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Relation Between Self-Reported Affect and Drug Urges and Cravings in Continuing and Withdrawing Smokers

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In 2 experiments we investigated the effects of withdrawal and stress on the affective correlates of urges to smoke. In both, habitual cigarette smokers were divided into continuing and withdrawing smoker groups. In the 1st study, 44 adults reported current mood, urge, and expectations over a 24-hr period. In the 2nd, a controlled laboratory study, urge, affect, and physiological data were obtained from continuing and withdrawing groups ($N = 64$) exposed to high- or low-stress conditions. Urges among withdrawing smokers were positively associated with negative affect and negatively associated with positive affect; continuing smokers reported urges that were directly associated with positive affect and unrelated to negative affect. Stress and withdrawal produced urge self-reports that were related to negative affect. Moreover, subjects who smoked after exposure to withdrawal and stress reported greater pleasure and arousal than did other subjects.

Withdrawal-based and homeostatically based theories of addiction emphasize that negative reinforcement is the principal motivation for the addict to use a drug. According to such theories addicts quickly acquire tolerance to the initial, appetitive effects of the drug and eventually take it merely to avoid or escape the agony of withdrawal (e.g., Siegel, 1983; Solomon, 1977). Recent models of addiction have emphasized positive reinforcement and priming mechanisms in maintaining drug use (Baker, Morse, & Sherman, 1987; Stewart, de Wit, & Eikelboom, 1984; also see McAuliffe et al., 1986). These models assert that the drug may produce pleasure or positive affect by acting on brain reward systems. In theory, these brain reward systems produce pleasure or positive affect, arousal or activity, and a heightened probability of pursuing previously rewarded operants (Baker et al., 1987; Stewart, 1984; also see Panksepp, 1986).

The two types of models yield different predictions about the affective and physiological events that may elicit drug use and characterize drug motivational states. Negative reinforcement models suggest that reduced direct drug effects, negative moods, and withdrawal symptoms and signs may precede and be positively related to measures of drug motivation. Conversely, models that emphasize priming mechanisms suggest that drug motivation ought to be associated with the presence of the drug in the body and with direct, appetitive drug effects. Indeed, numerous studies have been conducted in which physiological measures of withdrawal or direct drug effects have been correlated with assessments of drug motivation (see Baker et al., 1987). In general, these have not yielded a consistent pattern of findings (Tiffany, 1990), perhaps because the physiological indexes used were not sufficiently sensitive to the affective consequences of drug use or abstinence. For example, many such indexes (e.g., heart rate) serve vital metabolic functions that limit their reflection of motivational states.

We undertook this study to explore the affective correlates of self-reported desire to use a drug. We related affect to drug motivation measures because negative reinforcement models and priming models yield very different predictions about the affect–drug motivation relation. Negative reinforcement models hold that negative affect, secondary either to withdrawal (Hughes & Hatsukami, 1986) or to other events, ought to serve as a cue for drug self-administration and for the subjective phenomena labeled as *cravings* and *urges* (Wise, 1988). Therefore, if negative reinforcement models are correct, self-reported desire to take the drug and positive expectations about drug effects ought to be positively related to negative affect. If priming models are valid, when the drug is present in the body, positive affect (an output of reward system activation) ought to be positively associated with drug motivation measures. Both of these outcomes are consistent with views that drug urges are processed in neural systems involved in the mediation of affect (Baker et al., 1987; Niaura et al., 1988). The integration of withdrawal-based, negative affect models and incentive-based, positive affect ones offers the promise of a more complete account of drug-use motivation.

Experiment 1

In this study, smokers rated their affect, urge level, and positive expectations about smoking. Half of the smokers abstained over the 24-hr course of the study, whereas the other half smoked ad lib. We made the following prediction on the basis of

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previous findings (Sherman, Baker, & Morse, 1986) and on the basis of theory. (a) Among continuing smokers, self-reported urges to smoke and expectations of smoking benefits would be positively related to positive affect. In theory, the drug (nicotine) would increase positive affect (see Henningfield, 1984), which would prime the motivation to smoke further. It was not necessary that the drug per se primed positive affect; other incentive stimuli could also activate brain reward systems (Wise, 1988) and increase urges to smoke. Unrelenting self-administration was, of course, checked by toxic high-dose drug effects. Withdrawal symptomatology was held to be of limited importance in maintaining self-administration in ad lib smokers. (b) Because withdrawal from drug activates brain systems that yield negative affect (anxiety, anger, and depression), withdrawing smokers ought to report greater negative affect than continuing smokers. Among these smokers, measures of smoking motivation (urge ratings and expectations) would be positively related to negative affect: The greater the negative affect, the greater the opportunity for negative reinforcement. In theory, positive affect would typically not prime smoking motivation in withdrawing smokers because withdrawal might produce profound negative affect and, at extreme ranges, negative and positive affective processes would be mutually inhibitory (Diener & Iran-Nejad, 1986). (c) If smoking motivation was primed by the direct effects of smoking and nicotine in addition to withdrawal, then continuing smokers would report at least moderate levels of motivation to smoke despite their ad lib access to nicotine and the absence of any withdrawal symptoms. (d) If priming and withdrawal influenced smoking motivation through their impacts on affective processing systems, then measures of trait affect or affective lability would predict subsequent levels of smoking motivation.

Method

Subjects

The subjects were 44 adult smokers recruited through newspaper advertisements and fliers. Volunteers were screened by expired air carbon monoxide (CO) analysis to ensure that they were regular cigarette smokers (minimum CO = 14.0 parts per million [ppm]). All but 4 of the accepted volunteers (2 in each group) completed the study and were paid $12.00.

Subjects were randomly assigned to a continuing smoker group (n = 21) or a withdrawing smoker group (n = 23) at the first of two consecutive evening meetings. Table 1 presents relevant subject information for the two groups. There were no significant group differences on any of the variables (all $ps > .05$) except for daily cigarette consumption as evidenced by a significant analysis of variance (ANOVA) group effect, $F(1, 42) = 4.14$, $p = .05$.

Table 1
Subject Information: Experiment 1

Variable	Continuing smokers		Withdrawing smokers	
	M	*SD*	*M*	*SD*
Age	23.6	5.8	27.8	8.6
No. years smoking	8.6	7.7	10.5	8.3
Baseline carbon monoxide (parts per million)	24.5	9.9	25.9	10.8
Consumption	23.2	5.8	28.0	9.5

Note. Consumption = number of cigarettes smoked per day. The percentages of women in each group were 30% and 52% in the continuing smoking and withdrawing groups, respectively.

Dependent Measures

The dependent measure battery, the Mood and Smoking Urge Questionnaire (MSUQ), contains items to assess expectations about the effects of smoking, the urge to smoke, and mood and attributions about mood. The directions instructed subjects to indicate for each of the dimensions how they felt at the moment they were completing the battery. Initial items on this questionnaire were four adjectives (*pleasant, unhappy, happy,* and *unpleasant*) that constituted a brief positive–negative mood instrument used by Diener and Iran-Nejad (1986). These items permitted concurrent validation with the Mood Adjective Check List (MACL) mood items presented later in the questionnaire.

Subjects' current expectations about the effects of smoking were sampled by eight theoretically derived items. These were based on research that has identified putative reinforcing effects of smoking (O. F. Pomerleau & Pomerleau, 1984; Tomkins, 1966), on theories of drug motivation that emphasize withdrawal as a motivator of smoking, and on the factor structure of the Reasons for Smoking Questionnaire (Ikard, Green, & Horn, 1969). The expectations sampled, each presented with a 9-point Likert format, were that cigarettes would have the following effects: improve affect, reduce unpleasant physical sensations, facilitate social functioning, reduce intrusive thoughts about smoking, provide something to fiddle with, taste good, enhance performance, and help occupy time. The anchors for this and all other Likert scales in the MSUQ were *not at all* (1), *moderately* (5), and *extremely* (9).

The MSUQ also contained five urge questions, also in a 9-point Likert format. These were taken from the Withdrawal Symptoms Questionnaire (WSQ) Craving subscale (Shiffman & Jarvik, 1976). The internal consistency (coefficient alpha) of the urge scale in this sample was .89 (determined for a randomly selected rating occasion). The next part of the MSUQ was an abbreviated version of the MACL (Nowlis, 1965), again in 9-point Likert format. Included in the MSUQ were the MACL scales of Aggression, Anxiety, Sadness, Vigor, Elation, and Surgency, each assessed by three items.[1]

In addition to the MSUQ, all subjects completed the Affect Intensity Measure (AIM), which served as a measure of the subject's characteristic strength of affective reaction. Research has shown that AIM scores predict viewing time of affectively valenced slides, the motivating effects of an auditory stressor, and self-ratings of daily affect intensity and affect variability (Larsen & Diener, 1987). This measure is a 40-item questionnaire that contains self-descriptions rated on a 6-point scale from *never* (1) to *always* (6).

Procedure

Subjects met in groups of 3–8 on consecutive weekday evenings. After a general description of the study, informed consent was ob-

[1] Because the measurement of affective state is crucial to our analytic strategy, we used Diener and Iran-Nejad's (1986) mood instrument to determine the concurrent validity of the Mood Adjective Check List (MACL), our principal affect measure. Negative affect MACL scales were consistently positively correlated with ratings of *unhappy* and *unpleasant*; 81% of the correlations were significant at the $p < .05$ level, and 69% of the correlations exceeded .49. Correlations among MACL positive affect scales and ratings of *happy* and *pleasant* were comparably consistent and significant.

tained. Next, CO samples were collected, and the subjects completed a smoking history questionnaire. The CO was analyzed with a Model 2000 Ecolyzer (Energetics Science, New York, NY). Those who failed to reach the cutoff were paid $2.00 and dismissed. Then subjects were given the MSUQ and the AIM. After they completed these questionnaires, a heart rate measure (30-s pulse) was obtained. Next, the subjects were given their randomly determined group assignment and an envelope with five MSUQs to be completed at 2130 hr and at 2-hr intervals from 1030 hr to 1630 hr on the following day. Continuing smokers were given tally sheets sized to fit into the cellophane wrapper of a cigarette package cover, on which they were asked to record the number of cigarettes smoked during the next 24 hr. Withdrawing smokers were instructed not to smoke. All subjects were then assigned times at which to call the following morning and report selected responses from their most recent MSUQ form. This procedure, which required only 1–2 min of a subject's time, was aimed at enhancing attention to the measure and at providing a reliability check. All subjects were asked to return at the same time the following evening. At this second evening session, subjects again completed the MSUQ, and pulse and CO measures were obtained.

Results

Effects of Withdrawal

The withdrawing smokers reported smoking an average of 1.0 (SD = 3.5) cigarettes between the first and second evening sessions, whereas continuing smokers reported smoking 31.0 (SD = 14.3) cigarettes over the same period, $F(1, 41) = 94.7$, $p < .001$. The reported reduction in smoking by withdrawing smokers was associated with the classic physiological withdrawal signs—lowered CO values (from M = 24.5 ppm, SD = 9.9, to M = 7.0 ppm, SD = 4.2), $t(22) = 8.29$, $p < .001$, and lowered heart rates (from M = 86.7 beats/min, SD = 10.8, to M = 77.0 beats/min, SD = 16.8), $t(22) = 2.75$, $p = .012$. The effect of withdrawal on affect is indicated by significantly higher scores among withdrawing smokers than among continuing smokers on MACL scales that index negative affect (Aggression, Anxiety, and Sadness), as shown by repeated measures analyses of covariance (ANCOVAs), with baseline ratings covaried, group Fs$(1, 35) > 7.18$, ps $< .011$. In the same analyses with positive affect MACL scales, continuing smokers produced higher scores than withdrawing smokers on the Surgency and Elation scales, group Fs$(1, 35) > 7.34$, ps $< .01$.

Characterizing Smoking Urge Self-Reports

A repeated measures ANOVA revealed a significant effect of group on urge rating, $F(1, 36) = 48.98$, $p < .0001$; withdrawing smokers reported higher urges. The mean urge rating for continuing smokers (5.4) corresponded to the Likert-scale descriptor of *moderate* craving, whereas the withdrawing smokers' mean (7.5) was slightly beyond the midway point of the *moderate* to *extreme* range.

Figures 1 and 2 reveal that the urge self-reports of withdrawing and continuing smokers were associated with distinct affective states. For withdrawing smokers, both the negative affect–urge and the positive affect–urge correlation matrices were significant with the omnibus test (Cohen & Cohen, 1983), which signifies that the matrices contained more significant values than were expected by chance, $\chi^2(1, N = 18) = 58.5$, $p < .001$, and $\chi^2(1, N = 18) = 109.3$, $p < .001$, for the negative and positive affect matrices, respectively. Only the positive affect–urge matrix was significant for the continuing smokers, $\chi^2(1, N = 18) = 46.5$, $p < .001$. For withdrawing smokers, urges were a direct function of negative affect and an inverse function of positive affect. For continuing smokers, urges were a direct function of positive affect but not negative affect. In particular, it was the relation between positive affect and urge self-reports that distinguished the two groups. Hierarchical regressions of urge self-reports on the mean of the three positive affect scale scores (Surgency, Elation, and Vigor) and the group coding and interaction term (Group × Positive Affect) were conducted for each Rating Occasion 2–7; 14 of the 18 multiple regressions revealed a significant interaction between group and positive affect in the prediction of urge ratings (sR^2s = .06–.17). This indicates that positive affect ratings were differentially related to urge ratings for continuing and for withdrawing smokers, and that this difference was often statistically significant. Positive affect was directly related to urge self-reports for continuing smokers and inversely related for withdrawing smokers.

Withdrawal increased expectations about the reinforcing effects of smoking. A repeated measures ANOVA with expectation ratings averaged across Rating Occasions 2–7 and with each expectation treated as a repeated measure revealed a significant group effect, $F(1, 42) = 21.56$, $p < .01$, wherein withdrawing smokers endorsed higher expectations than continuing smokers. Although some expectations appeared to be more highly influenced by withdrawal than others, there was no significant Group × Expectation interaction, $F(7, 294) = 1.90$, $p = .069$. The most highly endorsed expectation about smoking for both continuing and withdrawing smokers was that a cigarette would taste good. Correlations between urge and expectancy ratings revealed positive associations across all expectations, and the highest correlations involved the expectation that a cigarette would taste good (rs = .67 and .68 for continuing and withdrawing smokers, respectively) and the expectation that smoking would help the smoker to stop thinking about smoking (rs = .56 and .66, respectively). For both groups the general pattern was for negative affect to be directly related to expectations and for positive affect to be inversely related, although this pattern was decidedly stronger among withdrawing smokers. An exception to this pattern was found for the taste expectation, which among continuing smokers was significantly, directly associated with positive affect and unrelated to negative affect.

Individual Differences in Affect and Urge Self-Report

The results indicate a relation between traitlike affective intensity as measured by the AIM and smoking urges in withdrawing smokers (Table 2). Although affect intensity was positively related to self-reported urges among withdrawing smokers, the relation tended to be negative and modest among continuing smokers.

Discussion

Experiment 1 showed that self-reported urges of withdrawing smokers were directly related to negative affect and inversely

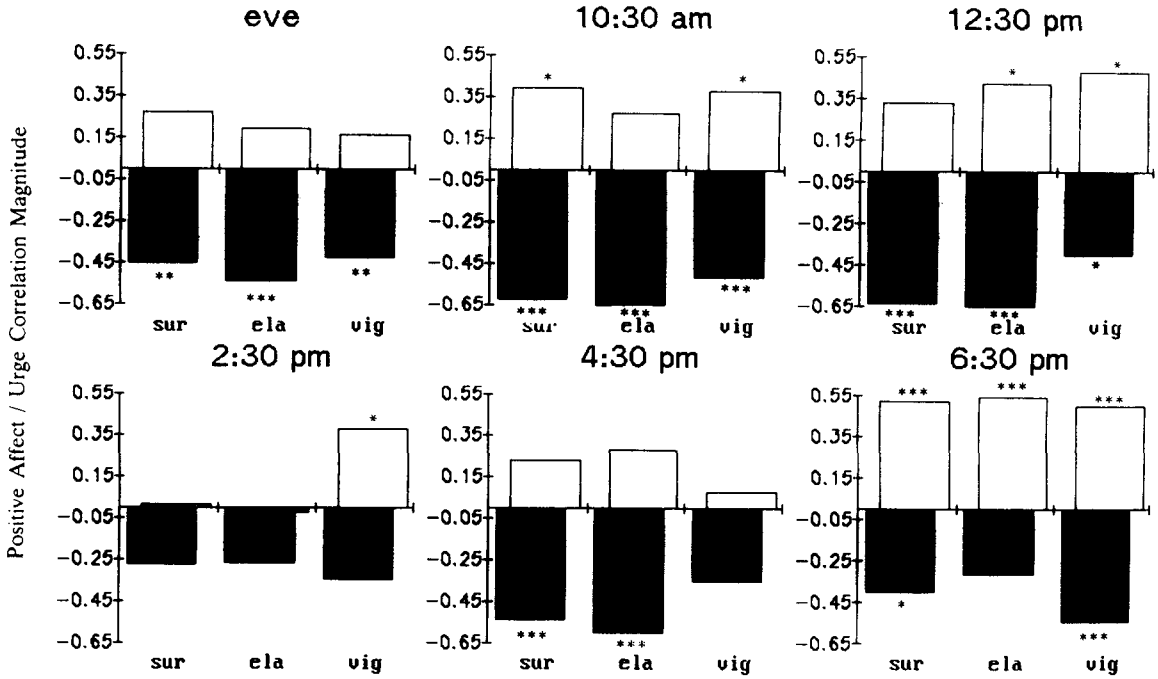

Figure 1. Magnitude of correlations between urge ratings and Mood Adjective Check List positive affect scales of Surgency (sur), Elation (ela), and Vigor (vig) at various rating intervals. (EVE = 2030 hr or 2130 hr, 2 hr after the initial meeting. Open bars are correlation values for continuing smokers, and solid bars are for withdrawing smokers. $^{*}p < .05$. $^{**}p < .025$. $^{***}p < .01$. All tests are one-tailed.)

related to positive affect. The self-reported urges of ad lib, continuing smokers tended to be directly related to positive affect and unrelated to negative affect. These data are generally consistent with a model of smoking and drug motivation in which drug-motivational information is processed through two distinct routes (Baker et al., 1987; Wise, 1988).

Expectation ratings were included to provide concurrent validity with respect to urge ratings. Withdrawing smokers reported higher expectancy ratings than did continuing smokers, and all expectancy ratings were directly related to concomitant negative affect ratings, except for the expectation that a cigarette would taste good. The expectation that a cigarette would taste good was directly related to positive affect only among continuing smokers. This suggests that particular expectations may be linked to particular affective states. However, more research on expectation–affect links is necessary before any conclusions can be drawn.

The observed inverse relation between positive affect and urges among withdrawing smokers may reflect the strong negative affective valence in that group. Withdrawing smokers scored significantly higher than continuing smokers on negative affect scales. Research has shown that positive and negative valences are especially likely to be inversely related at extreme values (Diener & Iran-Nejad, 1986). Thus, we argue that urges in withdrawing smokers are driven primarily by negative affect and that the negative relation between these urges and positive affect is merely a consequence of the antagonism between extreme affective valences. Consistent with this, positive and negative affect scale scores were consistently negatively related among withdrawing but not continuing smokers (data not shown). We argue that if continuing smokers report more extreme values of positive affect, their urge ratings will be consistently inversely related to negative affect scores.

Finally, our results suggest that a measure of trait affective intensity (i.e., the AIM) administered in the drugged state can predict level of urges that smokers will report during withdrawal. Thus, the extent to which persons experience mood swings or affective reactivity in daily life is related to the extent to which they will report urges when they quit smoking. The absence of a relation between trait affective intensity and urges in ad lib smokers may be attributable to the fact that the AIM is relatively insensitive to positive affect (Larsen & Diener, 1987) and that this was the affect associated with urges among continuing smokers.

The results of Experiment 1, and associated interpretations, must be evaluated in light of various caveats. First, the sample is of modest size, and this may render it vulnerable to sampling biases of unknown sorts. Second, we used a single type of measure of drug motivation (self-report), and this may have produced a different pattern of interrelations from what may have obtained had we used alternative assessments (see Baker & Brandon, 1990). Third, the explicit inquiry into affect, urge level, and withdrawal entailed by this research may by itself have influenced levels of interrelations among the variables.

Experiment 2

In Experiment 2, we used additional measures to replicate systematically in a second sample the relations between affect

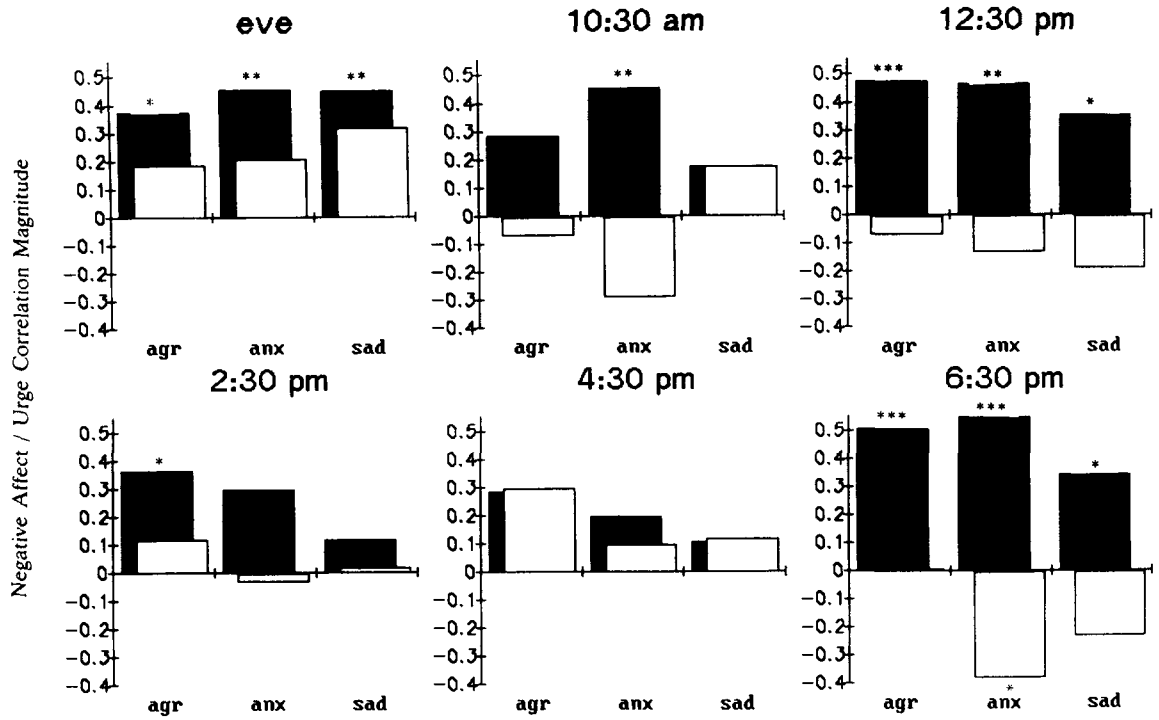

Figure 2. Magnitude of correlation between urge ratings and Mood Adjective Check List negative affect scales of Aggression (agr), Anxiety (anx), and Sadness (sad) at various rating intervals. (EVE = 2030 hr or 2130 hr, 2 hr after the initial meeting. Open bars are correlation values for continuing smokers, and solid bars are for withdrawing smokers. $*p < .05$. $**p < .025$. $***p < .01$. All tests are one-tailed.)

and urges observed in Experiment 1; that is, we tested the hypothesis that measures of drug motivation are directly related to negative affect among withdrawing smokers but directly related to positive affect among continuing smokers. If the affective basis of drug-use motivation in these two groups is indeed different, then this motivation may be influenced differently by stimuli with affective impact. This leads to the following hypotheses: A stressful stimulus ought to decrease positive affect among ad lib smokers and therefore decrease their urge self-reports. Conversely, the same stressor may increase negative affect among withdrawing smokers and therefore increase their urge self-reports.

Other hypotheses emanate from our belief that priming models can account for the direct relation between positive affect and urge self-reports seen among ad lib smokers. Priming models hold that drugs stimulate brain reward mechanisms producing positive affect, arousal and activity, and a tendency to pursue operants (e.g., drug self-administration, if that is the dominant response). This suggests the following hypotheses: (a) Initial drug intake by withdrawing smokers will be accompanied by a shift in the affective correlates of urges from negative to positive affect; and (b) the magnitude of these shifts in pleasure and arousal will be directly related to urge self-report.

Table 2
Affect Intensity Measure and Urge Ratings Correlations

Smoking group	Rating Occasion					
	2	3	4	5	6	7
Withdrawing	−.05	.47*	.51*	.30	.27	.46*
Continuing	−.39	−.25	−.13	.11	−.49*	−.17

* $p = .05$. ** $p = .01$.

Method

Subjects

Sixty-four female smokers participated in the study. Because of the greater availability of women in the sample population, we decided to restrict recruitment to reduce within-cell error. Smokers either volunteered for credit in their introductory psychology course or were solicited for pay ($10.00) in a newspaper advertisement. As in Experiment 1, potential subjects were screened by expired-air CO analysis to ensure that they were regular smokers (minimum CO = 14 ppm). Smokers were randomly assigned to four treatment conditions ($ns = 16$): withdrawing smokers under low and high stress and continuing smokers under low and high stress. Table 3 presents selected demographic and descriptive smoking information for smokers assigned to each treatment condition. There were no significant differences between groups on any of these variables except for the number of cigarettes smoked daily. An ANOVA revealed a statistically significant Smoking Status × Stress Level interaction, $F(1, 60) = 7.06$, $p < .01$. Inspection of group means suggests smokers assigned to the withdrawing, high-stress treatment smoked more cigarettes daily than those assigned to the other treatment conditions.

Table 3
Subject Information: Experiment 2

	Continuing smokers				Withdrawing smokers			
	Low stress		High stress		Low stress		High stress	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	22.1	5.8	19.9	2.9	20.4	4.1	22.9	6.9
Education	14.1	1.5	13.6	0.8	14.1	1.8	14.0	1.6
No. years smoking	5.6	4.7	4.4	1.6	5.8	3.9	7.8	6.7
Consumption	24.4	9.4	21.3	5.1	22.4	5.3	29.1	8.7

Note. Education = highest level of education achieved in years; consumption = number of cigarettes smoked per day.

Self-Report Measures

The subjects used a computerized joystick rating system to rate their pleasure, arousal, and urges. The joystick device was mounted in a small box attached to the right arm of the recliner in which the subject sat. The joystick controlled a computer-generated horizontal bar graph that was displayed on a monitor placed on a table to the subject's right. Each bar-graph rating provided a score between 1 and 256. The scores were fed into a computer and stored on floppy disk. The low end of the pleasure rating scale was defined as *feeling terrible* and the high end as *feeling great.* For arousal, the low end of the scale was defined as *bored, sleepy, or sluggish* and the high end as *very awake, stimulated, or alert.* The low end of the urge scale was defined as *absolutely no desire for a cigarette at the moment* and the high end as *wanting a cigarette more than you've ever wanted one before.* The WSQ was used. The Social Affection scale of the MACL was included with the six other measures used in the first study (Aggression, Anxiety, Sadness, Vigor, Elation, and Surgency) to explore further the relation between positive affect and continuing smoking status.

Procedure

Smokers were initially screened over the telephone to ensure they had smoked approximately 20 cigarettes per day during the previous year and that they were without hearing or cardiac problems. The subjects came to the laboratory on three occasions for an orientation session (approximately 1½ hr), a group assignment session (approximately ¼ hr), and a laboratory session (approximately 2 hr). At the orientation session, written consent and a CO assessment were obtained. If the smoker met the CO-level criterion (CO > 14 ppm), she was taken to the psychophysiological recording room and was connected to heart rate, pulse volume, and skin conductance transducers. The temperature-controlled subject room was connected by wires to an adjoining room where the polygraph was located. The subject was seated in a comfortable recliner and wore head phones to be used for stimulus delivery during the experimental session. A white-noise generator masked distracting sounds. Skin conductance was measured directly with two 0.8-cm^2 Beckman Instruments (Schiller Park, IL) silver silver chloride electrodes placed on the palm of a subject's nondominant hand and connected to a Grass Instruments (Quincy, MA) Model 7A polygraph with a Model 7P1B preamplifier and a passive constant voltage circuit. The conductance medium for electrodermal measurement was Unibase (Parke-Davis, Morris Plains, NJ) mixed with saline to produce a 0.05-mol electrolyte. Heart rate was measured with Beckman 0.8-cm^2 silver silver chloride electrodes with Beckman electrolyte; two electrodes were attached to the lower rib cage and one to the collarbone. These electrodes were connected to a Grass Model 7P4DF cardiotachometer that detected R-wave occurrence, from which interbeat intervals were computer derived. The pulse volume photocell transducer was taped to the index finger of the subject's nondominant hand; the photocell signal was fed to a Grass Model 7P1B preamplifier. After the electrodes were attached, the subject filled out a smoking history form, and 10 min of physiological data were obtained. These physiological data were not analyzed, as the intent of the orientation session was to acclimate subjects to the recording procedures.

At the group assignment session, subjects were administered the MACL and the WSQ. A CO sample was taken, and heart rate was measured by monitoring wrist pulse for 15 s. Subjects assigned to the withdrawing smokers treatment were asked to abstain from smoking until the experimental session 24 hr later, and subjects assigned to the continuing smokers treatment were asked to continue smoking as usual. Subjects were also assigned to the low- or high-stress conditions but were not so informed. Subjects were asked to return to the laboratory at the same time the next day and to bring an extra pack of their own brand of cigarette.

The laboratory session was divided into three periods, baseline, stress, and poststress–smoke (see Table 4).

Multiple joystick assessments of pleasure, arousal, and urge were obtained during each of these periods and constituted the primary dependent measures. As we believed that these ratings would be more informative if they were made after subjects' exposure to a cigarette, four identical cigarette trials were distributed throughout the session, wherein subjects were exposed to 3 cigarettes in each trial (12 total cigarettes). During these trials the subjects sat quietly with their eyes closed until they heard a tone, at which time they opened their eyes and looked at a lighted cigarette held by the experimenter. At a second tone the subjects took a puff on the cigarette, without inhaling, and then closed their eyes again. The experimenter observed carefully for any sign of inhalation by the subjects. Three such presentations, each with a fresh cigarette of the subject's brand, constituted a cigarette trial.

At the start of the baseline period, subjects completed the MACL and WSQ; these measures were again obtained at the end of the experiment. Continuing, but not withdrawing, smokers smoked a cigarette during the baseline period. A CO sample was taken from withdrawing smokers to ensure that their level was sufficiently low (CO < 11 ppm) to participate further. The subjects were connected to the physiological transducers and completed baseline joystick ratings, activities that lasted about 20–25 min. Then subjects were instructed to rest for 5 min while physiological baseline data were taken. Next came the first cigarette trial, which was preceded and followed by joystick ratings. In the final phase of this period, continuing smokers smoked a cigarette ad lib to ensure that they did not enter withdrawal, whereas withdrawing smokers sham smoked, that is, they went through all the motions of smoking with an unlit cigarette.

Table 4
Laboratory Session Outline for Experiment 2

Baseline
Joystick ratings
Rest (5 min)
Joystick ratings
Cigarette Trial 1
Joystick ratings
Prestress ad lib smoking period (withdrawing smokers sham smoked)
Stress
Joystick ratings
Social stressor or reading
Joystick ratings
Cigarette Trial 2
Joystick ratings
Noise stressor or tone (warned)
Joystick ratings
Noise stressor or tone (unwarned)
Joystick ratings
Cigarette Trial 3
Joystick ratings
Poststress–smoke
Poststress ad lib smoking period (all subjects smoked)
Joystick ratings
Cigarette Trial 4
Joystick ratings

Note. The social stressor and reading and noise stress and tone manipulations were counterbalanced, as was the order of presentation of warned and unwarned noise and tone. Only high-stress subjects were exposed to the social stressor and the noise stress; low-stress subjects read and listened to tones during these periods.

During the stress period, high-stress subjects were exposed to a social interaction task and to aversive noise blasts, in counterbalanced order. In the social interaction task, subjects were instructed to talk to a silent male research confederate for 3 min to try to make as favorable an impression as possible; a 3-min anticipation period preceded the actual interaction. Subjects in the low-stress condition were asked to read silently a neutral textbook passage for 6 min. The laboratory assistant was not in the room during the social interaction or reading tasks. Joystick ratings were taken both after these instructions were given and after the task was complete (Table 4).

The second manipulation during this stress period involved presentation of aversive noise blasts to high-stress subjects or of pure tones to low-stress subjects. Two blocks of noise or tone presentations, separated by a set of joystick ratings, were given in counterbalanced order. In one block, the noise or tone was preceded by a warning tone; in the other block, the stimulus was delivered without warning. Cigarette Trial 2 was presented between stressors (social interaction or reading and noise or tone), and Cigarette Trial 3 came at the end of the stress period (i.e., after the final stressor).

In the final phase of the experiment, the poststress–smoke period, all subjects were given 5 min to smoke their own cigarettes ad lib. The subjects made joystick ratings immediately after this ad lib smoking experience (postsmoke ratings) and again after the final cigarette trial (Cigarette Trial 4). A CO assessment was taken, and the final debriefing was given.

Statistical Analyses

Separate sets of analyses of self-report data were made for the three different periods of the experimental session. For all but the baseline period, multiple joystick ratings within a period were collapsed to constitute means. First, the baseline joystick ratings, collected before the 5-min rest period and before any experimental manipulation (see Table 4), were analyzed to assess the effect of withdrawal. Second, joystick data obtained during the stress period were collapsed and analyzed to determine the effects of the stressor. The initial joystick rating period immediately followed instructions about the impending task and thus is appropriately grouped with the other stress ratings. (Results were the same with or without these data included in the stress analyses.) Finally, data gathered after the subjects in both groups were allowed to smoke (poststress–smoke) were collapsed by averaging ratings obtained after the poststress ad lib smoking period and after the final cigarette trial (Trial 4). These data were analyzed to test the hypothesis that drug administration shifts the correlates of smoking urges from negative affect to positive affect. To examine effects within each experimental period, we first conducted omnibus multivariate analyses of variance (MANOVAs) on families of related measures, with smoking status (withdrawing vs. continuing) and stress (high vs. low) as variables. Next, independent ANOVAs were used to assess the contribution of each dependent variable to statistically significant variables in the MANOVAs.

A similar strategy was adopted for analysis of the psychophysiological variables. First, a 2 × 2 MANOVA was conducted on means of psychophysiological measures obtained during the 5-min baseline rest period, except for the pulse volume measure. An ANOVA on the pulse volume data revealed no significant effect of nicotine or stress condition on this measure. However, because no calibration standard exists for this measure, only changes from baseline values are considered meaningful. Smoking status and stress were again entered as variables in the baseline MANOVA. Stress condition was entered to determine whether baseline differences compromised interpretation of later stress effects. Again, ANOVAs were performed to evaluate the contribution of individual dependent variables to significant MANOVA variables. Next, the same analyses were performed on means of psychophysiological variables (including pulse volume) obtained during the two 3-min intervals of the social interaction (stress) period. This epoch was selected for stress period psychophysiological analysis because, in contrast to the noise trial periods, blocks of artifact-free data were available. Physiological data for the poststress–smoke period merely revealed standard effects of nicotine delivery after a period of abstinence (e.g., decreased heart rate interbeat interval and increased CO) and are not discussed.

Results

Baseline Comparisons

Psychophysiological data. The psychophysiological data were analyzed to determine whether they revealed differences to be expected in a comparison of nicotine-using and withdrawing groups. The MANOVA of these measures at baseline (i.e., heart rate interbeat interval, skin conductance, and CO) yielded a statistically significant effect of smoking status, $F(4, 51) = 50.05$, $p < .0001$, but not of stress or the interaction of these two variables. As expected, withdrawing smokers had significantly lower CO levels than did continuing smokers, $F(1, 60) = 221.90$, $p < .001$, and slower heart rates (longer interbeat intervals), $F(1, 60) = 5.57$, $p < .022$. An ANOVA revealed that skin conductance was not differentially affected by smoking status.

Self-report data. In order to establish that subjective sequelae of the withdrawal syndrome were also present, a MANOVA of the 17 subjective report measures (viz., the MACL and

WSQ scales and the joystick ratings) was conducted. It yielded a statistically significant effect of smoking status, $F(17, 43) = 3.13$, $p < .002$, but no significant effect of stress or the interaction of these two variables. Withdrawing smokers rated significantly higher levels of Aggression ($M = 9.00$, $SD = 4.16$) and significantly lower levels of Surgency ($M = 8.71$, $SD = 3.69$) than did continuing smokers on the MACL ($M = 7.06$, $SD = 1.52$, and $M = 10.75$, $SD = 4.17$, for Aggression and Surgency, respectively) $Fs(1, 60) > 5.03$, $ps < .03$. The WSQ revealed that withdrawing smokers scored significantly higher on the Craving and Psychological Discomfort scales, $Fs(1, 58) > 10.75$, $ps < .002$. Withdrawing smokers indicated significantly greater urges on the joystick measure than continuing smokers, $F(1, 60) = 26.74$, $p < .001$. Thus, withdrawing smokers reported high initial levels of urges, whereas those that had continued to smoke reported low to moderate levels. Correlational analysis of the joystick measures provided strong evidence for their concurrent validity.[2]

Effects of Stress Manipulations

Psychophysiological data. To determine whether the social interaction manipulation produced physiological effects expected of this nominal stressor, a MANOVA for maximum and minimum interbeat interval, pulse volume level (residualized with respect to baseline values), and skin conductance level was performed. (Some subjects did not contribute data to the psychophysiological analyses because of equipment problems.) These measures were taken from two successive 3-min periods. For subjects in the high-stress condition (social interaction), the first period was before the entry of the confederate (anticipation); during the second period the subject talked about herself to the confederate. This analysis revealed statistically significant effects of both smoking status and stress, $Fs(3, 54) > 4.31$, $ps < .009$, but no interaction of these two variables or interactions with their repeated assessment (during anticipation or talking). Subsequent ANOVAs indicated that only interbeat interval was influenced significantly by smoking status, $F(1, 56) = 7.09$, $p < .011$. As in the previous analyses withdrawing smokers had longer interbeat intervals (maximum interval, $M = 956.00$ ms, $SD = 89.17$) than did continuing smokers ($M = 886.31$ ms, $SD = 144.27$). All three dependent measures were significantly influenced by the social interaction stressor, $Fs(1, 56) > 4.69$, $ps < .05$. High-stress subjects had higher heart rates, higher skin conductance levels, and decreased residualized pulse volumes in relation to low-stress subjects. The influence of stress on pulse volume did not interact with baseline pulse volume values, and there was no Smoking Status × Stress interaction. Similar stress effects were found for the three psychophysiological variables across the other stress periods.

Self-report data. Both smoking status and stress level significantly affected the joystick measures, MANOVA $Fs(3, 58) > 9.65$, $ps < .001$. Univariate tests of the effect of smoking status were significant only for urges, $F(1, 60) = 51.34$, $p < .0001$ (see Figure 3). Withdrawing smokers reported greater urges than did continuing smokers. The social interaction stress manipulation reliably affected only arousal, $F(1, 60) = 10.87$, $p < .001$ (Figure 4). Contrary to our prediction, stress and smoking status did not interact in the production of urge ratings. Table 5 displays the correlations between arousal and urge ratings and the correlations between pleasure and urge ratings during the stress periods, as well as the baseline and poststress–smoke periods. These values were obtained from means of ratings collected just before and just after the noise (tones or noise blasts) and social interaction (or reading) stressors. The figures show that the most positive correlations are from low-stress continuing smokers, whereas the least positive or most negative correlations are from high-stress withdrawing subjects. The correlation between arousal and urges was positive and significant for both continuing groups but not for withdrawing groups. The correlation between pleasure and urges was also positive and significant for all continuing subjects, but the correlation was significantly negative for high-stress withdrawing smokers. In fact, the difference in the pleasure–urge correlations between low-stress continuing and high-stress withdrawing subjects for the stress period was significant ($z = 2.49$, $p = .012$). Therefore, self-reported urges of continuing smokers tended to be a positive function of arousal and pleasure. Withdrawal, and especially withdrawal paired with stress, tended to reduce or reverse these relations.

Effects of Smoking (Self-Report Data)

A MANOVA of the poststress–smoke epoch joystick ratings averaged across the two rating periods in this epoch indicated smoking status significantly influenced these dependent measures, $F(3, 58) = 3.37$, $p < .02$. Both urge and arousal were elevated among withdrawing smokers, $Fs(1, 60) > 6.59$, $ps < .015$ (Figures 3 and 4). There was no evidence of an overall stress effect. However, the interaction of smoking status and stress was statistically significant, $F(3, 58) = 2.73$, $p < .052$. Subsequent ANOVAs indicated a statistically reliable interaction of these two variables for pleasure, $F(1, 60) = 7.67$, $p < .01$ (Figure 5), and urges, $F(1, 60) = 3.91$, $p = .053$, and near statistical significance for arousal, $F(1, 60) = 3.47$, $p < .068$. Individual comparisons on urge and pleasure ratings revealed that among

[2] Mood Adjective Check List (MACL) subscales taken at baseline for all subjects provide evidence of concurrent validity of the joystick measures. The joystick measure of urges was directly related to the Withdrawal Smoking Questionnaire Craving ($r = .69$) and Psychological Discomfort ($r = .39$) scales and to measures of negative affect (for Aggression, $r = .38$; for Anxiety, $r = .35$). Joystick pleasure ratings were directly related to Surgency ($r = .47$), Elation ($r = .53$), and Vigor ($r = .35$), and were inversely related to negative affect (for Aggression, $r = -.34$; for Anxiety, $r = -.25$). At baseline, arousal ratings also appeared to reflect primarily positive affect. Across all subjects, reduced carbon monoxide levels were associated with higher urges ($r = -.48$). When joystick urge ratings were analyzed separately for withdrawing and continuing smokers, the results showed that for withdrawing smokers, baseline urges were characterized by a positive association with the MACL scales of Aggression ($r = .43$) and Anxiety ($r = .48$) and with the Withdrawal Smoking Questionnaire scales of Psychological Discomfort ($r = .50$) and Physical Symptoms ($r = .36$) of withdrawal. For continuing smokers, joystick urge was negatively associated with the MACL Sadness scale but was not significantly correlated with any other variables. All of the correlations listed here are significant at the $p < .01$ level except for the Anxiety–Pleasure correlation ($r = -.25$, $p < .05$).

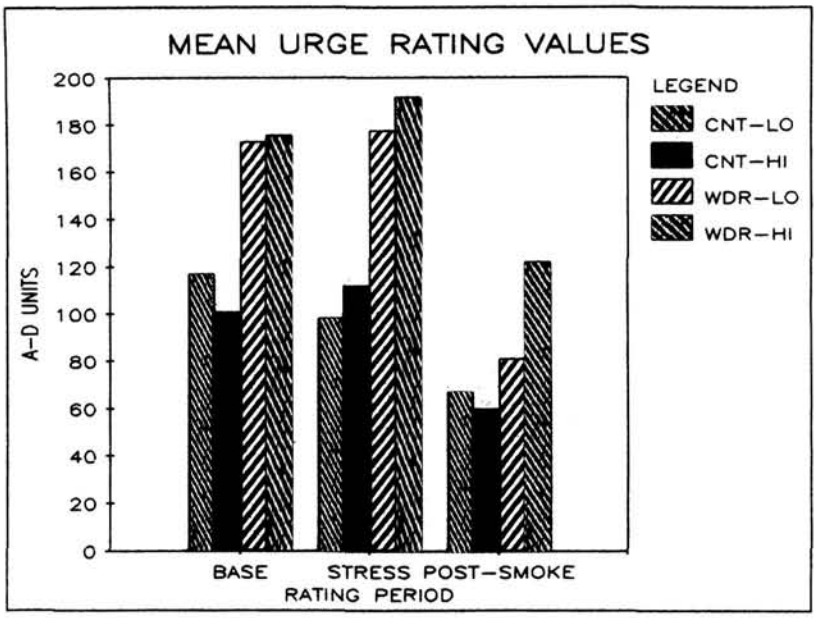

Figure 3. Joystick ratings of urge to smoke by group at baseline, during the stress period, and after the opportunity to smoke. (CNT-LO = continuing smokers–low stress; CNT-HI = continuing smokers–high stress; WDR-LO = withdrawing smokers–low stress; and WDR-HI = withdrawing smokers–high stress.)

withdrawing smokers, high-stress subjects differed from low-stress subjects on pleasure and urge ratings ($ps < .007$). Stress was unrelated to these ratings among continuing smokers. Similarly, among high-stress subjects, withdrawal produced higher pleasure and craving ratings ($ps < .009$).

After the opportunity to smoke, high-stress withdrawing smokers displayed a change in the relation between pleasure and urge. During stress, for high-stress withdrawing smokers, urge was negatively associated with pleasure ($r = -.43$, $p < .05$; Table 5). After smoking, however, a positive relation between these two measures was obtained for high-stress withdrawing smokers ($r = .46$, $p = .05$), which indicates that the urge to smoke was now associated with greater pleasure (Table 5). Moreover, smoking also caused urge to be positively related to arousal ratings for high-stress withdrawing smokers, whereas prior ratings had been negatively related or unrelated. A statistical comparison for dependent correlations (Steiger, 1980) revealed that these shifts in correlation magnitude from the stress to poststress–smoke periods were significant for high-stress withdrawing smokers, $ts(13) > 2.15$, $ps < .05$.

Discussion

In relation to continuing smokers, the withdrawing smokers displayed evidence of nicotine withdrawal symptoms; withdrawing subjects had slower heart rates and reported greater psychological distress than did continuing smokers. Baseline urge and affect data offered weak support for our prediction that among withdrawing smokers, urges would be directly related to negative affect and indirectly associated with positive affect. Although urge joystick ratings were positively associated with the MACL scales of Aggression and Anxiety and the WSQ Psychological Discomfort scale, the urge ratings of withdrawing smokers were only weakly negatively associated with joystick pleasure ratings. Among continuing smokers, urges tended to be directly related to positive affect. During both the baseline and the stress periods, joystick urge and pleasure ratings were consistently positively related. Thus, although the four groups did not differ over much of the experiment in affective valence levels as assessed by the joystick measure, they did differ in the affective correlates of urges. Therefore, the results of Experiment 2 are generally consistent with the results of previous research on the affective correlates of urges (Experiment 1, this article; Sherman et al., 1986).

The hypothesis that stress would increase urges among withdrawing smokers and decrease urges among continuing smokers during the period of the stressor was not supported. The data suggest that the stressors were effective in eliciting responses often associated with stress: increased heart rates, increased skin conductance levels, decreased pulse volume, and increased arousal self-ratings. It is unclear why the stressors did not significantly influence mean levels of pleasure or urge ratings made during the stress period. Ceiling effects did not appear to be involved, as high-stress withdrawing subjects typically had room to register greater urge values during the stress assessments and standard deviations showed little evidence of restrictions of variance.

Although mean urge ratings were little affected by stress, stress in conjunction with smoking status may have affected the coherence of urge self-reports with arousal and pleasure ratings (Table 5). Thus, high-stress withdrawing smokers and low-stress continuing smokers produced pleasure–urge correlations that differed significantly. These data provide modest support for the notion that pharmacological and nonpharmacological

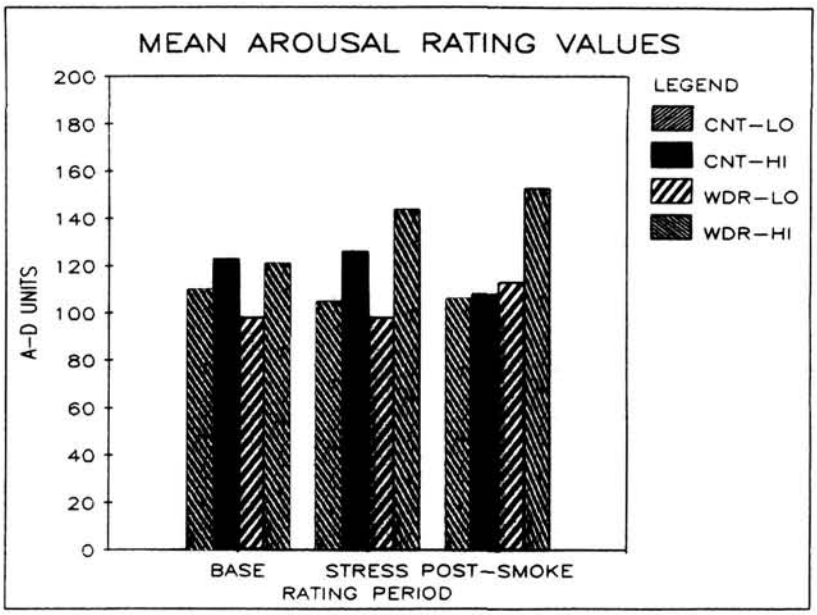

Figure 4. Joystick ratings of arousal by group at baseline, during the stress period, and after the opportunity to smoke. (CNT-LO = continuing smokers–low stress; CNT-HI = continuing smokers–high stress; WDR-LO = withdrawing smokers–low stress; and WDR-HI = withdrawing smokers–high stress.)

events that increase negative affect may have additive or interactive effects on the coherence of affective valence measures with drug motivational response measures.

Although stress and smoking status did not interact significantly during the stress period, these variables did interact as they influenced ratings made after the smoking opportunity. After smoking, high-stress withdrawing subjects produced higher urge and pleasure ratings than did all other subjects. The data do not reveal specific mechanisms responsible for this. However, the data do reveal a pattern of affective change that may be relevant to mechanisms involved. Before smoking, high-stress withdrawing subjects showed a pattern in which smoking urges were negatively related to pleasure. Smoking produced more pleasure in these subjects than in any others, and it also significantly shifted the affective correlates of urges in this group—after smoking, urges were directly related to pleasure. A simple model that accounts for these data is one in which intense negative affect inflates the incentive value of smoking: The greater the negative affect, the greater is the desire to smoke. Moreover, it can be assumed that negative reinforcement motives, in contrast to positive reinforcement motives, have a greater capacity to influence drug-seeking and self-report (e.g., withdrawing smokers reported stronger urges than did continuing smokers). Once smoking has occurred and has yielded pleasure, then urges are a positive function of the pleasure experienced. Because subjects experiencing maximal negative reinforcement tend to experience the greatest pleasure from smoking, they also report the strongest residual urges once urges become a function of positive affect. This simple model holds that negative-reinforcement motives predominate during withdrawal or drug-free periods (or perhaps at any time that negative affective influences outweigh positive ones) and that these can exert the stronger influence on drug-motivated behaviors. However, positive reinforcement motives may predominate in the intoxicated state (or when the organism is in a net, positive affective state). Wise (1988) noted that to the extent that drug motivation is produced by reward system activation (brain mechanisms of positive reinforcement), one expects to see behavioral activation and arousal concomitant with measures of drug motivation. In this regard, we found strong and consistent positive correlations between arousal and urge under conditions intended to maximize positive reinforcement motivation.

Table 5
Arousal and Pleasure With Urge Correlations

Period	Continuing smokers			Withdrawing smokers		
	Low stress	High stress	All	Low stress	High stress	All
	Pleasure and urge					
Baseline	.28	.51*	.36	−.29	−.19	−.14
Stress	.47*	.42*	.36	.16	−.43*	.03
Poststress–smoke	.34	.52*	.43*	.56**	.46*	.61**
	Arousal and urge					
Baseline	.20	.51*	.38	−.18	−.32	−.18
Stress	.61**	.44*	.51*	.19	.08	.28
Poststress–smoke	.57**	.69**	.61**	.30	.65**	.57**

Note. Significance values reflect one-tailed tests because of the a priori directional predictions involved.
* $p < .05$. ** $p < .01$.

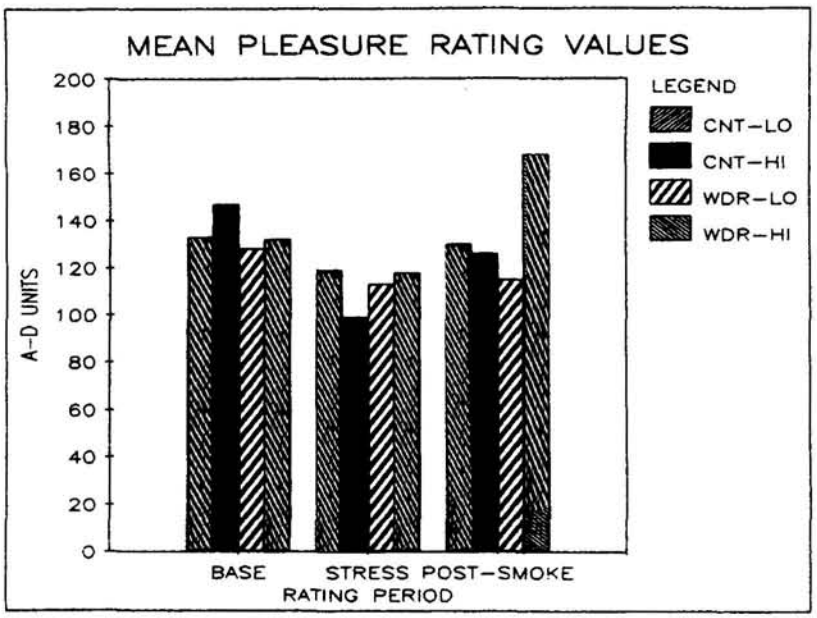

Figure 5. Joystick ratings of pleasure by group at baseline, during the stress period, and after the opportunity to smoke. (CNT-LO = continuing smokers–low stress; CNT-HI = continuing smokers–high stress; WDR-LO = withdrawing smokers–low stress; and WDR-HI = withdrawing smokers–high stress.)

This descriptive model faces several problems. First, it demands that the affective change observed after smoking was produced by smoking per se and not the passage of time since the stressor. In fact, in our pilot research and in subsequent research (Zinser, Davidson, & Baker, 1989), we have found in relevant experimental contexts that smoking per se, not the passage of time, yields such dramatic affective change. Second, this explanation addresses the phenomenon at a superficial level. It does not suggest or reveal reasons that high-stress withdrawing smokers enjoyed smoking more. For instance, were such smokers in greater withdrawal because stress increased nicotine excretion (Schachter et al., 1977)? Did such smokers smoke the proffered cigarette differently than other smokers and did this produce the different affective consequences (C. S. Pomerleau & Pomerleau, 1987)?

General Discussion

The research presented in this article shows that although withdrawing smokers reported stronger urges than continuing smokers (those who smoked ad lib), continuing smokers nevertheless reported moderate levels of urges. This agrees with a report (Mirin, Meyer, McNamee, & McDougle, 1976) that showed that despite ready access to heroin, heroin addicts continue to report significant levels of urge. Also, the self-reported urges of continuing and withdrawing smokers had different affective correlates. Among withdrawing smokers, urges tended to be directly related to negative affect and inversely related to positive affect. Among continuing smokers, urges were directly related to positive affect. These data conflict with models of addiction that posit a single major affective determinant of drug use, for example, withdrawal alleviation (Solomon, 1977; Wikler, 1973) and underscore Wise's (1988) advocacy of "a perspective that is obvious on reflection, but that often evaded our thinking: there is a biological basis for 'psychological' dependence and for drug cravings that are not rooted in withdrawal distress or some other source of negative affect" (p. 125). Moreover, data from continuing smokers conflict with suggestions that addicts self-label as urges only those states that arise out of frustration of automatized drug use production rules or action plans (e.g., Tiffany, 1990). It seems that subjects in this research labeled as urges the pleasurable anticipation of smoking or the pleasant aftereffects of smoking.

It is possible to construct scenarios in which the affective correlates of urges do not reflect both positive and negative reinforcement processes. For instance, one can postulate that all urges are related to negative reinforcement. If drug deprivation is mild, as in the case of continuing smokers, then the anticipation of negative reinforcement produces pleasure that is associated with urge self-reports. However, if deprivation is prolonged, then negative affect will predominate, and because it is severe, it will not be overshadowed by pleasurable anticipation, and negative affect magnitude will be related to urge self-report magnitude. Such an account does not, of course, negate the fact that among ad lib drug users self-reported urges can be a function of positive affect and pleasurable anticipation. Also, there is no evidence in our data that mild withdrawal and its consequences were associated with increased urges in continuing smokers. In fact, among these subjects in Experiment 1, negative affect was never significantly positively related to urge magnitude—the only significant relation was a negative one. Finally, this model ignores basic psychopharmacologic data on the existence of positive reinforcing and priming effects of psy-

chomotor stimulants and the fact that such effects are functionally distinct from negative reinforcement. For instance, positive and negative reinforcing effects of these drugs occur at distinct brain sites, presence of drug in the body primes reengagement of drug self-administration, positive reinforcing effects of drug occur in brain systems that mediate approach behaviors to nonpharmacologic appetitive stimuli, and so on (e.g., Hernandez & Hoebel, 1988; Stewart et al., 1984; Wise, 1988).

In Experiment 2, stress and withdrawal did not combine to yield stronger urge self-reports, but there was some evidence that these two negative-affect–producing stimuli increased the coherence of urge and affective valence self-reports. Although withdrawal and stress did not combine to produce greater urges while smokers were undergoing stress, they did interact in influencing affective and urge ratings once smokers smoked. Subjects who were both withdrawing and stressed produced the highest urge and pleasure ratings in response to smoking. This finding may be relevant to the frequency with which a lapse leads to relapse in withdrawing smokers exposed to stress (e.g., Brandon, Tiffany, Obremski, & Baker, 1990). In one sense, these results are prosaic; that is, persons made unhappy by stress and withdrawal become happier after the opportunity to escape drug deprivation. However, if one adhered to negative reinforcement notions exclusively, one might expect postsmoking urges to reflect primarily unrelieved negative affect, or one might expect pleasure ratings to signify satisfaction and a quiescence of negative mood, withdrawal, and urges. In the latter case, pleasure may be negatively related to self-reported urges. In fact, what was found was that urges came to be significantly associated with positive affect.

We note that the design we used did not allow us to separate expectancy effects from pharmacological ones. To disentangle these effects would require use of a balanced placebo design; this needs to be addressed in future research. Finally, a trait measure of affect intensity predicted the magnitude of urges of smokers when they were later withdrawing from cigarettes. This finding is similar to other recent reports that measures of trait affect predict magnitude or characteristics of addictive behavior (Cannon, Leeka, Patterson, & Baker, 1990). This suggests that measures of affective processing may be useful for characterizing individual differences in drug use motivation.

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