approximately 3 hr in the laboratory. The WS participants were compensated an additional $20 for adherence to the tobacco deprivation criterion. Laboratory sessions were generally conducted in the early afternoon. There were no systematic differences across groups in the time of day the laboratory session was completed.

EMS Measurement

Startle-eliciting noise probes (50-ms 102-dB white noise burst with instantaneous rise time) were presented 3, 7, 12, and 15 s after image onset across trials. Startle blink response was recorded from 50 ms before probe onset (baseline) to 250 ms after probe onset from electrodes positioned under the right eye. The raw electromyogram signal was sampled at 2000 Hz, bandpass filtered (30–500 Hz; 24 dB/octave roll-off), smoothed (rectified then lowpass filtered at 30 Hz; 24 dB/octave), and baseline corrected.

Startle blink magnitude[2] was scored as the peak response between 20 and 120 ms after probe onset. Initial negative emotional response intensity was assessed by probes 3 s after image onset (preregulation instruction). The effect of voluntary emotion regulation processes was assessed by probes 7, 12, and 15 s after image onset (postregulation instruction).

Self-Report Measures

During the screening session, smokers completed a smoking history questionnaire, the Fagerström Test of Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991), and the Wisconsin Inventory of Smoking Dependence Motives (Piper et al., 2004). During the laboratory session, smokers completed the Wisconsin Smoking Withdrawal Scale (WSWS; Welsch et al., 1999) twice, before and after the task, to assess tobacco withdrawal symptoms.

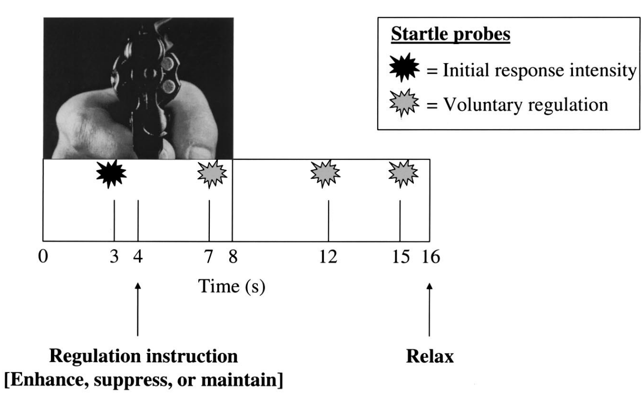

Figure 1. Schematic of trial structure for voluntary emotion regulation task. Each image was presented for 8 s. A digitized voice instructed participants to "enhance," "suppress," or "maintain" their current emotional response 4 s after image onset. Each trial ended with presentation of the word *RELAX* 16 s after image onset. Startle probes were presented 3, 7, 12, or 15 s after image onset. The startle probe at Probe Time 1 (i.e., preregulation instruction) was used to assess initial affective reactivity. Probes at Times 2–4 (i.e., postregulation instruction) were combined to assess affect following voluntary emotion regulation. Additional method details are provided in Jackson et al. (2000).

Results

Self-Report Cigarette Use, Dependence, and Withdrawal Symptoms Among Smokers

The smokers reported considerable cigarette use (cigarettes/day = 17.8, SD = 11.2; age first cigarette = 14.7 years, SD = 2.0; age began daily use = 17.2 years, SD = 3.4; years daily smoking = 10.4 years, SD = 10.8; baseline CO = 15.6, SD = 6.5). Smoking Group (CS vs. WS) × Gender (male vs. female) analyses of variance (ANOVAs) revealed no significant smoking group effects for any of these measures (all ps > .23).

Consistent with instructions, WS participants reported abstinence from cigarettes for an average of 26.5 hr (SD = 4.9) prior to the laboratory session. All CS participants smoked immediately prior to the experimental task. WS participants' mean CO level (M = 2.6, SD = 2.4) was significantly lower than that for the CS participants (M = 17.6, SD = 9.1) at the start of the laboratory session, $F(1, 46) = 61.02$, $p < .01$, $\eta_p^2 = .57$.[3] Self-reported overall withdrawal symptoms (WSWS; potential score range = 0–4) were analyzed in a Smoking Group × Gender × Assessment Time (1 vs. 2) ANOVA. A significant smoking group effect was observed, $F(1, 43) = 12.71$, $p < .01$, $\eta_p^2 = .23$, with WS participants reporting significantly higher overall withdrawal across both assessment times (M = 2.3, SD = 0.5) than did CS participants (M = 1.8, SD = 0.5). Comparable ANOVAs were also conducted on the affect-related subscales of the WSWS (Anxiety, Anger, and Sadness). Relative to CS participants, WS participants reported significantly elevated overall Anxiety (M = 2.5, SD = 0.1, vs. M = 2.0, SD = 1.0), $F(1, 43) = 9.09$, $p < .01$, $\eta_p^2 = .17$, and Anger (M = 2.2, SD = 0.2, vs. M = 1.5, SD = 0.2), $F(1, 43) = 8.43$, $p < .01$, $\eta_p^2 = .16$. No significant smoking group effect was observed for the WSWS Sadness subscale.

Smoking Group Planned Orthogonal Contrast (POC) Analysis Strategy

POCs were used to test primary predictions about tobacco withdrawal effects on initial negative emotional response and emotion regulation. The smoking group factor (NS vs. CS vs. WS) was decomposed into two orthogonal contrasts: a withdrawal contrast (WS vs. CS and NS) and a smoking contrast (CS vs. NS).

[2] Startle magnitude was standardized within participants (i.e., converted to T scores) to reduce individual differences in overall startle magnitude. Comparable analyses with raw score startle response as the dependent measure replicate exactly the pattern of results reported for this standardized measure.

[3] Partial η^2 effect size estimates are reported to document the magnitude of either theoretically or methodologically critical effects. $\eta_p^2 = SS_{effect}/(SS_{effect} + SS_{error})$ and is analogous to a squared partial correlation from multiple regression models. Accordingly, Cohen (1992) has operationally defined squared partial correlations of .02, .15, and .35 as small, medium, and large effects, respectively.

The clearest support for a tobacco withdrawal effect on emotion response or regulation would be offered by a significant withdrawal contrast with no differences observed between the CS and NS control groups (i.e., a nonsignificant smoking contrast).

Initial Negative Emotional Response Intensity

Startle magnitude at Probe Time 1 (3 s after image onset; preregulation instruction) was analyzed within a mixed model ANOVA with smoking group POCs as between-subjects factors and image valence (neutral vs. unpleasant) as a within-subject factor.[4] This analysis was conducted to demonstrate that the unpleasant images were effective at eliciting an initial negative emotional response and to test the effect of withdrawal on initial negative emotional response intensity. A significant main effect of image valence was observed, $F(1, 93) = 24.34$, $p < .01$, $\eta_p^2 = .21$, confirming the predicted increase in startle magnitude during the unpleasant images. However, the Withdrawal POC × Image Valence interaction was not significant, $F(1, 93) = 0.49$, $p = .49$, $\eta_p^2 = .01$ (see the top panel of Figure 2). Similarly, the Smoking POC × Image Valence interaction was also not significant, $F(1, 93) = 1.85$, $p = .18$, $\eta_p^2 = .02$. Neither smoking group POC main effect was significant.

Voluntary Emotion Regulation

Startle magnitude at Probe Times 2–4 (7, 12, and 15 s after image onset; *postregulation instruction*)[5] was analyzed within a mixed model ANOVA with smoking group POCs and gender as between-subjects factors and regulation instruction condition (suppress–unpleasant vs. maintain–unpleasant vs. enhance–unpleasant vs. maintain–neutral)[6] as a within-subject factor to determine if tobacco withdrawal impaired voluntary emotion regulation. A large and significant main effect of regulation instruction was observed, $F(3, 279) = 62.09$, $p < .01$, $\eta_p^2 = .40$, indicating that participants could volitionally regulate their negative emotional response. To further examine this regulation instruction effect, we tested two specific regulation contrasts: the *suppression* contrast (suppress–unpleasant vs. maintain–unpleasant) and the *enhancement* contrast (enhance–unpleasant vs. maintain–unpleasant). Both the suppression and enhancement contrasts were significant, ts(95) = 6.46 and 7.17, respectively, ps < .01, such that relative to the maintain–negative emotion condition, participants' startle magnitude to unpleasant images reliably decreased when they were instructed to suppress their negative emotion and increased when they were instructed to enhance their negative emotion.

The predicted Withdrawal POC × Regulation Instruction interaction was not significant, $F(3, 279) = 0.70$, $p = .55$, $\eta_p^2 = .01$ (see the bottom panel of Figure 2). Similarly, the Smoking POC × Image Valence interaction was also not significant, $F(3, 279) = 0.31$, $p = .81$, $\eta_p^2 = .00$. Neither smoking group POC main effect was significant.

Power Analysis

To determine the power to detect tobacco withdrawal effects on initial emotional response intensity and emotion regulation, we conducted power analyses with Power Analysis and Sample Size software (PASS; www.ncss.com) that provides the necessary algorithms to estimate power for within-subject and mixed model effects (see K. Mueller & Barton, 1989; K. Mueller, LaVange, Landesman, & Ramey, 1992). These analyses required an estimate of the variance–covariance structure among the within-subject variates that we estimated using data from the entire study sample. Power for three effect sizes was evaluated (η_p^2 = .10, .15, and .20) given the range of observed withdrawal effects on self-reported affective and other withdrawal symptoms in the current study (η_p^2s ranged from .16 to .23). Obviously, power was higher to test for the larger main effect of emotion regulation instruction ($\eta_p^2 = .41$). The powers to detect a Withdrawal POC × Image Valence interaction (i.e., test of withdrawal on initial emotional response intensity) with an alpha of .05 with 24 WS participants and 72 CS and NS participants were .891, .984, and .998 for effect sizes of η_p^2 = .10, .15, and .20, respectively. The powers to detect a Withdrawal POC × Regulation Instruction interaction (i.e., test of withdrawal on voluntary emotion regulation) with an alpha of .05 with 24 WS participants and 72 CS and NS participants were .845, .977, and .997 for effect sizes of η_p^2 = .10, .15, and .20, respectively.

Discussion

Consistent with the large self-report literature on tobacco withdrawal, withdrawn smokers self-reported increased negative affective symptoms (i.e., anxiety and anger). However, EMS results suggest that this self-reported withdrawal-related affective disturbance does not appear to be associated with an exaggerated intensity of the initial negative emotional response to a relatively punctate, explicit stressor. Robust, but comparable, EMS was observed among WS, CS, and NS participants during initial exposure to unpleasant images, indicating equivalent initial negative emotional response intensity. Startle response results also indicate that WS participants did not evidence impaired ability to volitionally regulate their negative emotional response when explicitly instructed to do so.

The demonstration of normal emotional response intensity and intact voluntary emotion regulation skill during tobacco withdrawal has important implications for understanding the motiva-

[4] Gender did not moderate (i.e., interact with) smoking group POCs in the analyses of either initial negative emotional response intensity or voluntary emotion regulation. Therefore, gender was not included as a factor in the final reported analyses. However, a significant Gender × Regulation Instruction interaction was observed, $F(3, 270) = 2.91$, $p = .04$, $\eta_p^2 = .03$. Follow-up analyses indicated gender differences in the ability to suppress negative affect. Specifically, men were less able to volitionally suppress their negative affect (suppress–maintain contrast score of −1.3) than were women (suppress–maintain contrast score of −2.7). No gender differences were observed in the ability to volitionally enhance negative affect.

[5] Initial analysis included probe time as a within-subject factor. However, because probe time did not moderate (i.e., interact with) any effects involving smoking group, reported analyses are collapsed across probe times.

[6] Huynh Feldt corrected p values are reported for all effects involving the regulation instruction condition factor to correct for possible violations of the sphericity assumption.

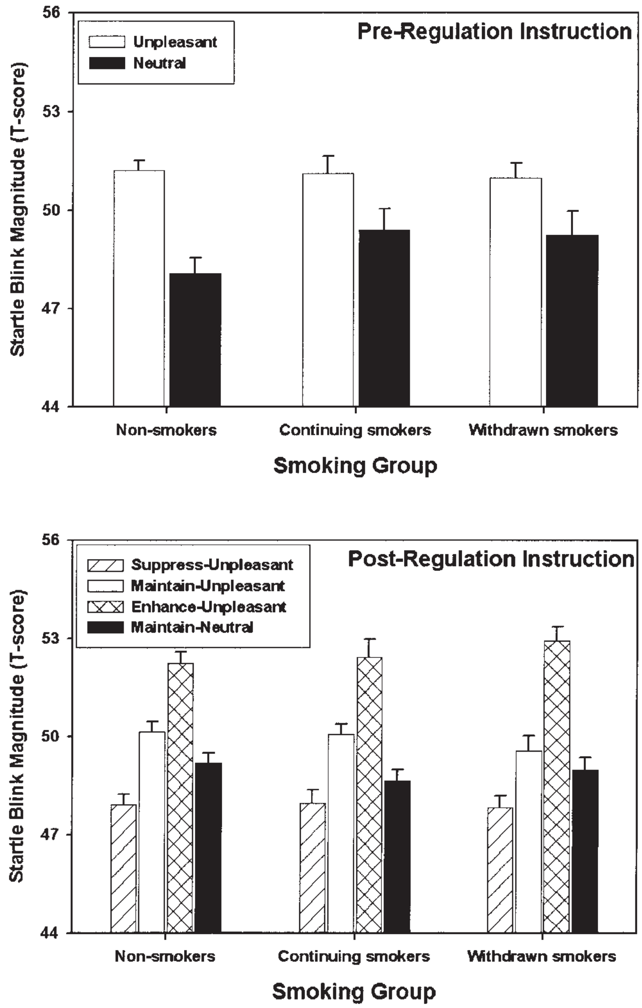

Figure 2. Top: Preregulation instruction startle response magnitude by smoking group and image valence. Both continuing and withdrawn smokers demonstrated significant, robust, and comparable image valence effects (potentiated startle response to unpleasant vs. neutral images). Smoking group did not moderate (i.e., interact with) this image valence effect, which indicates equivalent initial negative emotional response intensity among withdrawn and continuing smokers. Bottom: Postregulation startle response magnitude by smoking group and regulation instruction condition. Both continuing and withdrawn smokers demonstrated significant, robust, and comparable regulation instruction effects. Smoking group did not moderate (i.e., interact with) this regulation instruction effect. This indicates equivalent ability to volitionally regulate negative emotional response among withdrawn and continuing smokers. Error bars indicate standard errors of the mean.

tional properties of drug withdrawal and treatment of drug dependence (e.g., see the STAR model; Gilbert, 1997; Kassel et al., 2003). However, null effects can be meaningfully interpreted only when researchers are confident that the methodology used would have detected such effects if they did exist. In this study, this confidence rests on the demonstration that tobacco withdrawal was potently manipulated, startle response was sensitive to changes in emotional response overall and emotion changes resulting from voluntary regulation, and the overall design had adequate power to detect meaningful effect sizes.

Design factors and data from manipulation checks confirm a potent tobacco withdrawal manipulation. Self-report and biochemical indices confirm that the actual smokers recruited appear to be nicotine dependent (e.g., 17.8 cigarettes/day, baseline expired CO level of $\geq$10 ppm, 10.4 years daily smoking; FTND score of 4.1). Compliance with the rigorous 24-hr withdrawal requirements (many laboratory studies actually use notably shorter withdrawal periods; e.g., 12-hr deprivation) was confirmed by self-report and CO level. Moreover, a significant and very large effect size (η^2 = .57) difference in CO levels was observed between WS and CS participants during the experimental session. Finally, there were significant and moderately large effect size (η^2s = 0.16–0.23) differences in self-reported negative affect and other withdrawal symptoms between WS and CS participants. Thus, the absence of significant withdrawal effects on emotional response intensity and voluntary emotion regulation did not result from a failure to potently manipulate tobacco withdrawal.

A wealth of empirical evidence has established the construct validity of EMS (Bradley et al., 1999). In this study, the startle response appears to be a sensitive measure of negative emotional response to unpleasant image viewing and changes in this emotional response from voluntary emotion regulation processes. Significant and robust negative emotional response to unpleasant images was detected preregulation instruction. Similarly, analysis of the startle response postregulation instruction confirmed participants' ability to volitionally suppress or enhance this negative emotional response when instructed. Finally, adequate power (range of .85–.99) to detect meaningful effect sizes (η^2s from .10–.20) for predicted withdrawal effects was provided. Given the reliable manipulation of withdrawal, the sensitivity of the affect assessment, and the power to detect meaningful effects, it seems reasonable to conclude that tobacco withdrawal does not reliably alter either the intensity of the initial negative emotional response or the ability to volitionally regulate this emotional response to a brief, explicit stressor.

These results are important because they constrain interpretation of smokers' self-reported affective disturbance during withdrawal. Smokers report affective disturbances such as anxiety, increased stress, irritability, and dysphoria during smoking withdrawal (Hughes et al., 1994). However, results from this and other recent research (Geier et al., 2000) suggest that the source of this affective disturbance during withdrawal does not lie in exaggerated reactions to brief environmental stressors as one might assume from smokers' choice of self-report terms such as *stressed* and *irritable*. Moreover, the current results do not suggest that smokers (either withdrawn or nicotine satiated) have increased difficulty volitionally regulating their emotional response to these external, punctate stressors.

This demonstration of robust voluntary negative emotion regulation during tobacco withdrawal may have implications for the development of smoking cessation treatment programs. If smokers in withdrawal can effortfully modify their affective reactions when instructed, interventions designed to increase voluntary emotion regulation in high-risk situations may reduce stress-induced relapse to smoking. In addition, providing smokers with the knowledge that they are not helpless in the face of negative affect when they quit smoking may provide additional motivation and confidence for their quit attempts. Of course, the clinical implications of these results must be interpreted very cautiously given constraints associated with the manipulation of emotion regulation in this experimental task. For example, this task required regulation of negative emotion to an exogenous stressor for only a brief period (i.e., 12 s per trial). It may be that the continued vigilance required to combat withdrawal symptoms depletes the cognitive resources necessary to sustain a voluntary emotion regulation strategy over a longer period of time. Thus, use of a longer duration stressor (e.g., valence-blocked procedures; Bradley, Cuthbert, & Lang, 1996) might uncover regulation deficits due to increased fatigue during withdrawal. Future research should also examine the time course of withdrawal effects on negative emotional response and regulation. Piasecki and colleagues (2000) have demonstrated the importance of considering withdrawal trajectories over the course of weeks. Application of the current methods in multiple sessions over an extended withdrawal period (e.g., during a smoking cessation program) may reveal important withdrawal effects that are not observed immediately postcessation. Moreover, it must be acknowledged that the smokers in this study were not motivated to permanently maintain abstinence (i.e., they were not seeking treatment).

Confidence in the robustness of voluntary emotion regulation skill during tobacco withdrawal would be further increased through conceptual replication with other measures and in paradigms that place different regulation demands on participants. For example, in the Jackson et al. (2000) emotion regulation paradigm, participants are explicitly instructed when to regulate their negative affect. However, smokers in the real world may fail to identify critical contexts in which voluntary emotion regulation should be used. Finally, future research should consider important individual differences among smokers that may mask effects in group-level analyses. Although the current results do not suggest an overall deficit in emotion regulation during tobacco withdrawal, it is possible that significant affective disturbance may exist among subgroups of withdrawn smokers.

Conclusion

Research to date has established that tobacco withdrawal produces robust, detrimental affective consequences (Baker et al., 2004). However, clarification of the precise nature of these affective changes is necessary, and basic affective science provides important theory and tools to guide this research. This report highlights the potential precision provided by a component process approach to the study of affect (Davidson et al., 2000). Despite the self-report of general affective disturbance during tobacco withdrawal, startle response results indicate that 24-hr tobacco withdrawal does not alter smokers' initial negative emotional response to a punctate, explicit stressor or smokers' ability to volitionally regulate this emotional response when instructed. Considerable systematic research remains to fully characterize the affective dynamics of tobacco withdrawal.

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