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## Effects of Smoking Urge on Temporal Cognition

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### Abstract

The authors examined temporal aspects of smoking urge. In Experiment 1, smokers assigned to high- or low-urge conditions were informed they would be allowed to smoke in 2.5 min. They next completed measures of time perception. High-urge smokers reported 45 s to pass significantly more slowly than did low-urge smokers. In Experiment 2, the high-urge smokers from Experiment 1 anticipated that their urges would climb steadily over the next 45 min if they were not permitted to smoke. Another group of high-urge smokers actually reported their urges over 45 min. These urge ratings did not show the steady rise anticipated by the first group. Results suggest that smoking urge may affect time perception and that craving smokers overpredict the duration and intensity of their own future smoking urges if they abstain.

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Recently there has been increased interest in the study of drug craving. One research aim has been to examine the effects of cravings on cognitive processes thought to be linked to drug use. (Throughout we use the terms *urge* and *craving* interchangeably; see Sayette et al., 2000.) Studies have focused on several aspects of cognition thought to be related to craving (Sayette, 1999; Tiffany, 1990). Craving may bias attention, such that subtle cues for drug use become more salient (Gross, Jarvik, & Rosenblatt, 1993). Moreover, this attentional bias predicts smoking relapse (Waters et al., 2003). Research also suggests that smokers generate (Sayette & Hufford, 1997) and evaluate (Sayette, Martin, Wertz, Shiffman, & Perrott, 2001) smoking-related information differently when craving than when not craving, such that smoking becomes more attractive when craving. It is thought that such shifts in processing may partly mediate the relation between urge and substance use (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Sayette, 2004).

One area that has been relatively ignored by addiction researchers is the effect of craving on temporal cognition. As highlighted by both economic and behavioral economic models, use of addictive substances often reflects an acceptance of delayed costs in exchange for immediate benefits (see Loewenstein, 1999). Such impatience is exacerbated when participants are craving (Giordano et al., 2002). One factor that may influence one's level of impatience is the

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perception of the passage of time. Time perception is an important influence on behavior and is a crucial determinant of how individuals represent their environment. Time perception affects both attitudes and motivations. For instance, feeling that time is passing while waiting in line at a store may lead a shopper to abandon the purchase (Zakay & Block, 1997). Presumably, time perception also could influence a smoker's motivation to continue resisting a cigarette craving.

Time perception research includes the study of both *prospective* and *retrospective* judgments. During prospective timing, time draws upon attentional resources, causing time to appear to pass more slowly (Block & Zakay, 1997). We used a prospective task to test whether a perceived reward (smoking) at the end of a specified time period would cause time to pass more slowly during high-craving than low-craving states. Retrospective time perceptions are thought to be influenced by several factors. These include changes in mood or cognition as well as what participants are doing, with complex tasks generally feeling longer than simple tasks (Zakay & Block, 1997). Accordingly, this study tested the hypothesis that craving would increase retrospective time estimations. By including measures of both prospective and retrospective time perception, we aimed to provide a broad assessment of the effects of craving on time perception. These measures differed in a number of ways, though, and thus this study was not designed to contrast the effects of craving on these two types of time judgment.

In addition to measures of time perception, anticipated urge duration is a domain of temporal cognition that may explain why craving can increase risk for drug lapses. Research has found that anticipated feelings (e.g., regret) about performing a particular behavior affect health-related behaviors, such as condom use (Norman & Conner, 1995). Presumably, the anticipated duration of an emotional state also may affect behavior. If we believe that unpleasant feelings will soon pass, we may be willing to “tough it out.”

There is evidence that moods tend to fluctuate and that even strong emotional states eventually diminish (Jansen, 1998; Solomon & Corbit, 1974). Similarly, cravings have been described as momentary “pulsatile” states (Gawin, 1991). Marlatt (1985) referred to cravings as ocean waves that grow gradually until they crest and subside. Following peak craving levels (produced through a combination of nicotine deprivation and exposure to *in vivo* smoking cues), urge ratings begin to drop fairly quickly (Niaura et al., 1999; Sayette & Parrott, 1999; Shiffman et al., 2003). Of interest is whether addicts—at the moment they are craving—realize that their cravings may be short-lived.

In summary, two studies tested the effects of smoking urge on temporal cognition. Experiment 1 examined the effects of craving on time perception, and Experiment 2 tested the effects of craving on anticipated duration of cravings. We tested two main hypotheses: (a) that smokers in a high-craving state would estimate time to pass more slowly than would smokers in a low-craving state, and (b) that while in a high-craving state, smokers would overpredict the duration and intensity of their own future cravings over a 45-min interval.

## Experiment 1

### Method

**Participants**—Male and female smokers ( $n = 80$ ) not currently interested in quitting, aged 18 to 40, were recruited through newspaper advertisements and local flyers inviting inquiries from smokers willing to refrain from smoking for part of a day. Exclusion criteria included illiteracy and medical conditions that ethically contraindicated smoking. Informed consent was obtained from all participants. Participants had to have smoked between 15 and 30 cigarettes a day for the past 12 months.

Following a screening session and baseline carbon monoxide (CO) sample, eligible participants were randomly assigned to one of two craving conditions. High-crave participants were asked to abstain from smoking for at least 12 hr, whereas low-crave smokers could smoke as they normally would. The two groups did not differ on age ( $M = 23.0$  years,  $SD = 5.0$ ), ethnicity (94% Caucasian, 6% African American), gender (43% female), marital status (73% single), number of cigarettes per day (21.4,  $SD = 5.2$ ), or scores on either the Impression Management ( $M = 6.2$ ,  $SD = 3.2$ ) or Self-Deception ( $M = 5.2$ ,  $SD = 3.4$ ) subscales of the Balanced Inventory of Desirable Responding (BIDR; Paulhus, 1991). The BIDR was included to determine whether the two groups differed in reporting biases.

Eligible participants were invited to attend a 2-hr lab session for which they would be paid \$45. They were informed that they might be required to abstain from smoking for 12 hr prior to arrival at the lab and that breath samples would be obtained to ensure that they had conformed to the instructions. Prior to the day of the experimental session, all participants visited the lab to provide written consent for the possible 12-hr abstinence and provided an initial “baseline” CO recording. At that time, participants were told to bring a pack of their preferred brand of cigarettes to the upcoming experimental session.

**Measures**—Participants completed a questionnaire battery. This included a demographic form; a standard form for assessing smoking history, patterns, and current interest in quitting (see Sayette et al., 2001); the BIDR; and the Smoking Consequences Questionnaire—Twelve (SCQ-12), a 12-item version of the SCQ-Adult (Copeland, Brandon, & Quinn, 1995), listing beliefs about possible consequences of smoking. Each consequence (rated on a scale ranging from 0 = *not likely at all* to 9 = *definitely*) indicates the probability that the consequence will occur. Earlier, we used an abbreviated, 24-item version of the SCQ-Adult, which had discriminated between heavy and light smokers and between deprived and nondeprived smokers (Sayette, Martin, Hull, Wertz, & Perrott, 2003). To further reduce response burden, the new version included 6 negative items (“My throat burns after smoking”; “The more I smoke, the more I risk my health”; “Smoking is taking years off my life”; “I look ridiculous while smoking”; “Smoking irritates my mouth and throat”; and “Smoking is hazardous to my health”) and 6 positive items (“Smoking keeps my weight down”; “When I smoke, the taste is pleasant”; “Smoking calms me down when I feel nervous”; “When I’m angry, a cigarette can calm me down”; “I feel more at ease with other people if I have a cigarette”; and “Smoking temporarily reduces those repeated urges for cigarettes”).

Self-reported urge to smoke was assessed using a rating scale ranging from 0 (*absolutely no urge to smoke at all*) to 100 (*strongest urge to smoke I’ve ever experienced*) (Juliano & Brandon, 1998; Sayette et al., 2001). During the experimental session (described below), participants completed three measures of time perception (a 45-s prospective timing measure, a 90-s prospective timing measure, and a retrospective timing measure). Participants in the high-crave condition also completed an anticipated urge scale.

## Procedure

**Arrival:** Participants arrived for the experiment between noon and 3 p.m. Upon arrival, participant identification was checked. Participants sat in a comfortable chair behind a desk in an experimental room containing no clocks. After obtaining informed consent, we checked compliance with deprivation instructions by asking participants to report the last time they had smoked a cigarette. CO level also was recorded. To reduce the chance of partial deprivation, nondeprived smokers had to have a CO level above 15 ppm. CO levels for nicotine-deprived smokers had to drop at least 50% from their original, nondeprived CO level recorded on the day they signed the deprivation consent form. There were two exceptions to this rule: Nicotine-deprived smokers whose CO level was 10 or less did not have to drop by 50%, and regardless

of percentage drop, CO levels for the deprived smokers had to be below 20 ppm. These exceptions aimed to prevent false exclusions and false inclusions, respectively, into the deprived group. Three participants from the nicotine-deprived group and 2 from the nondeprived group were excluded for admitting having smoked or for having CO readings that fell outside these accepted limits.

Participants next presented their cigarettes to the experimenter, who returned them after the session. They also removed all jewelry and watches. They then completed the 15-min baseline assessment, including a pre-cue-exposure urge rating.

**Cue exposure:** To create high- and low-craving sessions, nondeprived participants received the control cue, and deprived subjects received the smoking cue. We have used this approach previously to create high- and low-craving conditions characterized by vastly different urge ratings (Sayette & Hufford, 1994; Sayette et al., 2003). Our aim was not to test the separate effects of nicotine deprivation and smoking cue exposure but to examine differences in cognitive processes during high and low craving states. A combination of abstinence and drug cue exposure provides an especially potent craving manipulation (Rohsenow, Niaura, Childress, Abrams, & Monti, 1990-1991).

For the *control cue*, a tray containing a plastic cover was placed on the desk in front of the low-crave participants. They were instructed not to touch the tray. Twenty seconds later, they were instructed via intercom to pick up the cover. Participants found a roll of tape underneath. They were asked to hold the tape in their dominant hand and to look at it. After 15 s, they rated their urge to smoke and then placed the tape back on the tray.

For the *cigarette cue*, nicotine-deprived participants also were instructed to pick up the cover on the tray, which revealed the cigarette pack, a lighter, and an ashtray. They were told to remove a cigarette from the box and to light it without putting it in their mouths, by holding it in the flame for several seconds until the tobacco began to burn. Next they were told to put down the lighter, hold the cigarette in a comfortable manner, and look at it. Twenty seconds after lighting the cigarette, they rated their urge to smoke. Finally, they placed their cigarette in the ashtray.

**Craving-Related Measures**—After cue exposure, participants completed the *SCQ-12*. They then estimated, to the nearest minute and second, the amount of time since they had lifted the cover on the tray during exposure (*retrospective timing*). They next were told they could smoke if they wished in exactly 2.5 min. They were asked to indicate when they believed 45 s and 90 s had elapsed, without counting aloud, by signaling the experimenter (*prospective timing*). They did so by holding up signs when they believed 45 s and 90 s had elapsed. (This activity was videotaped using a time code to calculate actual time latencies.) Finally, participants were debriefed and compensated before leaving the laboratory.

## Results and Discussion

**Manipulation Check**—To examine the effects of our craving manipulation, we computed a  $2 \times 2$  repeated measures analysis of variance (ANOVA), with craving condition as a between-subjects variable and time (pre-cue-exposure and post-cue-exposure urge ratings) as a repeated variable. There were main effects for craving condition,  $F(1, 73) = 435.4, p < .0001$ , with high-crave smokers reporting significantly greater urges than low-crave smokers, and for time,  $F(1, 73) = 51.4, p < .0001$ , with urges higher after cue exposure than before. This latter effect was modified by a Craving Condition  $\times$  Time interaction,  $F(1, 73) = 39.0, p < .0001$ , such that the high-crave smokers reported a greater increase in urge following cue exposure than did the low-crave smokers. Urge ratings for high-crave participants rose from 72.4 ( $SD = 16.9$ ) to 83.2 ( $SD = 16.7$ ), whereas low cravers reported scores of 9.1 ( $SD = 12.0$ ) and 9.8 ( $SD = 11.9$ ) before

and after cue exposure, respectively. These data indicate that our high-crave and low-crave groups were experiencing the necessary levels of craving following cue exposure to test our hypotheses.

**Time Perception**—There were two types of measures of time perception: prospective estimates (45 s and 90 s) and a retrospective estimate. Consistent with prior research, a ratio of estimated time to actual time was derived so that a ratio greater than 1.0 indicated time overestimation, such that time is perceived to pass more slowly than “real” time (Block & Zakay, 1997; Vohs & Schmeichel, 2003). The two prospective measures were highly correlated with each other,  $r(74) = .84$ , but uncorrelated with the retrospective measure. A multivariate analysis of variance examined the effects of craving condition across the two prospective measures. As expected, the high-crave group estimated longer time intervals than did the low-crave group,  $F(1, 72) = 4.1, p < .05$ . There was a trend suggesting a Measure  $\times$  Craving Condition interaction, Wilks's  $\lambda = .961, F(1, 73) = 2.9, p < .10$ . Univariate analyses of variance were next conducted separately for the 45-s and 90-s durations. For the 45-s interval, smokers in the low-crave condition estimated time to pass more quickly (ratio = 0.92) than did those in the high-crave condition (ratio = 1.03),  $F(1, 73) = 5.1, p < .03$ . Although in the same direction, differences did not reach significance for the 90-s measure,  $F(1, 73) = 2.4, p < .13$ . For the retrospective measure, though in the predicted direction, the effect did not approach significance ( $F < 1$ ). These findings provide some evidence that cigarette craving influences time perception.

**Smoking Expectancies**—An ANOVA revealed that high-crave smokers reported the probability of positive outcomes to be greater ( $M = 6.4, SD = 1.4$ ) than did low-crave smokers ( $M = 5.3, SD = 1.2$ ),  $F(1, 73) = 8.4, p < .01$ . Although in the predicted (i.e., opposite) direction, the effect was nonsignificant for negative outcomes ( $p < .21$ ). As in past studies (Sayette et al., 2001), we also examined the probability of positive outcomes relative to negative ones, which revealed a significant effect,  $F(1, 73) = 9.5, p < .005$ . Smokers in the high-crave condition evaluated positive outcomes (relative to negative outcomes) to be more probable than did smokers in the low-crave group. These data suggest that craving can affect the evaluation of information related to smoking outcomes.

## Experiment 2

Experiment 2 was designed to examine the effects of participants' smoking craving on anticipation of the intensity and duration of their craving over the course of a 45-min interval.

### Method

**Participants**—Participants were the 38 smokers from Experiment 1 assigned to the high-crave condition. (In Experiment 2, this group of participants is labeled *anticipate*, as the urges were anticipated but not actually experienced.) A second group ( $n = 32$ ) was recruited using the same methods as in Experiment 1. (This group is labeled *experience*, as the urges were actually experienced during the study.) For the experience group, participants' mean age was 24.9 ( $SD = 5.2$ ). Fifty percent of the sample was female; 81% were Caucasian and 19% African American; and 53% were single. They smoked 20.7 ( $SD = 5.4$ ) cigarettes a day, and they scored an average of 7.0 ( $SD = 3.4$ ) on the BIDR Impression Management subscale and 5.3 ( $SD = 3.4$ ) on the Self-Deception subscale.

### Procedure

**Anticipate group:** Immediately after smoking cue exposure (described earlier), anticipate smokers estimated (using the 0-100 scale) their future urges—if they were not permitted to smoke—after 5 min, 10 min, 15 min, 25 min, 35 min, and 45 min.



**Experience group:** Participants, who had abstained from smoking for 12 hr, received the same smoking cue exposure manipulation used in Experiment 1. Urge-to-smoke ratings were collected before and during cue exposure. Participants sat quietly in the experimental room. (To prevent distraction, they were not permitted to engage in activities such as reading, writing, listening to music, and so forth.) At 5 min, 10 min, 15 min, 25 min, 35 min, and 45 min, participants were asked to rate their urge to smoke. Following the final assessment, participants were debriefed, paid, and permitted to leave.

## Results and Discussion

**Anticipate Group**—As noted above, participants in the anticipate group reported an urge of 74.2 just before smoking cue exposure and 83.2 following smoking cue exposure, suggesting that they were experiencing a strong urge to smoke. To examine the pattern of urges that these participants anticipated experiencing over 45 min if not allowed to smoke, we computed a repeated measures ANOVA with time as a within-subject variable. As shown in Figure 1, a significant effect emerged,  $F(6, 222) = 9.3, p < .0001$ , indicating that smokers estimated that their urges would steadily rise over the entire 45-min period.

**Experience Group**—A repeated measures ANOVA with time (pre-cue exposure, post-cue exposure) as a within-subject variable showed that exposure to smoking cues intensified urge ratings in these nicotine-deprived smokers,  $F(1, 31) = 19.6, p < .0001$ . Smokers' urge before cue exposure was 65.3 ( $SD = 26.8$ ) and after cue exposure was 74.5 ( $SD = 28.2$ ).

A repeated measures ANOVA was conducted to determine whether urge ratings changed over the course of 45 min. (Five participants did not complete urge ratings at all seven time periods and were omitted from this analysis.) The effect of time was not significant ( $F < 1$ ). Of interest to the current study, these data indicated that participants' urge ratings did not increase over the course of the 45-min interval (see Figure 1).

To contrast urge ratings from the experience group with ratings from the anticipate group, we conducted a 2 (rating type: anticipate vs. experience) by 6 (time) repeated measures analysis of covariance with urge scores adjusted for cue exposure urge. There was a marginally significant effect of rating type,  $F(1, 62) = 3.4, p < .08$ ; a main effect of time,  $F(5, 310) = 15.6, p < .0001$ ; and, of particular relevance to the current study, a Rating Type  $\times$  Time interaction,  $F(5, 310) = 5.2, p < .0001$ . As seen in Figure 1, anticipated cravings steadily rose over the course of time, but actual ratings did not. These data suggest that the high-crave smokers in Experiment 1, who anticipated that their urges would steadily rise over the course of 45 min, were in fact overpredicting their urges.

## General Discussion

This study examined the effects of craving on two aspects of temporal cognition: time perception and anticipated urge duration. The present data provide some support for the notion that time passes more slowly for high-crave participants than for low-crave participants.

The finding that high-crave participants experienced 45 s to pass more slowly than did low-crave participants is in accord with a recently published study by Klein, Corwin, and Stine (2003). They also found smokers' estimations of a 45-s interval to differ when they were nicotine deprived compared with when they were non-deprived. Unlike our study, which assessed prospective time using a production technique, Klein et al. relied on verbal estimation, in which one reports the length of a time span (see Zakay & Block, 1997, for a discussion of approaches to duration estimation). Klein et al. found that deprived smokers judged time to pass more slowly than did nondeprived smokers but, unlike our study, also found perceived time durations to be longer than actual time. (A meta-analysis of time perception studies shows

that, consistent with results in our low-crave condition, both retrospective and prospective paradigms tend to yield slight underestimates of duration; Block & Zakay, 1997.) Klein et al. also found time perceptions for deprived smokers to be slower than time perceptions for a control group of nonsmokers. In sum, smokers who are craving appear to find brief time periods to pass more slowly than do smokers who are not craving. We were surprised that the effect for 90 s did not quite reach significance. Because the 90-s and 45-s values were highly correlated and because the size of the effects was similar for the two intervals, we are inclined to think that there is more that is similar than different between these two prospective measures.

Our retrospective measure of time duration failed to detect an effect of craving. It has been observed that retrospective measures are more variable than prospective estimates (Block & Zakay, 1997). It also may be that our retrospective measure combined two contrasting effects on time perception: On one hand, a desire to smoke should have caused the time to pass more slowly, while on the other hand, verbal duration estimates tend to decrease when there are greater processing demands (Zakay & Block, 1997). Because the time frames for the prospective tasks were less than 2 min and the time frame for the retrospective task was about 6 min, it also is difficult to directly compare the two types of measures. Future research using alternative retrospective measures would be useful.

The prospective timing data suggesting that craving leads to overestimation of time duration fit into a more general theory of time perception and self-regulation recently proposed by Vohs and Schmeichel (2003). These investigators describe an “extended now” period as one featuring increased time perception during moments requiring sustained self-regulation: “The extended now state would likely narrow attention such that current feelings, thoughts, impulses, urges, and desires would be given extra weight, whereas distal (or even near-future) goals, ambitions, or plans would seem less consequential” (Vohs & Schmeichel, 2003, p. 219). A smoker who is craving but who struggles to resist the impulse to smoke provides a good example of this type of self-regulation task. This focus on time perception is thought to be instrumental in determining how implicit or explicit decisions regarding self-regulation are made (Vohs & Schmeichel, 2003). Specifically, Vohs and Schmeichel found that increased time perceptions during moments requiring self-regulation led to diminished capacity for self-control during subsequent tasks.

This study also examined the degree to which smokers who were craving would accurately predict the time course of the experience. There is both conceptual and empirical support for Marlatt's (1985) proposition that cravings tend to diminish not long after reaching peak. Nevertheless, as hypothesized, it appears that while craving, smokers who were craving expected that their urges would steadily increase over a subsequent 45-min interval if they did not smoke. Experiment 2 also examined the trajectory of craving over a 45-min interval while smokers who were craving a cigarette sat quietly. The lack of stimulation likely boosted urges relative to the natural environment (filled with distraction) and thus provided an especially conservative approach to considering whether cravings rise steadily over time. Even so, urge ratings did not rise over time, suggesting that, indeed, smokers overpredict the duration and intensity of their future cravings. Additional research is warranted to determine whether exaggerated perceptions of the persistence of craving may help to undermine efforts to quit.

This study provided an opportunity to test the effects of craving on the evaluation of smoking-related information. Previously, we had reported a trend such that deprived smokers found the probability of positive outcomes to be relatively higher than negative outcomes (Sayette et al., 2001). The present study, which found a significant effect for craving condition, provides stronger evidence that cigarette craving can affect the way in which smoking-related information is evaluated. Future research that also examines the way in which non-smoking-related information is evaluated would be useful.

Several limitations should be mentioned. As noted above, the time perception data—though showing the predicted pattern (i.e., time passed more slowly for high cravers than low cravers)—found high-crave smokers to be fairly accurate in their prospective judgments. Across many studies, however, it appears that prospective durations tend to be slightly underestimated (Block & Zakay, 1997, p. 191). This tendency is consistent with the performance of low-crave participants in the current study and suggests a context in which to interpret the “accurate” estimates provided by high-crave smokers.

Our data do not address the specificity of the 45-s time perception effect. Research in which smokers who are craving estimate time just prior to receiving a different (nonsmoking) type of reinforcer would be useful. It also is unclear whether the anticipated duration of future cravings would parallel anticipation of other feeling states (e.g., “How anxious will you be over the next 45 min?”). We believe that the combination of nicotine deprivation and cue exposure enhanced craving to smoke, which in turn affected temporal cognition. Our study cannot rule out, however, the possibility that our craving manipulation affected experiences besides craving (e.g., other withdrawal symptoms). By using one (12-hr) deprivation condition, we cannot say how other time frames would operate, though similar findings have been reported using 24-hr abstinence (Klein et al., 2003).

Our attempt to show that smokers overpredicted the trajectory of their future cravings by testing a second group of smokers was imperfect. We decided against obtaining actual urge ratings from the first group of “anticipate” participants owing to concern that the act of predicting future urges would affect subsequent “actual” ratings. Thus, we ran different participants in the experience and anticipate groups. Regarding the experience condition, we considered introducing distracters into the study (not unlike many real-world situations), which likely would have reduced urge ratings across the 45-min period. Our aim, however, was to conduct a stringent test that excluded stimuli that might have lowered urges, yet still show an overestimation of urge intensity and duration.

Despite these limitations, these findings highlight the importance of temporal cognition as an area of investigation for smoking researchers. There are multiple studies suggesting a link between craving and smoking relapse (e.g., Killen & Fortmann, 1997; Shiffman et al., 1997). The past decade has seen attempts to identify cognitive mechanisms that mediate this association. One approach is to identify various cognitive processes that appear to enhance the attractiveness of smoking or that exacerbate the negative affect and craving often associated with nicotine deprivation. To this end, evidence is accumulating to suggest that cigarette craving affects (a) the salience of smoking cues in the environment; (b) judgments about the positive and negative aspects of smoking; (c) distribution of limited-capacity attentional resources such that performance on a range of smoking-irrelevant tasks is impaired; and (d) temporal cognition, such that time passes more slowly when craving than when not craving and that smokers expect that, if unchecked, a craving experience will intensify over time (Sayette, 2004). As these effects become more established in the literature, it is likely that new models of craving that emphasize cognitive processing will be developed.

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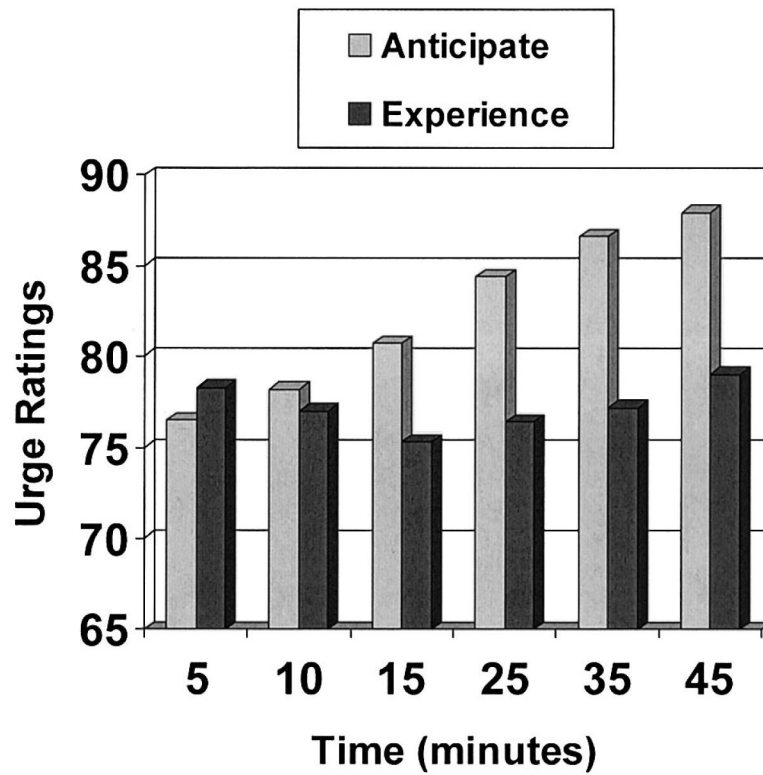
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**Figure 1.** Anticipated and actual urge ratings over a 45-min period (adjusted for smoking cue exposure urge rating) for smokers in high-crave conditions.