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Perceived smoking availability differentially affects mood and reaction time

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Abstract

Introduction—This between subjects study explored the relationship between smoking availability and smoking motivation and is the first study to include three smoking availability time points. This allowed for an examination of an extended period of smoking unavailability, and a test of the linearity of the relationships between smoking availability and smoking motivation measures.

Methods—Ninety 3-hour abstinent smokers (mean ~15 cigarettes per day) were randomly assigned to one of three availability manipulations while being exposed to smoking stimuli (i.e., pack of cigarettes): smoke in 20 min, smoke in 3 h, or smoke in 24 h. Participants completed pre- and post-manipulation measures of urge, positive affect and negative affect, and simple reaction time.

Results—The belief that smoking would next be available in 24 h resulted in a significant decrease in positive affect and increase in negative affect relative to the 3 h and 20 min conditions. A Lack of Fit test suggested a linear relationship between smoking availability and affect. A quadratic model appeared to be a better fit for the relationship between smoking availability and simple reaction time with participants in the 24 h and 20 min conditions showing a greater slowing of reaction time relative to the 3 h condition. There were no effects of the manipulations on self-reported urge, but baseline ceiling effects were noted.

Conclusions—Future investigations that manipulate three or more periods of time before smoking is available will help to better elucidate the nature of the relationship between smoking availability and smoking motivation.

Keywords

Smoking availability; Urge; Positive affect; Negative affect; Cognitive interference; Drug use opportunity

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1. Introduction

Stimuli associated with drug taking can elicit conditioned reactions in drug users that presumably increase drug taking motivation and behavior. This phenomenon, referred to as cue reactivity, is conceptualized based on principles of classical conditioning (Reynolds & Monti, 2012; Rohsenow, Childress, Monti, Niaura, & Abrams, 1991). Stimuli present during drug administration (e.g., drug related paraphernalia, mood states) that reliably predict drug use become conditioned stimuli (CS's) that elicit conditioned responses (CR's). Controlled laboratory research demonstrates that exposure to drug associated stimuli results in cue-specific responding reflected as increased drug craving, as well changes in mood, autonomic responses, and brain activity, which is believed to be a result of prior conditioning. Cue exposure therapies are premised on the idea that repeated exposure to drug stimuli without drug ingestion produces extinction of conditioned responding, and a resultant decrease in drug taking motivation and behavior (Conklin & Tiffany, 2001).

An important element underlying the occurrence or strength of conditioned responding to drug-related cues is the expectation that drug consumption will actually take place, often referred to as “drug availability” or “drug use opportunity”. From a conditioning perspective, the knowledge that the drug is available for use may be conceptualized as an important cognitive component of the stimulus-complex signaling drug delivery (Wertz & Sayette, 2001b) or serves as an occasion setter that signals the association between drug-related stimuli and the drug (Wertz & Sayette, 2001a).

Controlled laboratory studies have manipulated smoking availability and demonstrated its important role in cue reactivity. Juliano and Brandon (1998) found that smokers told that they could smoke within 20 min reported stronger urges than those told that smoking would not be permitted until the end of the 3 h session. Smoking cues increased urges *only* among smokers who believed that smoking would take place within 20 min. Sayette and colleagues observed greater positive affect (Sayette & Hufford, 1995; Sayette et al., 2003) and greater urges (Sayette et al., 2003) among participants in cue exposure sessions when they believed that smoking would take place or when the expected delays before smoking were shorter (i.e., 15 s > 30s > 60s). Moreover, greater brain activity has been observed in regions associated with attention, arousal, and reward processing among smokers who are told that smoking would be permitted during the cue reactivity session compared to those expecting to wait 4 h (McBride, Barrett, Kelly, Aw, & Dagher, 2006) or 2 h before smoking, even in the absence of significant effects on self-reported urges to smoke (Wilson, Sayette, Delgado, & Fiez, 2005; Wilson, Sayette, Delgado, & Fiez, 2008; Wilson, Sayette, & Fiez, 2011). Smokers exposed to either a lit cigarette or a cup of water while being told that there is a 0%, 50%, or 100% chance of consuming the cue display increased craving ratings in the presence of the cigarette as a function of the increasing probability of smoking, with the greatest differences between cigarette and water cues when smoking is 100% probable (Carter & Tiffany, 2001). These studies have also observed decreasing positive affect and increasing negative affect as the smoking probability decreases (Bailey, Goedeker, & Tiffany, 2010; Carter & Tiffany, 2001). Finally, studies manipulating smoking availability by exposing smokers to stimuli that signal smoking (CS+) or not smoking (CS–), observe greater urges when smoking is expected versus when it is not, especially when smoking

stimuli are present (Dols, van den Hout, Kindt, & Willems, 2002; Dols, Willems, van den Hout, & Bittoun, 2000), and/or when there is an awareness of the contingency between the stimuli and smoking (Field & Duka, 2001; Lavez, Herzog, & Brandon, 1999).

In summary, the extant laboratory research demonstrates that smoking availability influences smoker's responses across various domains suggestive of increased smoking motivation when smoking is expected to take place sooner than later, or as the probability of immediate smoking increases. However, all prior studies manipulating availability involved relatively short periods of time, with a maximum delay of only 4 h. No prior studies have evaluated immediate reactions to the expectation that smoking will be unavailable for *an extended period of time*. This is surprising because naturalistic conditions often expose smokers to situations in which there is an expectation of extended abstinence including work days, air travel (Dar, Rosen-Korakin, Shapira, Gottlieb, & Frenk, 2010), or running out of money for cigarettes. Quit attempts, inpatient hospitalizations, or religious observances (Dar, Stronguin, Marouani, Krupsky, & Frenk, 2005) may also involve expectations of extended abstinence.

To address this important gap in the literature the present study examined the influence of an extended period of time of smoking unavailability on smoking motivation. In this randomized between-subjects study smokers were exposed to smoking cues while being instructed that smoking would be permitted in 20 min, 3 h, or 24 h. It was hypothesized that participants in the 20 min condition would experience greater urge to smoke, greater positive affect, and lower negative affect than the 3 h condition. The comparisons with the 24 h condition were exploratory. Manipulating three time points also allowed us to examine if a linear or non-linear model best represented the relationship between smoking availability and the measured outcomes. In addition, participants completed a simple auditory reaction time task as a measure of cognitive interference. This was included to further explore an unexpected finding in Juliano and Brandon (1998) that the slowest reaction times were found among those in the smoking unavailable condition who were exposed to smoking stimuli. Moreover, correlations among the dependent measures were evaluated to test the hypotheses that cognitive interference would correlate with urge (Juliano & Brandon, 1998; Sayette & Hufford, 1994; Tiffany, 1990) and that negative affect would be more strongly associated with urges as smoking became more unavailable (Baker, Morse, & Sherman, 1986; Carter & Tiffany, 2001).

2. Method

2.1. Participants

This study was approved by the American University Institutional Review Board. Ninety participants were recruited from the campus and local Washington D.C area. Three participants dropped out and data from two participants did not save to the computer. Study completers (N = 85, 69% Male) smoked a mean of 15.06 (SD 4.41) cigarettes per day for 13.62 (SD 12.44) years and had a mean age of 31.74 (SD 14.26). The sample was comprised largely of those who identified as Caucasian (53%) or African-American (46%). Thirty-six percent were full-time college students. Table 1 shows demographics and background information by condition.

2.2. Measures

2.2.1. Alveolar carbon monoxide breath sample (COa)—Breath samples were obtained using a Bedfont Micro Breathalyzer (Medford, NJ). Carbon monoxide readings were collected to encourage compliance with the three hours of abstinence required before the first session. As this is an imprecise measure of actual smoking exposure, it was employed as a “bogus pipeline” procedure.

2.2.2. Fagerström Test for nicotine dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991)—This is a widely used six-item measure of nicotine dependence that yields a total score between 0 and 10.

2.2.3. Diener & Emmons Positive and Negative Affect Scale (Diener & Emmons, 1984)—This scale lists four positive (‘happy’, ‘joyful’, ‘pleased’, and ‘enjoyment/fun’) and five negative (‘depressed/blue’, ‘unhappy’, ‘frustrated’, ‘worry’, and ‘angry/hostile’) emotions that participants rated as experiencing from 1 = not at all to 7 = extremely much. Cronbach's alpha averaged .905 for the positive scale, and .868 for the negative scale.

2.2.4. Urge Rating Scale (Kozlowski, Pillitteri, Sweeney, Whitefield, & Graham, 1996)—Participants completed this 3-item measure that assessed desire, want, and craving to smoke. Each item was rated from 1 = strongly disagree to 7 = strongly agree. Cronbach's alpha averaged .864.

2.2.5. Simple reaction time—Participants were asked to respond as quickly as possible to a series of tones (72 dB, 600Hz, 250 ms duration, with inter-stimulus intervals averaging 20 s; Juliano & Brandon, 1998). Participants completed one practice session consisting of four trials, and then completed six trials before and after the manipulation. Consistent with prior research, only the mean of the first 2 reaction time trials were used in the analyses (Cepeda-Benito & Tiffany, 1996; Juliano & Brandon, 1998; Sayette & Hufford, 1994).

2.3. Procedure

2.3.1. Phone screen—Participants were informed that the experiment required up to two laboratory visits, scheduled 24 h apart and would pay \$35. Eligibility criteria included smoking at least 10 cigarettes per day for at least one year, age between 18 and 65, and not knowing anyone who had already participated in the study. Participants were instructed to bring their cigarettes and to abstain from tobacco products for three hours prior to the first session to control for recent smoke exposure and increase sensitivity to the manipulation (Juliano & Brandon, 1998).

2.3.2. Experimental session—During informed consent participants were reminded that the session could last for three hours, participation may involve smoking abstinence, and a follow-up session would take place the next day. Participants reported when they last smoked, to ensure that the three hour abstinence requirement was met. A CO breath sample was taken and the experimenter obtained the participant's cigarettes, placing them out of view. Baseline measures were administered. The experimenter returned to the room and

delivered one of three manipulations. Depending on random assignment, participants were told that they would next be able to smoke in 20 min, 3 h, or 24 h all under the guise that participants would need to return the next day for an assessment of smoking exposure. While the experimenter delivered the manipulation they surreptitiously removed a box that held the CO monitor, which now clearly exposed the smoking-related stimuli (i.e., the participant's pack of cigarettes, ashtray, and lighter). This procedure was used to reduce the potential reactivity that may occur if the experimenter were to physically place down the smoking stimuli while telling the participant they will not be permitted to smoke, as was done in Juliano and Brandon (1998). Participants then completed post-manipulation measures of affect, urge, and simple reaction time. At this time, the experiment was complete and participants were compensated and debriefed. No smoking took place.

3. Results

3.1. Data analytic strategy

There were no significant differences among the groups on any variables at baseline (see Table 1). Data from two participants with strong outliers on negative mood and reaction time were excluded from the analyses. Difference scores were created by subtracting the pre-manipulation scores from the post-manipulation scores and a series of planned comparisons among the conditions were conducted using independent sample t-tests. Including gender and student status as covariates had no impact on the findings and thus t-tests are reported. A Lack of Fit test assessed if each outcome measure was related to the three smoking availability time points in a linear or non-linear fashion.

3.2. Self-reported smoking urge

Planned comparisons revealed no differences in self-reported urge to smoke (see Fig. 1). The Lack of Fit test indicated a linear relationship fit the data ($p = .582$).

3.3. Positive affect and negative affect

As shown in Fig. 2, there was a significant effect of the availability manipulation on affect such that individuals in the 24 h condition had greater increases in negative affect and decreases in positive affect than those in the 3 h and 20 min conditions. Participants in the 24 h condition showed greater decreases in positive affect compared to those in the 3 h condition $t(55) = -2.07$, $p = .043$, Cohen's $d = 0.553$, and those in the 20 min condition, $t(54) = -2.92$, $p = .005$, Cohen's $d = 0.794$. The difference between the 20 min condition and 3 h condition was not significant, $t(55) = 1.12$, $p = .267$, Cohen's $d = 0.294$. Likewise, participants in the 24 h condition showed greater increases in negative affect compared to those in the 3 h condition $t(53) = 2.66$, $p = .01$, Cohen's $d = .730$, and those in the 20 min condition, $t(53) = 2.45$, $p = .018$, Cohen's $d = .655$. The difference between the 20 min condition and 3 h condition was not significant, $t(54) = .338$, $p = .737$, Cohen's $d = .115$. There was a significant linear association between positive mood and smoking availability, $R^2 = .11$, $F(1,84) = 10.07$, $p = .002$. Similarly, there was a significant linear association observed for negative mood and smoking availability, $R^2 = .11$, $F(1,82) = 9.49$, $p = .003$. Furthermore, the Lack of Fit test indicated that the linear model was more appropriate than the non-linear model for both positive affect and negative affect ($ps > .53$).

3.4. Reaction time

As shown in Fig. 3, participants in 24 h condition had a greater slowing of reaction time compared to the 3 h condition, $t(53) = -2.37, p = .021$, Cohen's $d = 0.651$, but not compared to the 20 min condition. The greater slowing in reaction time in the 20 min condition compared to the 3 h condition revealed a strong trend, $t(53) = -1.88, p = .065$, Cohen's $d = 0.507$. The Lack of Fit test indicated that a non-linear model best fits these data. In the regression analysis, with variables time and time² entered, the quadratic factor ($\beta = .84, p = .049$) was significant.

3.5. Correlations among the dependent measures

When groups were combined, there was a positive correlation between self-reported urge change and negative affect change, $r(83) = .373, p = .001$ and a negative correlation between urge change and positive affect change, $r(85) = -.235, p = .031$. Positive affect change and negative affect change were negatively correlated, $r(83) = -.331, p = .002$. As shown in Table 2, when evaluated by condition, significant correlations were only observed between urge and negative affect and urge and positive affect in the 24 h condition, $r(27) = .601, p = .001$, and $r(28) = -.381, p = .046$ respectively.

There were no significant correlations among reaction time change and changes on any of the other dependent measures when the conditions were evaluated separately or combined.

4. Discussion

This study sought to further explore the nature of the relationship between smoking availability and smoking motivation by measuring smokers' reactions to three different lengths of time before smoking would be available (i.e., 20 min, 3 h, and 24 h). We observed significant effects of the experimental manipulations on mood and reaction time, but not urge. Many prior studies manipulating smoking availability have found urge or craving effects with greater urge observed when smoking is available sooner than later. However, a number of prior studies have also failed to find effects on urge while still observing effects on other dependent measures (Field & Duka, 2004; McBride et al., 2006; Wilson et al., 2005; Wilson et al., 2008; Wilson et al., 2011). We used a three-item measure of urge believing it to be a psychometric improvement over the one-item measure used in Juliano and Brandon (1998). However, the anchors of *strongly disagree* to *strongly agree* with three-hour abstinent smokers may have restricted the possible range of change scores as all three levels of the manipulation were designed to increase urge to some extent. Prior to the manipulation, 25% of participants had the highest possible mean for urge and 45% had a mean value of 6 or greater on the 7 point scale. Thus, it is possible that baseline ceiling effects on the urge measure may have obscured potential effects of the manipulation.

Individuals in the 24 h condition had significantly decreased positive affect and increased negative affect relative to the 3 h and 20 min conditions, with no difference between the latter two conditions (Fig. 2). Juliano and Brandon (1998) also failed to find differences in positive or negative affect between the 3 h and 20 min conditions. However, Sayette et al. (2003) found that as the delay before expected smoking increased from 15 s to 30s to 60s, positive affect decreased. Studies that have manipulated the probability of smoking have

found decreased positive affect and increased negative affect as the probability of smoking decreases (Bailey et al., 2010; Carter & Tiffany, 2001). Similarly, we found that the three smoking availability time points used in this study showed a linear relationship with positive affect and negative affect, with positive affect decreasing, and negative affect increasing as time to smoke increased.

We observed the strongest correlations between urge and affect in the 24 h condition, with negative affect change scores significantly positively associated with urge change scores and positive affect change scores significantly negatively associated with urge change scores. These findings are consistent with prior studies that found the strongest associations between urge and affect when smoking was 0% probable (Bailey et al., 2010; Carter & Tiffany, 2001). It is also interesting to note that similar to prior studies the direction of the relationship between positive affect and urge was non-significantly *positive* in the most available condition and significantly negative in the least available condition. This pattern of data is somewhat consistent with Baker et al.'s (1986) dual-affect model of craving that posits that craving can be associated with both positive affect and negative affect depending on the circumstances including information about when a drug is available or not. In particular, this model predicts that craving is elicited with negative affect when cigarettes are unavailable and positive affect when cigarettes are available. The relationship between affect and expected time before smoking is available may have clinical implications as mood disturbances when smoking is expected to be unavailable could undermine quitting motivation. Counseling could target mood in anticipation of the first 24 h of abstinence to prevent an affect-related smoking lapse.

Evidence of a non-linear relationship emerged when examining the three smoking availability time points and cognitive interference, such that the most immediate (20 min) and the most distal time point (24 h) showed the greatest reaction times. There was a significant difference in reaction time between the 24 h condition and the 3 h condition, with those expecting to wait 24 h before smoking having slower reaction times than those expecting to wait 3 h. There was also a curious trend of slower reaction time in the 20 min condition as compared to the 3 h condition. These findings are inconsistent with those of Juliano and Brandon (1998) who found slower reaction times in the 3 h condition relative to the 20 min condition but *only* when smoking stimuli were present. The current study altered the way in which the smoking stimuli were presented to reduce potential participant reactivity that may occur when telling participants they cannot smoke while at the same time placing smoking stimuli in front of them. This methodological difference may have contributed to the differences in findings between the two studies. Self-reported urge and reaction time change scores were not correlated in the present study as was found in Juliano and Brandon (1998). Further research is needed to determine the consistency and meaning of reaction time differences among the groups. Using different assessments of reaction time may also be beneficial, since our assessment of simple reaction time is limited in its ability to detect cognitive disruption.

This study has limitations that should be noted. Three participants originally assigned to the 24 h condition dropped out immediately after receiving their abstinence instructions and thus post-manipulation data were not collected for these individuals. This selection bias

could have decreased power and the observed effects of the manipulations. Because all groups were exposed to smoking stimuli, this study cannot assess the independent effects of environmental stimuli and smoking availability on smoking motivation. Also, there was no way of ensuring that participants in the 24 h condition planned to abstain for 24 h at the time that data were collected. We attempted to enhance the believability of the manipulation by scheduling a second visit and telling participants that we would be able to detect any smoking with a carbon monoxide test. Manipulations involving expectations of extended abstinence would have greater internal validity in a controlled environment. Our sample consisted of individuals who were not making an active smoking quit attempt, which may decrease the generalizability of our findings, as quitting motivation could be a potential moderator of effects (see Wilson et al., 2011). Future research should continue to examine how motivation to quit smoking influences reactions to smoking-related stimuli and smoking availability, with a particular focus on extended periods of smoking unavailability.

Future research studies should manipulate three or more time points of smoking availability to confirm if there is a resultant linear or non-linear pattern of responding across different indices of smoking motivation. Smoking unavailability is becoming a more common phenomenon with increasing adoption of smoke-free workplaces as well as smoke-free public places (e.g., parks and beaches). It is possible that urge to smoke decreases when smoking is not expected for some circumscribed period of time due to Pavlovian processes, but then increases upon expecting that smoking will not be available for a lengthier period of time due to anticipatory anxiety, frustration, impatience, or the anticipation of withdrawal. The finding that participants in the 24 h condition showed the poorest mood, greatest urge, and greatest reaction time should be explored in future studies. It is important to know if the expectation that one cannot smoke for an *extended* period of time causes affective and urge changes among smokers who are trying to quit as this could have implications for smoking cessation success.

Additional research is needed to determine the precise nature of the relationships between different smoking availability time points and various indicators of smoking motivation. This research will help to further elucidate the importance of cognitive factors in smoking motivation and behavior, and may help guide the development of exposure based and cognitively based therapeutic interventions.

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References

- Bailey SR, Goedeker KC, Tiffany ST. The impact of cigarette deprivation and cigarette availability on cue-reactivity in smokers. *Addiction*. 2010; 105(2):364–372. doi:ADD2760. [PubMed: 19922514]
- Baker, TB.; Morse, E.; Sherman, JE. The motivation to use drugs: A psychobiological analysis of urges. In: Rivers, PC., editor. *The Nebraska Symposium on Motivation: Alcohol Use and Abuse*. Lincoln, NE: University of Nebraska Press; 1986. p. 257-323.

- Carter BL, Tiffany ST. The cue-availability paradigm: The effects of cigarette availability on cue reactivity in smokers. *Experimental and Clinical Psychopharmacology*. 2001; 9(2):183–190. <http://dx.doi.org/10.1037//1064-1297.9.2.183>. [PubMed: 11518094]
- Cepeda-Benito A, Tiffany ST. The use of a dual-task procedure for the assessment of cognitive effort associated with cigarette craving. *Psychopharmacology*. 1996; 127:155–163. [PubMed: 8888382]
- Conklin CA, Tiffany ST. Applying extinction research and theory to cue-exposure addiction treatments. *Addiction*. 2001; 97:155–167. [PubMed: 11860387]
- Dar R, Rosen-Korakin N, Shapira O, Gottlieb Y, Frenk H. The craving to smoke in flight attendants: Relations with smoking deprivation, anticipation of smoking, and actual smoking. *Journal of Abnormal Psychology*. 2010; 119(1):248–253. doi:2010-02209-018. [PubMed: 20141262]
- Dar R, Stronguin F, Marouani R, Krupsky M, Frenk H. Craving to smoke in orthodox Jewish smokers on the Sabbath: A comparison to a baseline and forced abstinence workday. *Psychopharmacology*. 2005; 183:294–299. [PubMed: 16237578]
- Diener E, Emmons RA. The independence of positive and negative affect. *Journal of Personality and Social Psychology*. 1984; 47(5):1105–1117. [PubMed: 6520704]
- Dols M, van den Hout M, Kindt M, Willems B. The urge to smoke depends on the expectation of smoking. *Addiction*. 2002; 97(1):87–93. [PubMed: 11895274]
- Dols M, Willems B, van den Hout M, Bittoun R. Smokers can learn to influence their urge to smoke. *Addiction*. 2000; 25(1):103–108.
- Field M, Duka T. Smoking expectancy mediates the conditioned responses to arbitrary smoking cues. *Behavioral Pharmacology*. 2001; 12(3):183–194.
- Field M, Duka T. Cue reactivity in smokers: The effects of perceived cigarette availability and gender. *Pharmacology, Biochemistry and Behavior*. 2004; 78:647–652.
- Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerstrom Test for Nicotine Dependence: A revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addiction*. 1991; 86(9):1119–1127. [PubMed: 1932883]
- Juliano LM, Brandon TH. Reactivity to instructed smoking availability and environmental cues: Evidence with urge and reaction time. *Experimental and Clinical Psychopharmacology*. 1998; 6(1):45–53. [PubMed: 9526145]
- Kozlowski LT, Pillitteri JL, Sweeney CT, Whitefield KE, Graham JW. Asking questions about urges or cravings for cigarettes. *Psychology of Addictive Behaviors*. 1996; 10(4):248–260.
- Lavez AB, Herzog TA, Brandon TH. Classical conditioning of environmental cues to cigarette smoking. *Experimental and Clinical Psychopharmacology*. 1999; 7(1):56–63. [PubMed: 10036610]
- McBride D, Barrett SP, Kelly JT, Aw A, Dagher A. Effects of expectancy and abstinence on the neural response to smoking cues in cigarette smokers: An Fmri study. *Neuropsychopharmacology*. 2006; 31:2728–2738. [PubMed: 16598192]
- Reynolds, EK.; Monti, PM. The Cue Reactivity Paradigm in Addiction Research. In: Mackillop, J.; deWit, H., editors. *The Wiley-Blackwell Handbook of Addiction Psychopharmacology*. Hoboken, New Jersey: John Wiley & Sons, Ltd; 2012. p. 381–410.
- Rohsenow DJ, Childress AR, Monti PM, Niaura RS, Abrams DB. Cue reactivity in addictive behaviors: Theoretical and treatment implications. *Substance Use & Misuse*. 1991; 25(S7–S8): 957–993.
- Sayette MA, Hufford MR. Effects of cue exposure and deprivation on cognitive resources in smokers. *Journal of Abnormal Psychology*. 1994; 103(4):812–818. [PubMed: 7822584]
- Sayette MA, Hufford MR. Urge and affect: A facial coding analysis of smokers. *Experimental and Clinical Psychopharmacology*. 1995; 3(4):417–423.
- Sayette MA, Wertz JM, Martin CS, Cohn JF, Perrott MA, Hobel J. Effects of smoking opportunity on cue-elicited urge: A facial coding analysis. *Experimental and Clinical Psychopharmacology*. 2003; 11(3):218–227. [PubMed: 12940501]
- Tiffany ST. A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review*. 1990; 97(2):147–168. [PubMed: 2186423]
- Wertz JM, Sayette MA. Effects of smoking opportunity on attentional bias in smokers. *Psychology of Addictive Behaviors*. 2001a; 15(3):268–271. [PubMed: 11563808]

- Wertz JM, Sayette MA. A review of the effects of perceived drug use opportunity on self-reported urge. *Experimental and Clinical Psychopharmacology*. 2001b; 9(1):3–13. [PubMed: 11519632]
- Wilson SJ, Sayette M, Delgado M, Fiez JA. Instructed smoking expectancy modulates cue-elicited neural activity: A preliminary study. *Nicotine and Tobacco Research*. 2005; 7(4):637–645. [PubMed: 16085533]
- Wilson SJ, Sayette M, Delgado M, Fiez JA. Effect of smoking opportunity on responses to monetary gain and loss in the caudate nucleus. *Journal of Abnormal Psychology*. 2008; 117(2):428–462. [PubMed: 18489219]
- Wilson SJ, Sayette MA, Fiez JA. Quitting-unmotivated and quitting-motivated cigarette smokers exhibit different patterns of cue-elicited brain activation when anticipating an opportunity to smoke. *Journal of Abnormal Psychology*. 2011; 121(1):198. [PubMed: 21859165]

Highlights

- The expected amount of time before smoking is available influences smoking motivation.
- No prior studies have examined extended periods of unavailability, greater than 4 hours.
- We tested 3 periods of unavailability: 20 mins, 3 hrs, 24hrs.
- We found a linear relationship between affect and availability.
- A quadratic model was better fit for availability and simple reaction time.

Fig. 1.
The effect of smoking availability on urge. Error bars illustrate the standard error of the mean. No significant differences were observed between any of the conditions.

Fig. 2.

The effect of smoking availability on positive affect and negative affect. Error bars illustrate standard error of the mean. Participants in the 24 h condition showed significant decreases in positive affect and significant increases in negative affect compared to those in the 3 h and 20 min conditions. No other significant differences were observed. $*p < .05$.

Fig. 3.

The effect of smoking availability on reaction time. Reaction time change is measured in milliseconds (ms). Error bars illustrate standard error of the mean. Participants in 24 h condition had a greater slowing of reaction time compared to the 3 h condition. No other significant differences were observed. $*p < .05$.

Table 1

Background information and baseline dependent variables by condition.

Variable Mean (SD) *	20 min condition (N = 28)	3 h condition (N = 29)	24 h condition (N = 28)
Age	33.93 (14.88)	29.83 (12.96)	31.55 (15.07)
Gender (% females)	31%	38%	24%
Cigarettes per day	15.76 (5.57)	15.72 (4.10)	13.69 (3.01)
Years smoking	15.45 (13.08)	13.31 (11.56)	12.04 (12.83)
FTND	4.41 (1.76)	4.65 (1.67)	3.59 (2.15)
% Caucasian	42%	58%	58%
% African American	58%	38%	42%
% Other	0%	4%	0%
Student (% full-time)	34%	38%	38%
Desire to quit (7 pt scale)	4.21 (1.72)	3.86 (1.88)	4.14 (1.75)
Urge (7 pt scale)	5.02 (1.68)	5.49 (1.51)	4.86 (1.66)
Positive mood (7 pt scale)	3.78 (1.25)	3.50 (1.34)	4.25 (1.37)
Negative mood (7 pt scale)	2.40 (1.22)	2.93 (1.36)	2.89 (1.39)
Baseline reaction time (ms)	331.61 (91.54)	292.83 (86.09)	309.19 (87.64)

Note.

* There were no significant differences between the conditions on any baseline demographic or smoking history variables. FTND = Fagerström Test for Nicotine Dependence, pt = point, ms = milliseconds.

Table 2

Correlations among urge and affect by condition.

Condition	Negative affect	Positive affect
20 min	−0.139	0.256
3h	0.304	−0.252
24 h	0.597	−0.383*
Groups combined	.368	−.234*

Note. Significant correlations between urge and negative affect and urge and positive affect were observed when the groups were combined and only in the 24 h condition when conditions were examined separately.

*
 $p < .05$.