Published in final edited form as:
Exp Clin Psychopharmacol. 1999 May ; 7(2): 151–159.

Effects of Olfactory Stimuli on Urge Reduction in Smokers

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Abstract

This study examined the possibility that exposure to olfactory stimuli can reduce self-reported urge to smoke. After an initial assessment of self-reported urge, nicotine-deprived smokers evaluated the pleasantness of a series of 8 odors. Facial expressions during odor presentations were coded with P. Ekman and W. V. Friesen's (1978a) Facial Action Coding System. After odor administration, participants were exposed to smoking cues. Next, participants were administered their most pleasant, least pleasant, or a control odor (water) and reported their urge to smoke. Results indicated that sniffing either a pleasant or unpleasant odor reduced reported urge to smoke relative to the control odor. Reported pleasantness of the odors did not differentially affect urge reduction. Odors eliciting negative-affect-related expressions, however, were less effective than odors that did not elicit negative-affect-related expressions in reducing reported urge. Results of this preliminary investigation provide support for the consideration of odor stimuli as an approach to craving reduction.

Craving has long been considered central to addiction (World Health Organization, 1955). Although the exact role of craving in drug relapse is still debated (cf. Kassel & Shiffman, 1992; Tiffany, 1990), craving has been associated with increased probability of relapse (Brandon, Tiffany, & Baker, 1985; Killen & Fortmann, 1997; Shiffman et al., 1997). Independent of their link to relapse, cravings are frequently reported by addicts and may discourage efforts to even attempt cessation. Consequently, there has been considerable interest of late in understanding craving (e.g., National Institute on Alcohol Abuse and Alcoholism, 1997; National Institute on Drug Abuse, 1998; Pickens & Johanson, 1992).

One approach to craving research has been to elicit and then examine drug cravings, or urges, in the laboratory. A variety of craving inductions have been used, including drug use imagery, mood manipulations, and drug cue exposure techniques (Drobes & Tiffany, 1997; Rohsenow, Niaura, Childress, Abrams, & Monti, 1990–1991). Although craving has been reliably elicited in the laboratory (Carter & Tiffany, in press), until recently relatively little attention has focused on attempts to reduce drug craving. Studies using urge reduction manipulations typically have examined pharmacological agents (O'Brien, 1996; Schuckit, 1996). Attempts to diminish smoking cravings in the laboratory, for example, have used nicotine replacement treatments (e.g., Leischow et al., 1997; Rose, Herskovic, Trilling, & Jarvik, 1985). With few exceptions (e.g., Rose & Behm, 1994), however, rarely has research examined nondrug manipulations for reducing craving. The present study provided an initial investigation of the effectiveness of olfactory stimuli in reduction of smoking craving.

The proposition that odors might be especially well suited to reducing cravings receives support from a number of sources. First, recent models have emphasized the emotional properties of craving. Baker, Morse, and Sherman (1987), for example, posited that urges

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are affects, and that stimuli affecting emotional states should also influence craving. Neurobiological research has identified particular limbic structures known to be associated with emotion that are activated during craving experiences (Everitt, 1997; Zubieta et al., 1996). During moments of high craving, facial expressions associated with both positive and negative affect have been observed (Sayette & Hufford, 1995).

Second, emotions are more effectively manipulated through the sense of smell than through other sensory systems (Engen, 1982). The olfactory system appears to be directly linked to limbic structures, such as the amygdala, which are associated with emotion activation (Aggleton & Mishkin, 1986). In contrast, signals from other sensory systems are relayed to their respective association areas in the cortex and processed in the thalamus before being relayed to the amygdala, resulting in more highly processed and integrated sensory information (Aggleton & Mishkin, 1986). If craving is an emotional experience, then olfactory stimuli, which reliably influence affective states, also may affect craving.

Third, odors may be effective in reducing craving as a result of their impact on nonautomatic processing (i.e., cognitive processing that draws on limited-capacity resources). Tiffany (1990) posited that drug craving is supported by nonautomatic processes. Consistent with this position, multiple studies have found craving to be associated with increased demands on nonautomatic processing resources (e.g., Cepeda-Benito & Tiffany, 1996; Juliano & Brandon, 1998; Sayette & Hufford, 1994; Sayette et al., 1994; Wetter, Brandon, & Baker, 1992). Similarly, a central characteristic of olfactory stimuli is their demand on nonautomatic processing resources (Engen, 1982, 1991). Odors may be particularly well suited to redistributing limited-capacity processing resources previously allocated to processing an urge. Thus, olfactory stimuli might directly draw on these processing resources, leaving fewer cognitive resources available for craving.

One reason that odors may be especially likely to draw on nonautomatic processing resources is that they appear more likely to trigger memories, particularly emotional memories (Herz, in press), than other sensory systems. The olfactory system is tightly linked to memory centers in the brain, with only three synapses separating the olfactory nerve from the hippocampus (Schwerdtfeger, Buhl, & Germroth, 1990). Moreover, memories that are triggered by odors tend to be more emotional than memories triggered without olfactory cues (Herz & Cupchik, 1995). Demand on nonautomatic processing resources may be even greater when an odor triggers a fully elaborated representation in memory. Presumably, such a memory would leave even fewer resources available for processing the urge.

It has been suggested that nonautomatic processing resources reside in several different cognitive systems or “reservoirs” (Wickens, 1984). Cognitive processes drawing from these distinct domains may not compete for the same limited-capacity resources. Accordingly, performances on two cognitive tasks that demand processing resources from separate domains would be less likely to interfere with each other than if the two tasks required the same type of processing. If olfaction and craving stimuli elicit similar emotional processing, then odors may be especially effective in interfering with (i.e., distracting) craving experiences by competing for the same pool of limited-capacity processing resources.

Although we are unaware of studies testing whether odors can reduce craving,[1] a number of studies have demonstrated that olfactory stimuli associated with drug use can increase urge. For example, it has been shown that inpatient alcoholics who sniff an alcoholic drink

[1]Rose and colleagues (e.g., Rose & Behm, 1994) have investigated the effects of inhaling vapors or aerosols containing ingredients such as black pepper extract or citric acid on craving. These studies, however, appear to focus on respiratory tract sensations rather than on olfaction per se.

increase their urge to drink (Monti et al., 1987; Sayette et al., 1994). Towner, Ybasco, Rezai, Rose, and Contrada (1991) found that smoking cue exposure manipulations that included olfactory cues (a lit cigarette) were more likely to increase urge than a manipulation that did not include smell cues. Likewise, many participants in our previous smoking cue reactivity studies have noted during debriefing that the smell of the lit cigarette contributed to their urge. These observations suggest that olfactory stimuli play an important role in the elicitation of urges, and it remains to be seen whether they also are effective in attenuating urge.

According to Baker et al.’s (1987) two-affect theory of craving, urges activate either negative-affect networks (e.g., during drug withdrawal) or positive-affect networks (e.g., during nonwithdrawal states). Because these two systems are purported to be mutually inhibitory, the extent to which one system is activated should inhibit activation of the other. The valence of an emotional response (i.e., an hedonic evaluation) to a stimulus therefore becomes an important determinant of craving. Whereas stress manipulations increase withdrawal-based negative-affect urges, they do not strengthen the urges of non-withdrawn smokers (Zinser, Baker, Sherman, & Cannon, 1992). Unpleasant odors presented to nicotine-deprived smokers therefore may be less likely than pleasant odors to reduce urges. One aim of the present study was to assess the relationship between self-reported urge to smoke and hedonic evaluations of odors.

One increasingly popular approach to assessing emotion involves the coding of facial expression (Ekman & Rosenberg, 1997; Izard, 1979). Facial coding can be conducted unobtrusively and can capture affect in real time (Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Ekman, Davidson, & Friesen, 1990; Ekman, Friesen, & Ancoli, 1980). The most comprehensive system for assessing facial expression is the Facial Action Coding System (FACS; Ekman & Friesen, 1978a, 1978b). FACS is an anatomically based system derived from thousands of different expressions decomposed into 44 action units (AUs) that can be combined to describe all possible visible movements of the face. FACS is reliable and provides accurate and specific information across a range of emotional experiences (Ekman et al., 1980; Ekman, Friesen, & O’Sullivan, 1988; Ekman & Rosenberg, 1997). Although facial expressions can serve a variety of purposes, it is clear that many are related to subjective experience, with particular AUs differentially reflecting affective valence (Ekman & Friesen, 1982; Ekman & Rosenberg, 1997; Smith, 1989). (The terms *positive AUs* and *negative AUs* are used herein to refer to AUs related to affective valence.) The present study used FACS to assess participants’ responses to eight odors.

In summary, the present study evaluated the premise that administration of odors that produce hedonic evaluations can reduce reported urge to smoke. Smokers deprived of nicotine for a minimum of 6 hr, initially rated the pleasantness of eight odors. Participants next were exposed to smoking cues, a manipulation that, in conjunction with deprivation, has been found to effectively increase self-reported urge (Carter & Tiffany, in press; Rohsenow et al., 1990–1991; Sayette & Hufford, 1994). One of the previously administered odors (the odor previously rated as most pleasant, least pleasant, or a neutral control) then was administered to smokers during this high craving state, and reported urge was again assessed.

We expected that hedonically evaluative odors would reduce reported urge more than a neutral odor stimulus because the former stimuli would consume some of the limited-capacity resources required for urge processing, presumably resulting in a decrease in reported urge. Moreover, it was predicted that odors that triggered distinct emotional memories would be especially effective in reducing reported urge. Finally, this study tested (a) whether negatively evaluated odors would be less effective than those that were not negatively evaluated in reducing withdrawal-based urges and (b) whether odors positively evaluated would be more effective than those not positively evaluated in reducing these withdrawal-based urges.

Method

Participants

Sixty-three continuing smokers between 18 and 35 years of age were recruited from newspaper advertisements. Five participants were excluded from the study as a result of an inability to understand the measures (*n* = 3) or an inability to identify sample odors in a forced-choice recognition task (*n* = 2; Herz & Cupchik, 1992; see later description). Therefore, the present study consisted of 58 smokers (28 women and 30 men). Fifty of the participants were European American, 6 were African American, and 2 were Asian American. Individuals received $25 for their participation in the study. Informed consent was obtained from all participants. Participants' mean age was 22.7 years (*SD* = 3.2). They smoked an average of 18.4 cigarettes per day (*SD* = 2.7) and had smoked for an average of 5.6 years (*SD* = 3.3). Participants did not smoke for at least 6 hr before the experiment, which was assessed through a carbon monoxide (CO) breath sample (Vitalograph, Inc.) and self-report of compliance.

Measures

Participants completed a questionnaire battery. The set of forms included a multiple-choice odor descriptor test (Herz & Cupchik, 1992) that assessed deficits in olfactory ability; a smoking demographics form; the Affect Intensity Measure (AIM), which was designed to assess emotional reactivity (Larsen & Diener, 1987) and has been associated with smoking urges (Zinser et al., 1992); the Marlowe-Crowne Social-Desirability Scale (MCSD; Crowne & Marlowe, 1964), a measure of response bias that has predicted reports of affective states (e.g., Sayette, Contrada, & Wilson, 1990); and the Social Thoughts Scale, a collection of items that included one assessing current urge. This last questionnaire was composed of nine items, scaled from 0 to 100, sampling a range of behaviors and experiences pertaining to odors (e.g., How much do you like the smell of colognes?), alcohol (e.g., How much do you enjoy wine?), cigarettes (e.g., How much do you enjoy nonfiltered cigarettes?), and general mood state (How do you feel right now? [0 = *extremely bad*, 100 = *extremely good*). Two of the items assessed urges, one for alcohol and one to smoke a cigarette. Only the items regarding smoking urge and general mood state, which were both embedded in the middle of the form, were of interest. The goal of the remaining seven items was to obfuscate the purpose of the study (to examine craving) and thus potentially limit effects of demand characteristics.

After initial exposure to each of the eight odors, participants completed an aroma questionnaire adapted from items used by Herz and Cupchik (1995). This questionnaire measured self-reported odor responses on pleasantness, relaxation, intensity, and familiarity. Responses were rated from −5 (e.g., very unpleasant) to 5 (e.g., very pleasant), with 0 labeled as "neutral."[2]

During exposure to the eight odors, participants' facial expressions were videotaped for subsequent facial coding analyses.[3] Facial coding was conducted by a certified FACS coder (Dominic J. Parrott), and reliabilities were established via comparison coding by a second

[2]On the basis of our pilot test, a 0–7 scale was changed to an 11-point scale ranging from −5 to 5. This change occurred because a number of participants in the pilot study misused the 0–7 scale when rating the water stimulus. These participants rated the pleasantness of the water as 0 but, during debriefing, indicated that they found the odor to be neutral rather than "very unpleasant."

FACS certified coder who scored 2 of the 8 odor administration intervals (chosen at random) for all participants. In total, the second coder scored 116 intervals, or 25% of the coding in the entire study. Interrater reliabilities, calculated with Cohen's kappa, were .92 and .77 for negative and positive AUs, respectively.

During and after smoking cue exposure, self-reported urge was recorded. Participants were instructed to rate their current urge to smoke on a scale of 0–100 (0 = *no urge at all*, 100 = *the strongest urge I've ever felt*).

After cue exposure, an aroma-urge scale was administered. This instrument contained the five items from the aroma questionnaire. In addition, it assessed how the participant currently felt, ascertained whether or not a memory was evoked by the odor, and asked for a description of the memory (these last two items were adapted from Herz & Cupchik, 1992).

Odor Stimuli

Because individuals can experience different emotional reactions to the same odors (Engen, 1982), participants sampled multiple odors to determine which were perceived as most pleasant and unpleasant. Before initiation of this study, a pilot study tested the effectiveness of our odor manipulation. As a means of reducing potential confounding influences derived from sensory input other than olfaction, odor samples were presented to participants in opaque brown (sanitized cooking extract) bottles approximately 7.6 cm (3 in.) in height. There were no visual cues by which the odors could be distinguished. For later reference, jar bottoms were labeled with an identification number (Herz & Cupchik, 1992). Four of the odors, *coconut, banana, peppermint*, and *lemon*, were cooking extract oils (McCormick and Company, Inc., Hunt Valley, MD). The remaining four odors were produced in the following manner. A *Vicks* odor consisted of one-half liquid Vicks Vapo-Steam (Procter & Gamble, Cincinnati, OH) and one-half distilled water. A *vinegar* odor consisted of three-quarters Heinz distilled white vinegar (H.J. Heinz, Pittsburgh, PA) and one-quarter distilled water. A *floral* odor consisted of White Rain Orchid Petals shampoo (Gillette Company, Boston, MA), and the *neutral* odor was distilled water. General odor categories were adapted from those used in previous research (e.g., Herz & Cupchik, 1992, 1995).

In the pilot study, 41 smokers were asked to smell and rate the pleasantness of these different odors on an 8-point scale ranging from 0 (*not at all*) to 7 (*extremely*). Data revealed that the selected odors produced a wide range of pleasantness ratings. Of the 41 participants, 39 (95%) rated at least one of the eight odors as unpleasant (0–2) and one odor as pleasant (5–7). These odors were used in the present study.

Procedure

Participants were randomly assigned to one of three conditions that differed in regard to the odor administered after smoking cue exposure. Participants in Group 1 (*control* condition) sniffed distilled water, participants in Group 2 (*pleasant* condition) sniffed the odor that they previously had rated on the aroma questionnaire as being most pleasant, and participants in Group 3 (*unpleasant* condition) sniffed the odor that they previously had rated on the aroma

[3]The following AUs and AU configurations were coded as positive: 12 and 6 + 12, both of which could be accompanied by 1 + 2, 25, or 26 (Ekman et al., 1980, 1988, 1990; Sayette & Hufford, 1995; Smith, 1989). For expressions to be considered positive, AU 12 (the contraction of zygomatic major, in which the corners of the lips are raised) had to receive a minimum intensity rating of "b" using Friesen and Ekman's (1992) updated "a" to "e" intensity scale. Negative emotional expressions were defined by the absence of AU 12 and the presence of at least one of the following AUs: 9 (nose wrinkle), 10 (upper lip raise), unilateral 14 (dimpler), 15 (lip corner depress), 20 (lip stretch), and 1 + 4 (pulling the medial portion of the eyebrows upward and together). These AUs are thought to appear during the expression of negative emotion (Ekman & Friesen, 1982, 1986; Ekman et al., 1980; Gosselin, Kirouac, & Dore, 1995; Rozin, Lowery, & Ebert, 1994; Soussignan & Schaal, 1996; Vrana, 1993). For negative AUs, a minimum intensity rating of "b" was required to meet criteria (Friesen & Ekman, 1992).

questionnaire as being most unpleasant. The control condition was included for two reasons. First, it permitted evaluation of a potential confound in which decreases in reported urge during postexposure odor administration could be attributed to the act of sniffing per se. Second, this group provided a control for the effect of time on urges to smoke. That is, once the smoking cue exposure manipulation was completed, there might be a tendency for urges to drop slightly from peak levels.

All participants were contacted 1 day before the study began and reminded not to smoke on the day of the study. They were told that CO levels would be measured to ensure compliance. As a means of avoiding contamination during odor exposure, they were instructed not to wear cologne or perfume. They were also asked to bring to the laboratory their regular brand of cigarettes.

Participants entered the laboratory between noon and 2 p.m. and presented their cigarettes to the experimenter, who returned them after the session. A CO test was performed to check smoking abstinence. Participants were informed that the purpose of the study was to examine the sense of smell in smokers and that information on smoking behavior would be collected. At no point was smoking urge mentioned.

After consent had been obtained, participants were administered the multiple-choice odor descriptor test. This test was used to exclude anyone who had a deficient sense of smell (Herz & Cupchik, 1992). Participants were asked to smell five cooking extract oils (orange, pineapple, strawberry, root beer, and almond [McCormick and Company, Inc., Hunt Valley, MD]) and to check the odor descriptor corresponding to their smell experience. Four descriptors were included for each stimulus presentation. The selection of odor descriptors was designed to make the correct decision fairly easy. (Only 2 of the participants in the entire sample were excluded for mislabeling more than one odor.) Participants next completed an initial battery of questionnaires consisting of the smoking demographics form, the AIM, the MCSD, and the Social Thoughts Scale.

After completion of the initial questionnaire packet, participants were administered the eight odors. Order of odor administration was randomized. Odor sampling was conducted in a room with a ceiling fan to provide adequate ventilation. Participants sat in a comfortable chair behind a table. A video camera (Panasonic S-VHS AG-450) and an intercom were used in establishing communication between the experimental and control rooms. The door to the experimental room was kept closed during testing. The experimenter entered this room holding a bottle containing one of the odors and a copy of the aroma questionnaire. As a means of accounting for individual differences in odor sniffing, odor habituation, and response speed, the procedure was self-paced, and participants took short breaks (about 40 s) between each odor administration (Herz & Cupchik, 1992). Via intercom, the experimenter instructed participants to unscrew the cap on the bottle and smell its contents. During this time, participants were video recorded with a Panasonic 450 Super-VHS recorder and Super-VHS videotape. (Videos subsequently were time coded with a Horati AG-50 VITC translator to permit frame-by-frame analysis.)

After odor sniffing, which lasted approximately 6 s, participants were instructed to put down the bottle and to complete the aroma questionnaire. This procedure was repeated for each of the eight odors. After the final odor, a tray holding an inverted plastic bowl was placed on the participants' desk. This bowl covered cigarettes, an ashtray, and a lighter. From the control room, the experimenter instructed participants to remove the cover, light the cigarette without putting it in their mouths, and stare at it for 10s. After 10s, participants verbally rated their urge to smoke on the 0–100 scale.

Participants were next instructed to extinguish the cigarette. The tray then was removed from the room, and a bottle containing the odor corresponding to the participant's condition was placed on the desk. Forty-five seconds after extinguishing the cigarette, participants were asked to sniff this odor. After 3 s of sniffing the odor, participants again were asked to provide a verbal report of their urge to smoke. After the urge report, they completed the aroma-urge scale. Finally, participants were debriefed and compensated before leaving the laboratory.

Results

Baseline

As a means of ensuring equivalent groups, a series of analyses was conducted to determine whether the three groups were similar across key measures. Participants' scores on the AIM and MCSD were compared and revealed no group (control, pleasant, and unpleasant) differences (*p*s > .10). In addition, there were no differences among the groups in age, gender, race, and cigarettes smoked per day (all *p*s > .32). The three experimental groups were also compared to ensure similar reported urges at baseline and after cue exposure. Across groups, participants' baseline and postexposure urges did not differ. Nor were there group differences in the increase in reported urge from baseline to cue exposure (all *F*s < 0.3).

Manipulation Check

To ensure compliance with deprivation instructions, we asked participants, at the beginning of the session, when they had last smoked. In addition, CO levels were measured, with participants producing a mean CO level of 9.6 ppm ($SD = 3.9$). Individuals who either reported smoking within 6 hr of the session or produced a CO reading inconsistent with abstinence were not permitted to participate in the session and were asked to reschedule ($n = 3$).[4] To allow evaluation of the urge-reducing effects of the odors, it was crucial that the smoking cue exposure procedure elicit an urge. A repeated measures analysis of variance (ANOVA) revealed a significant increase in reported urge ($M = 72$) from baseline to cue exposure ($M = 83$), $F(1, 56) = 23.7$, $p < .0001$, providing support for the efficacy of our urge induction (see Table 1).

By design, the three groups were expected to differ on odor pleasantness ratings. Pleasantness ratings both before and after the exposure period for the particular odor administered after cue exposure were examined. At preexposure, the mean ratings on the −5 to 5 scale were 0.14 ($SD = 0.65$) for participants sniffing water, 4.22 ($SD = 0.81$) for participants sniffing the pleasant odor, and −3.84 ($SD = 0.81$) for participants sniffing the unpleasant odor. At postexposure, the corresponding ratings were −0.10 ($SD = 1.70$), 2.77 ($SD = 1.77$), and −2.63 ($SD = 2.27$). A pair of ANOVAs revealed a main effect for group at both time periods (*p*s < .0001). Follow-up tests indicated that the three experimental groups differed significantly from each other. Moreover, at both time periods, *t* tests revealed that pleasantness ratings differed from zero in the pleasant (*p*s < .0001) and unpleasant (*p*s < .0001) conditions but not in the water condition (*p*s > .80). Thus, participants sniffing water reported smelling a neutral stimulus, participants sniffing a pleasant odor reported sniffing a pleasant stimulus, and participants sniffing an unpleasant odor reported smelling an unpleasant stimulus.

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[4]Because CO levels are in part affected by smoking status, it is difficult to determine a single cutoff level to ensure a 6-hr deprivation. Zinser et al. (1992) used a CO level under 11 ppm to confirm a 24-hr deprivation period. To assess whether our 6-hr deprivation instructions were followed, we created two cutoffs. For those smoking more than 17 cigarettes per day, the cutoff was 20 ppm. For the remaining, lighter smokers, the cutoff was lowered to 15 ppm. (All but 5 of the participants in the sample had CO levels below 15 ppm.)

The three groups also differed on the other aroma questionnaire items. Specifically, significant group differences at preexposure (for the particular odor that was subsequently sniffed after cue exposure) emerged for intensity, $F(2, 55) = 34.8$, $p < .0001$; relaxation, $F(2, 55) = 163.6$, $p < .0001$; and familiarity, $F(2, 54) = 22.7$, $p < .0001$. Values were highest in Group 2 and lowest in Group 3 for relaxation and highest in Group 2 and lowest in Group 1 for intensity and familiarity. After cue exposure, significant group differences also appeared for intensity, $F(2, 55) = 15.2$, $p < .0001$; relaxation, $F(2, 55) = 29.4$, $p < .0001$; and familiarity, $F(2, 55) = 10.1$, $p < .0002$. Again, values were highest in Group 2 and lowest in Group 3 for relaxation and highest in Group 2 and lowest in Group 1 for intensity and familiarity.

A set of correlational analyses was computed to examine potential relations among the aroma questionnaire items for the odor that was presented after cue exposure. Pleasantness ratings were highly correlated with relaxation[5] ($r = .94$, $p < .0001$) and were associated with familiarity as well ($r = .33$, $p < .02$); however, they were not correlated with intensity ($r = .04$). Familiarity was correlated with intensity ($r = .59$, $p < .0001$) and relaxation ($r = .32$, $p < .02$). Relaxation and intensity ratings were uncorrelated ($r = .00$).

Effect of Odor on Reported Urge

To examine the effects of sniffing a hedonically evaluative odor on urge report, we computed a 2 (group: hedonically evaluative odor vs. neutral odor) × 2 (time) ANOVA with urge as the dependent variable and time before and after odor administration as a within-subject variable. There was no main effect for group ($p > .12$). A main effect of time indicated that, across groups, participants reported a drop in urge between the peak urge period and the subsequent odor administration, $F(1, 56) = 47.2$, $p < .0001$. Of most relevance to the present study was the significant Group × Time interaction, $F(1, 56) = 4.4$, $p < .05$. Participants who were presented with either their most or least pleasant odor reported a 21-point drop in urge (from 82 to 61), whereas those sniffing water dropped 11 points (from 85 to 74; see Table 1).

Two types of analyses were conducted to determine whether hedonic tone of the odor (pleasant or unpleasant) influenced urge. The first, based on pleasantness ratings, compared participants in the two nonneutral conditions. A 2 (group) × 2 (time) repeated measures ANOVA with urge as the dependent variable revealed that participants sniffing either their most pleasant or most unpleasant odor did not differ in reductions in reported urge ($F < 1$).

A second approach to determining the effect of emotional valence on urge reduction involved the FACS data. Facial expressions displayed while participants initially sniffed the odor that they subsequently received after the smoking cue exposure were examined. Twenty-six percent of participants who sniffed their most pleasant odor or a neutral odor expressed a negative AU. Forty-two percent of participants who sniffed their least pleasant odor expressed a negative AU, and this rate increased to 79% when a more liberal interpretation (described subsequently) of negative AUs was used.

A correlational analysis was computed to determine the relationship between the occurrence of negative AUs among Group 3 participants and reduction in reported urge. Although the size of this relationship ($r = -.27$, $p < .26$) can be characterized as a medium effect (Cohen, 1992), it did not reach significance as a result of the small sample size (Group 3: $n = 19$). To

[5]From the perspective of Baker et al. (1987), a withdrawal-based negative-affect urge should be inhibited by manipulations that are incompatible with negative affect. It was unclear whether odors that produced high ratings for pleasantness or for relaxation would be most suitable for reducing urge. In the present study, however, participants provided virtually identical responses to the pleasantness and relaxation items. Thus, our groups are distinguished on both pleasantness and relaxation dimensions.

further test for this possible relationship, we reanalyzed the data using a more liberal interpretation of negative AUs.[6] The recomputed correlations between negative AUs and urge reduction revealed an inverse correlation ($r = -.47$, $p < .05$). A similar association was found when occurrence of negative AUs was dichotomized (i.e., participants who either did or did not express a negative AU; $r = -.46$, $p < .05$). Participants who expressed negative AUs dropped in urge by 18 points after postexposure odor administration, whereas those who did not express a negative-affect-related AU dropped by 39 points.

In contrast to the negative AU data, positive AUs rarely occurred in our sample. Among the 39 participants across the two nonneutral odor conditions, only 10 positive AUs were observed, with only 4 of the AUs provided by participants in Group 2. Still, a positive correlation between occurrence of a positive AU and urge reduction approached significance ($r = .32$, $p < .06$). The more someone smelling an odor other than water expressed a positive AU, the more his or her reported urge to smoke dropped.

It is possible that the association between AUs and urge reduction was a function of individual differences in emotional expressivity. In other words, people who are most expressive in general might be most likely to report a drop in urge. One approach to testing this possibility is to examine participants' general expressivity, as measured by AUs evinced during the sampling of all eight odors. The correlation between total number of positive and negative AUs evinced across all eight odors sampled and drop in reported urge, however, was not significant ($r = -.10$, $p > .43$). The data also were examined separately for total negative AUs and positive AUs across the eight odors. Correlations between urge reduction and total negative AUs ($r = -.21$, $p < .11$) and total positive AUs ($r = .23$, $p < .09$), although failing to reach significance, suggest that overall negative expressivity is inversely correlated with urge reduction, whereas overall positive expressivity is positively related to urge reduction.

Median splits on the individual aroma questionnaire items (intensity, familiarity, relaxation, and pleasantness) were used to examine whether high ratings would be associated with greater urge reduction than low ratings after the postexposure odor administration. Participants with high intensity ratings reported a greater drop in urge ($M = 22.5$) than did those with low intensity ratings ($M = 11.0$), $F(1, 56) = 7.l$, $p < .01$. Similar findings emerged for familiarity, with those rating the odor as more familiar revealing a greater drop in reported urge ($M = 23.6$) than those with low scores ($M = 10.7$), $F(1, 56) = 9.2$, $p < .004$. In addition, correlational analyses revealed that drop in urge was associated with intensity ($r = .20$) and familiarity ($r = .21$) ratings, although neither correlation reached statistical significance at the .05 level. Analyses for relaxation and pleasantness after median splits of the data did not reveal significant effects (ps > .10).

To examine the effect of odor-evoked memories on craving, we compared urge reports of participants reporting memories with urge reports of those not reporting memories. Across the three groups, 28% ($n = 16$) of the participants reported a memory associated with the odor they smelled after cue exposure. A 2 (memory) × 2 (time) ANOVA with urge as the dependent variable revealed that, although in the expected direction, the increased drop in reported urge among those sniffing a memory-inducing odor did not reach significance ($p < .13$).

[6]These additional AUs sometimes have been interpreted as reflecting negative affect. Specifically, the following AUs were also included as negative AUs: AU 4 (brow lowerer; Cacioppo, Petty, Losch, & Kim, 1986; Vrana, 1993), AU 14 (dimpler; Ekman, 1992; Ekman & Friesen, 1982), AU 17 (chin raise; Gosselin et al., 1995; Soussignan & Schaal, 1996), AU 23 (lip tightener; Gosselin et al., 1995; Soussignan & Schaal, 1996), and AU 24 (lip press; Soussignan & Schaal, 1996). Expressions involving these AUs were considered displays of negative affect unless they also included AU 12, which suggests an expression associated with both positive and negative emotion, or an emotion blend (see Ekman, 1992, p. 155).

Correlational analyses were computed to examine potential associations between AIM and MCSD scores and urge reduction. The relationship between drop in reported urge after the postexposure odor presentation and AIM score failed to reach significance ($r = .20$, $p < .13$). Nor was there a significant relation between drop in reported urge and MCSD score ($r = .05$, $p > .7$). The correlation between MCSD score and reported urge after cue exposure approached significance ($r = -.25$, $p < .07$), indicating that higher scores on the MCSD were linked to lower urge reports during smoking cue exposure.

Discussion

This study provided an initial examination of the urge-reducing effects of olfactory stimuli. The major finding was that sniffing hedonically evaluative (pleasant and unpleasant) odors reduced reported urge to smoke. This drop in urge report cannot be attributed simply to the act of sniffing, because the effect was less pronounced for the group of participants who sniffed a neutral odor. Data indicate that pleasantness ratings were less critical than intensity or familiarity for predicting urge reduction. Odors rated as most intense and familiar would appear to attract the most nonautomatic processing resources. The association between scores on these latter two items and drop in reported urge is consistent with the view that urges draw on nonautomatic processing resources (Sayette & Hufford, 1994; Tiffany, 1990) and that stimuli (odors) that also demand these limited-capacity processing resources (Engen, 1982, 1991) will interfere with, or inhibit, urge responding. From an associative learning perspective, these data can be viewed as suggesting that the odors, which were dissimilar to the smoking cues, may have disrupted the processing of preparatory responses to smoking cues.[7]

Data pertinent to the hypothesis stemming from Baker et al.’s (1987) theory that participants’ withdrawal-based urges would be reduced by positive-affect-related olfactory stimuli more than negative-affect-related stimuli or neutral stimuli were mixed. On one hand, administration of odors rated by participants as either pleasant or unpleasant (or relaxed–unrelaxed) produced similar reductions in participants’ urge reports. On the other hand, facial expressions associated with negative affect and with positive affect provided tentative support for the theory. Participants who were exposed to an odor that had elicited negative AUs reported a smaller drop in urge than those who did not express negative AUs. In contrast, those participants who sniffed a nonneutral odor that had elicited positive AUs reported a larger drop in urge than those not evincing positive AUs. If positive AUs were manifested, then the odor was especially effective in reducing urges, even when participants rated the odor as being unpleasant. From the perspective of the two-affect theory of urges, to the extent that facial expression reflects affective experience (Ekman & Rosenberg, 1997), odors that produced a positive affective state inhibited negative-affect withdrawal-based urges, whereas odors eliciting a negative affective state were relatively ineffective in reducing these urges.

This interpretation must be tempered by the additional finding that individuals who expressed more positive AUs across the entire sample of odors tended to reveal the largest urge reduction. Although not significant, the small-to-medium inverse relationship between negative AUs and drop in urge suggests that individuals who displayed more negative AUs across the eight odors tended to report the smallest decreases in urge. These correlations support a person-level interpretation of the data, namely that “positive facial reactors” tended to be most sensitive to the urge-reducing effects of an odor and “negative affect reactors” appeared to be relatively insensitive to the urge-reducing effects of an odor. Future

[7]We acknowledge an anonymous reviewer for this observation.

research is needed to disentangle person-related and situation-related factors that account for the urge-reducing effects of odors.

In summary, the facial coding data provide some support for Baker et al.'s (1987) model, whereas the self-reported pleasantness data do not support the model. Perhaps the findings would have been more supportive of this model had our induction of negative-affect withdrawal-based urge been strengthened by using smokers who were more highly dependent on nicotine. None of the participants in this sample smoked more than 20 cigarettes per day. Also, more potent olfactory stimuli might have enhanced the urge-reducing effects. The odors used in this study elicited mildly to moderately pleasant and unpleasant ratings during postexposure sniffing. Future research involving heavier smokers and more potent odors would probably provide a better test of the theory.

Although odors that evoked memories did not significantly reduce participants' reported urge to smoke, a study with more power may have revealed this small effect to be significant. The current study assigned group membership according to rated pleasantness of odors rather than reported presence of a memory, and future research that assigns participants to groups according to whether memories were triggered would be better positioned to examine this issue.

In addition to replicating the finding that odors are effective in reducing urges, future research is needed to determine how durable the effect is and whether odors can reliably reduce urges over multiple craving episodes. It is notable here that odors have been found to be especially resistant to retroactive interference (Engen, Gillmore, & Mair, 1991). That is, once an odor becomes linked to a particular memory or emotional response, the association should persist.

Although we believe that the olfactory system is especially well suited to influence cravings, the current data do not address whether odors reduce urge more effectively than distractors relying on other sensory systems. Research involving other sensory modalities (e.g., tactile, visual, and auditory) can provide important information about the relative advantage of odors for reducing urges. From a methodological perspective, the procedure used in the present investigation may prove valuable for testing a variety of manipulations—pharmacologic and nonpharmacologic—designed to reduce drug craving.

Acknowledgments

This research was supported by National Institute on Drug Abuse Grant RO1 DA10605. This article is based in part on a University of Pittsburgh Honors College undergraduate thesis conducted by Dominic J. Parrott under the direction of Michael A. Sayette. Additional support for this project was provided by the University of Pittsburgh Honors College, the University of Pittsburgh Cancer Institute, and the Departments of Psychology and Psychiatry at the University of Pittsburgh.

We are grateful to Rachel Herz, Carey Ryan, Jonathan Schooler, David Allbritton, and Saul Shiffman for their helpful comments. Rachel Herz also provided valuable methodological suggestions regarding odor administration. We express our appreciation to Joan Wertz for coding a portion of the videotapes to establish reliability. We also thank Michael Perrott and the staff of the Alcohol and Smoking Research Laboratory for their assistance.

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Table 1

Mean Urge Ratings (0–100 Scale)

	Baseline		Post–smoking cue exposure		Postcue odor administration	
Group	***M***	***SD***	***M***	***SD***	***M***	***SD***
Control odor	74.5	21	84.9	14	73.9	15
Pleasant odor	69.6	21	82.7	12	63.8	24
Unpleasant odor	72.8	22	81.5	21	59.2	29