Published in final edited form as:

Exp Clin Psychopharmacol. 2009 April ; 17(2): 70–77. doi:10.1037/a0015617.

Evaluation of Cue Reactivity in the Natural Environment of Smokers Using Ecological Momentary Assessment

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Abstract

The cue reactivity (CR) paradigm has been used extensively to assess smokers' craving responses to smoking-related stimuli. To date, nearly all CR research has been conducted in laboratory settings; there has been no experimental research of the impact of smoking cues on smokers' craving in their natural environment. The present research combined CR procedures with ecological momentary assessment (CREMA); the latter has been used successfully to monitor a variety of behaviors in real time using handheld personal digital assistants (PDAs). Participants were 43 daily, heavy smokers ages 18 and older. PDAs were sent home with participants over an 8-day CREMA period. PDAs were used to record each cigarette smoked and to administer daily CR trials. CR stimuli consisted of photographs and imagery scripts that were either smoking related or neutral. CR trials were also administered in the laboratory, by means of PDAs, at the beginning and end of the CREMA period. Results from CREMA trials indicated that smoking-related cues significantly increased craving, compared with neutral cues for both photographs and imagery scripts. This pattern was also observed in the laboratory-based trials. Findings indicate that CREMA is well suited for the investigation of cue-elicited craving under real-world conditions.

Keywords

cigarette; craving; cue reactivity; ecological momentary assessment

The cue reactivity (CR) paradigm is an increasingly popular tool used to study addictive processes (Drummond, Tiffany, Glautier, & Remington, 1995). This paradigm involves the presentation of drug-related stimuli (e.g., a pack of cigarettes) to individuals with a history of drug use and monitoring their reactions (e.g., craving responses). The assumption underlying this paradigm is that the presentation of drug-related stimuli activates motivational processes that are central to the maintenance of drug use (Tiffany, Warthen, & Goedeker, 2008). Researchers have successfully used the CR paradigm to manipulate

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cravings for alcohol, cocaine, heroin, marijuana, and tobacco (Bauer & Kranzler, 1994; Carter & Tiffany, 1999; Conklin & Tiffany, 2001; Drobles & Tiffany, 1997; Sell et al., 2000; Singleton, Trotman, & Zavahir, Taylor, & Heishman, 2002; Sinha et al., 2003; Streeter et al., 2002; Stritzke, Breiner, Curtin, & Lang, 2004; Weinstein, Wilson, & Bailey, Myles, & Nutt, 1997). Carter and Tiffany's (1999) multidrug meta-analysis of over 40 CR studies confirmed that drug-related stimuli reliably invoke robust increases in craving and significant physiological responses among addicts.

To the best of our knowledge, CR research conducted to date has taken place solely in the laboratory. Inferences drawn from this research may be limited, as patterns of CR are likely to be affected by real-world factors that are difficult to simulate in the laboratory, such as drug-use behavior, drug availability, and various social and contextual influences. The identification of such variables would likely aid in our understanding of CR and may help clarify some of the inconsistencies found in the literature. For example, studies examining the efficacy of cue exposure treatment, which seeks to extinguish the addict's responsiveness to relevant drug cues in the hopes of preventing cue-driven drug use (Drummond et al., 1995), have yielded inconsistent results (Conklin & Tiffany, 2002). After their examination of this research, Conklin and Tiffany (2002) stressed the need to identify the most relevant cues, environments, and/or contextual factors that serve to modulate craving and influence drug use. The primary goal of this study was to develop methods to study CR in the natural environment.

To achieve our objectives, we created the CR ecological momentary assessment (EMA) procedure, or CREMA. EMA procedures involve giving participants personal digital assistant (PDA) computers to complete real-time assessments when target events take place (e.g., after smoking a cigarette) or when the PDA signals the start of an assessment (Stone & Shiffman, 1994). With CREMA, this technology has been adapted to allow the researcher to administer experimental, CR trials in natural settings and to gather real-time data such as craving levels, mood ratings, drug use behavior, temporal data, and contextual variables. Our ecological investigation of CR among smokers was well served by EMA technology. EMA procedures were specifically developed to track dynamic and rapidly shifting phenomena as they occur in real time (Stone & Shiffman, 1992, 1994), and EMA-based studies have successfully gathered real-world information on smoking behaviors and other smoking-related variables (e.g., Shiffman et al., 1997; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996; Shiffman, Paty, Gwaltney, & Dang, 2004).

In the present research, smokers were exposed to either smoking-related or smoking-neutral stimuli in both the natural environment and in the laboratory. Furthermore, we had participants record each cigarette smoked during the study. This allowed us to examine CR patterns in naturalistic settings and determine whether these real-world patterns differed from those observed under laboratory conditions. The procedures also allowed us to investigate whether the latency to smoke was shorter after smoking-cue exposures, compared with neutral-cue exposures.

The CREMA procedure was also used to examine the impact of the mode of cue presentation on craving reactivity. Of the studies that have directly compared across modes,

some have found that in vivo cues caused stronger reactions than videotaped cues for smokers (Niaura et al., 1998; Shadel, Niaura, & Abrams, 2001); however, the effects of imagery cues on craving have been similar in magnitude to in vivo cues for both alcohol and tobacco (Burton & Tiffany, 1997; Drobles & Tiffany, 1997; Weinstein, Lingford-Hughes, Martinez-Raga, & Marshall, 1998).

We compared the impact of both photographic and imagery cues in this study. Imagery procedures have been used extensively in smoking CR research and have consistently produced significant increases in craving (Burton & Tiffany, 1997; Cepeda-Benito & Tiffany, 1996; Conklin, Tiffany, & Vrana, 2000; Drobles & Tiffany, 1997; Elash, Tiffany, & Vrana, 1995; Maude-Griffin & Tiffany, 1996; Tiffany & Drobles, 1990). In this research, we used imaginal cues developed by Tiffany and colleagues (e.g., Cepeda-Benito & Tiffany, 1996; Conklin et al., 2000; Elash et al., 1995). These cues were presented in the form of brief smoking-relevant or smoking-neutral narratives that participants read and then actively imagined. Visual cues have also been effective at producing increases in self-reported smoking craving in the laboratory (e.g., Carter & Tiffany, 1999; Conklin, 2006; McDonough & Warren, 2001; Stritzke et al., 2004; Townshend & Duka, 2001). For this research, we developed a set of smoking and nonsmoking photographs that were viewed by participants on the PDAs. We used these two types of cue presentation modes to (a) increase the sensitivity of the CR assessments to the extent that there are individual differences in reactivity to the different presentation modes, (b) increase the generalizability of results, and (c) aid in identifying potential moderating relationships between other variables and CR as a function of the cue presentation mode.

Method

Participants

A total of 43 smokers (24 men, 19 women) who ranged in age from 20 to 67 years ($M = 39.6$, $SD = 10.9$) were recruited through advertisements. Inclusion criteria included being at least 18 years old, smoking a minimum of 15 cigarettes per day for the past year, not seeking to quit or restrict smoking, and an expired-air carbon monoxide (CO) level of 10 ppm or greater. Participants smoked an average of 23 cigarettes per day ($SD = 8.37$) and had an average expired-air CO level of 31 ppm ($SD = 12.57$). All participants met criteria for nicotine dependence as assessed by the Nicotine Addiction Taxon Scale (Goedeker & Tiffany, 2008). Participants received \$1.50 for each CREMA session completed and received a \$20 bonus for completing at least 28 of 32 total sessions.

Apparatus

Expired-air CO levels were assessed with a Vitalograph CO monitor (Vitalograph Inc., Lenexa, KS). Handheld PDA computers (Palm Tungsten E2, Palm Inc., Sunnyvale, CA) were used for data collection and cue presentations. All PDA functions that were not relevant to the study were inaccessible to participants. Participants were prompted to begin CR trials through the audible and visual alarm systems built into the PDAs. Purdue Momentary Assessment Tool software (Weiss, Beal, Lucy, & MacDermid, 2004) was used to program the CREMA procedures.

Measures

Craving was assessed using a four-item subscale of the Questionnaire of Smoking Urges (QSU; Tiffany & Drobes, 1991). These questions were: “Nothing would be better than smoking a cigarette right now,” “All I want right now is a cigarette,” “I have an urge for a cigarette,” and “I crave a cigarette right now.” Previous research has found this craving scale to be highly reliable ($\alpha = 0.95$) and sensitive to changes in craving due to drug-cue manipulations (e.g., Carter & Tiffany, 2001). Single-item measures were used to assess positive mood (“I am happy, joyful, or pleased”), negative mood (“I am depressed, angry, worried, or frustrated”), and validity checks (distractibility and attentiveness during cue presentations). All questions used a 5-point rating scale ranging from *strong disagreement* (1) to *strong agreement* (5).

Stimulus Materials

Photographic stimuli—Smoking photographs (20 total) depicted people smoking and smoking-related stimuli including burning cigarettes and cigarette packs. Nonsmoking photographs (20 total) depicted everyday activities and objects such as a person talking on a phone or a vase with flowers. The two photographic sets were matched on the presence of human figures and the gender of the people presented.

Imagery stimuli—Imagery stimuli for individual trials were selected from sets of 20 sentences describing smoking relevant scenarios and sets of 20 neutral scenarios that were matched on content and similarity of wording across both sets. An example of a smoking-relevant scenario is, “I am with my friends and we are laughing and having a good time. I watch some of them lighting up, and I think about joining them, knowing that smoking would make things even better.” An example of a smoking-neutral scenario is, “I am swaying lightly on a front porch swing. I see the sun setting slowly before me. I reach down, take off my shoes, and sit back to enjoy the scenery.” These imagery sentences, which were evaluated in previous research, have been shown to significantly increase craving on smoking-relevant trials, compared with neutral trials (Cepeda-Benito & Tiffany, 1996; Conklin & Tiffany, 2001; Elash et al., 1995). (Copies of all stimuli are available from Stephen T. Tiffany.)

Procedures

CR trials—CR trials were administered on the PDAs for both the laboratory and the naturalistic (i.e., CREMA) portions of the study. Five cue orders were developed, with cues counterbalanced and randomized across participants. Each cue appeared only once across the entire study. Each cue presentation involved brief instructions, the presentation of a single cue, and questions about the participant’s experience during the cue exposure. Imagery trials included instructions to read the scenario until fully understood. When ready, participants were instructed to tap the PDA screen, close their eyes, and imagine the scenario as vividly as possible until hearing the alarm. On photographic trials, participants were instructed to look carefully at the photograph until the alarm was presented. When ready, participants tapped the screen and a full-screen photograph was displayed. All cue exposures lasted 11 s. Exposure ratings collected after each cue trial included the four-item

QSU, positive and negative mood, vividness of the imagined scenario or how carefully the participant looked at the photograph, and the level of distraction.

Training and laboratory sessions—The initial laboratory session began with participants reading and signing the consent form, followed by collection of a CO level and then completion of a number of assessments. These assessments included the QSU (Tiffany & Drobes, 1991), the Mood Form (Diener & Emmons, 1984), and the Smoking History Form (SHF). The SHF included questions about previous and current smoking behavior; previous quit attempts; demographics; and items assessing nicotine dependence criteria from the *Diagnostic and Statistical Manual of Mental Disorders* (text revision; American Psychiatric Association, 2000), the Fagerström Test for Nicotine Dependence (Heatherton, Kozlowski, Frecker, & Fagerström, 1991), and the Nicotine Addiction Taxon Scale (Goedeker & Tiffany, 2008). Participants were then trained to use the PDAs to complete CR trials and track cigarette smoking. At the end of the training session, participants completed eight consecutive PDA-administered CR trials. These laboratory trials contained two cues from each cue type (i.e., smoking photo, neutral photo, smoking imagery, and neutral imagery). At the end of the training session, participants were given a PDA to use during the following 8-day CREMA period, after which they returned to the laboratory, completed another set of eight CR trials, were debriefed, and given compensation.

CREMA sessions—Participants were instructed to keep their PDAs with them at all times during the 8-day CREMA period to record each cigarette smoked and to complete each CREMA session when signaled. CREMA sessions occurred four times per day within a 12-hr window that was set at the beginning of the experiment by the participant. Each 12-hr period was divided into four equal time blocks of 3 hr each, and the PDAs randomly selected one time within each block to administer the session. The minimum time between CREMA sessions was 30 min. The start of a CREMA session was prompted by the PDA's alarm and a flashing screen. If participants were smoking when the PDA alarm was presented, they were instructed to finish their cigarette before completing the exposure session. Each CREMA session began by asking participants to record any unreported smoking. This was followed by a reminder to not smoke during the CREMA session, an assessment of current craving with the four-item QSU, and ratings of current positive and negative mood. After this, we administered two consecutive CR trials of the same cue type (e.g., two trials of smoking photographs). This allowed us to examine the differential influence of the various cue types upon latency to smoke. During the CREMA portion of the study, each cue type was presented an equal number of times within every 2-day period, within each of the four time blocks across the 8 days, and across the entire 8-day CREMA period.

Smoking reports—Participants were asked to record each cigarette as soon as they were done smoking and to not smoke while reporting the cigarette. During the report, participants were asked to record the time they smoked the cigarette, their current level of craving, and their current level of positive and negative mood.

Data reduction and analysis—The CREMA pretrial measures were aggregated across completed trials to form average baseline ratings for craving and mood. The CREMA posttrial variables were also aggregated across completed trials to form average ratings for craving, mood, vividness (imagery trials), focus (photographic trials), and distraction. These variables were analyzed using a within-participant, repeated-measures analysis of variance (ANOVA), with two levels of stimulus type (smoking and neutral), two levels of stimulus mode (photo and imagery) and two levels of temporal presentation order (first cue and second cue). The laboratory-based CR measures were also subjected to a within-participant ANOVA with two levels of stimulus type (smoking and neutral), two levels of stimulus mode (photo and imagery) and two levels of laboratory presentation (pre-CREMA and post-CREMA). Finally, laboratory based CR measures were aggregated across the laboratory presentation factor and compared with the CREMA posttrial variables with an ANOVA with context (laboratory and CREMA) and stimulus type (smoking and neutral) as within-participant factors. This analysis was intended to compare the relative magnitude of cue-specific craving across laboratory and CREMA settings.

Results

CREMA Completion Rate

On average, participants completed 29.07 (range = 23 to 32) of the 32 possible CREMA trials (90.84%), with no substantive difference in completion rates across trial types.

CREMA Data

Craving—Figure 1 depicts the combined level of craving assessed before cue presentations along with craving ratings given after cue presentations. Postcue ratings are shown separately for photographic and imagery stimuli as a function of smoking and neutral content. (See Table 1 for a complete listing of the CREMA craving ratings). Analyses of the postcue craving ratings revealed that smoking stimuli produced significantly stronger craving than neutral stimuli, $F(1, 42) = 69.74, p < .001$, partial $\eta^2 = .571$. The mode of stimulus presentation also influenced craving levels, $F(1, 42) = 9.02, p < .05$, with this effect modulated by the smoking content of the stimuli as indicated by a significant Type $\times$ Mode interaction, $F(1, 42) = 4.37, p < .05$. Simple main effects tests revealed a significant mode effect on neutral trials, $F(1, 42) = 19.07, p < .001$; with craving ratings higher with imagery cues than with photographs. There was no significant mode effect on smoking trials ($F < 1$). Significant main effects were also found for stimulus order, $F(1, 42) = 4.37, p < .05$; as well as a significant Type $\times$ Order interaction, $F(1, 42) = 4.46, p < .05$. As indicated by follow-up analyses, craving ratings were significantly higher on the second trial relative to the first trial for smoking cues only, $F(1, 42) = 7.31, p < .01$.

An examination of craving ratings given before and after cue presentations showed that postcue craving ratings were significantly higher than precue ratings on smoking-relevant trials, $t_s(42) = -5.90, p_s < .0001$. In contrast, craving was lower on postcue ratings, compared with precue ratings, on the smoking-neutral trials, $t_s(42) = 6.23, p_s < .0001$.

Positive mood—Analyses of postcue positive mood ratings (see Table 1) revealed a significant effect for type, $F(1, 42) = 28.33, p < .0001$; mode, $F(1, 42) = 41.51, p < .0001$; and order, $F(1, 42) = 5.41, p < .05$. In general, participants rated their positive mood as lower on smoking trials than on neutral trials. Positive mood ratings were also lower on photo trials than imagery trials and lower on the first trial, compared with the second trial.

Negative mood—Analyses of postcue negative mood ratings (see Table 1) generated a significant effect for type, $F(1, 42) = 27.33, p < .0001$; mode, $F(1, 42) = 6.76, p < .05$; and a Type $\times$ Order interaction, $F(1, 42) = 7.28, p < .05$. In general, participants reported higher negative mood on smoking trials relative to neutral trials. They also reported higher negative mood with exposure to photographic stimuli relative to imagery stimuli.

Vividness and focus—Analyses of vividness ratings on imagery trials and focus ratings on photographic trials (see Table 1) showed no significant main or interactive effects.

Distraction—Participants rated themselves as significantly more distracted on imagery trials than on photographic trials, $F(1, 42) = 12.43, p < .001$; and more distracted on the first trial of the CREMA sessions than the second trial, $F(1, 42) = 4.80, p < .05$. (See Table 1 for means.)

Laboratory Data

Craving—Figure 2 shows craving ratings collected from the laboratory CR procedure as a function of stimulus type and mode across the pre-CREMA and post-CREMA sessions. Presentations of smoking stimuli produced significantly stronger craving than neutral stimuli, $F(1, 42) = 121.72, p < .0001$, partial $\eta^2 = .652$. In addition, craving levels were generally higher on imagery trials than on photographic trials, $F(1, 42) = 4.85, p < .05$. Furthermore, craving levels were higher on the pre-CREMA sessions than on the post-CREMA sessions, $F(1, 42) = 20.79, p < .0001$. Finally, there was a significant Type $\times$ Mode $\times$ Session interaction, $F(1, 42) = 4.92, p < .05$. We evaluated this interaction by conducting separate ANOVAs on the pre-CREMA and post-CREMA data. On the pre-CREMA session, there was a significant Type $\times$ Mode interaction, $F(1, 42) = 6.51, p < .05$; with the cue-specific craving effect stronger on photographic trials than on imagery trials. In contrast, there was no Type $\times$ Mode interaction on post-CREMA sessions ($F < 1$).

Positive and negative moods—Participants reported significantly higher positive mood on neutral trials relative to smoking trials, $F(1, 42) = 22.09, p < .0001$; and significantly higher positive mood on imagery trials, compared with photographic trials, $F(1, 42) = 42.03, p < .0001$. (See Table 2 for means.) Participants reported significantly higher negative mood on smoking trials relative to neutral trials, $F(1, 42) = 11.17, p < .01$. (See Table 2 for means.)

Vividness, focus, and distraction—On imagery trials, participants gave higher ratings of vividness on the post-CREMA session than on the pre-CREMA session, $F(1, 42) = 21.33, p < .0001$. Similarly, on photographic trials, participants provided higher ratings of focus on the post-CREMA session relative to the pre-CREMA session, $F(1, 42) = 8.62, p < .01$. (See

Table 2 for means.) Participants rated themselves as significantly more distracted on the pre-CREMA session than on the post-CREMA session, $F(1, 42) = 12.50, p < .01$. (See Table 2 for means.)

CREMA Versus Laboratory Craving Comparison

An examination of the craving generated in the CREMA compared with the laboratory portions of the study produced a main effect for context, $F(1, 42) = 11.29, p < .001$; and type, $F(1, 42) = 119.42, p < .0001$; but no significant Context $\times$ Type interaction. In light of the significant differences in general craving levels across the two laboratory sessions, we conducted separate comparisons of the CREMA trials with each laboratory session. Craving during the pre-CREMA laboratory session was significantly higher compared with CREMA trials, $F(1, 42) = 19.28, p < .001$. There was no significant difference for craving on CREMA trials compared with the post-CREMA laboratory session.

Analysis of Cue Type on Latency to Smoke

The isolation of cue type (smoking neutral) and mode (imagery and photographic) within each block of CREMA trials allowed us to investigate the relationship between cue presentations and latency to smoke. Analyses were performed on latency to smoke after the presentation of smoking photographs ($M = 70.55$ min, $SD = 37.24$), neutral photographs ($M = 70.62$ min, $SD = 45.01$), smoking imagery ($M = 77.14$ min, $SD = 56.66$), and neutral imagery ($M = 68.61$ min, $SD = 32.31$). A repeated-measures ANOVA on smoking latency revealed no significant differences for type or mode. We compared the daily number of cigarettes that participants reported smoking on average before the study with actual daily cigarette reports averaged across the 8-day CREMA period. We found that participants logged a daily average of 12.79 cigarettes during the study, which was only 55.61% of their prestudy daily cigarette consumption. We performed additional latency analyses for participants whose smoking logs were at least 50% of prestudy smoking reports and 70% of prestudy smoking reports and found no relationship between cue presentations and latency to smoke in these subgroups.

Discussion

This study revealed that the CREMA procedure effectively elicited craving in the natural environment of active smokers. During the CREMA trials, craving ratings were significantly higher after presentation of smoking-related cues relative to presentations of neutral cues. Similar robust craving effects were found on analogous laboratory trials given before and after the CREMA procedure. The magnitude of these effects (partial η^2) was very large ranging from 57% to 65% of the composite variance. (Partial η^2 is the proportion of the effect plus its associated error variance that is attributable to the effect.) The results from the laboratory trials were consistent with a large body of previous laboratory-based CR research (e.g., Carter & Tiffany, 1999; Cepeda-Benito & Tiffany, 1996; Conklin et al., 2000). We also examined the change in craving during the CREMA procedure from precue presentations (baseline craving) to postcue presentations and found that craving increased in response to smoking cues but decreased for neutral cues. This pattern is similar to what was found in laboratory research conducted by Erblich and Bovbjerg (2004), who suggested that

the reduction in craving on neutral trials might be due to a refocusing of attentional resources on nonsmoking stimuli. This pattern also indicated that the most robust estimate of cue-specific craving effects may be generated using experimental procedures in which reactions to smoking-related cues are contrasted with reactions to neutral cues as opposed to baseline craving assessments.

The present study not only provided evidence for the viability of using experimental CR procedures in the real world, it also revealed a consistent pattern of strong cue-specific craving effects across contexts. An examination of cue-elicited craving effects for both the laboratory sessions (pre-CREMA and post-CREMA) and the 8-day CREMA session revealed nearly identical effect sizes. It is interesting that a comparison across sessions revealed higher overall craving ratings, regardless of cue type (smoking and neutral), for the pre-CREMA laboratory session, compared with either the CREMA session or the post-CREMA session. The fact that this difference was not found between the CREMA and the post-CREMA sessions suggests that something specific to the first laboratory session elevated general levels of craving. Given that participants sat through approximately 1 hr of training before the pre-CREMA sessions, whereas post-CREMA sessions were administered within minutes of the start of the session, these results may reflect nicotine abstinence effects. Past research with daily smokers has shown that craving increases significantly after only 1 hr of abstinence (Schuh & Stitzer, 1995; Tiffany & Drobes, 1991). Moreover, withdrawal-related craving and cue-elicited craving can both contribute additively to overall craving levels (Drobes & Tiffany, 1997; Drummond, 2000; Maude-Griffin & Tiffany, 1996; Tiffany, Cox, & Elash, 2000). Increased stress levels during the initial training session may have also played a role, as research has shown that stress tends to increase craving among smokers (e.g., Perkins & Grobe, 1992). Presumably, any stress effects would habituate over the course of the experiment. Finally, it is possible that, because the PDA was repeatedly paired with smoking reports during the CREMA phase of the study, participants learned to associate the PDA with craving relief. This learning history might inhibit craving levels reported during CREMA trials and post-CREMA laboratory sessions.

Analyses of the two presentation modalities used in the present study (imaginal and photographic) revealed that each cue set significantly increased the desire to smoke in response to smoking cues, compared with neutral cues. Furthermore, each cue set significantly increased craving on both CREMA trials and laboratory trials. Overall, the pattern of results indicates that the two presentation modalities produced similarly strong craving both in the laboratory and in the daily life of regular smokers. This is not surprising, as previous laboratory-based research suggests that both imagery and photographic cues are effective in triggering craving to smoke (e.g., Burton & Tiffany, 1997; Carter et al., 2006; Cepeda-Benito & Tiffany, 1996; Conklin, 2006; Stritzke et al., 2004).

In comparing the two presentation modalities used in this study, we found that the smoking cues of the two sets produced statistically similar craving effects. This was not true for neutral cues—neutral imaginal cues induced higher levels of craving than neutral photographic cues. This difference may be related to our use of a standardized set of imaginal cues that included neutral and smoking cues matched on content. As a result, although smoking cues were not mentioned explicitly in the neutral imagery material, some

of the neutral scripts may have described scenarios that triggered past memories of smoking, which, in turn, activated some craving. Conklin and Tiffany (2001) found that neutral imaginal cues that were personalized for each participant invoked less craving than did neutral imaginal cues from a standardized set. The use of standardized neutral cues that are restricted to scenarios where smoking is highly unlikely might reduce this effect.

Our investigation of participants' mood ratings in response to cue presentations revealed that they experienced higher negative mood and lower positive mood when shown smoking cues, compared with neutral cues. Participants also reported higher negative mood and lower positive mood in response to photographs, compared with imagery scripts, across cue type (smoking, neutral). This pattern of effects was found to be the same for both CREMA trials and laboratory trials. Previous laboratory-based investigations have also found that drug-related cues tend to elicit negative mood (see Tiffany, in press, for a review).

For CREMA trials, no significant differences were found regarding how closely participants focused on photographs, nor were there any differences concerning the level of vividness when imagining smoking and neutral scenarios. The finding that focus and vividness were higher on post-CREMA sessions, compared with pre-CREMA laboratory sessions, was possibly a manifestation of practice effects across sessions. As for distraction ratings, participants reported being more distracted when focusing on imaginal cues compared with looking at photographs regardless of whether the cues were smoking related or smoking neutral. This effect may index the relatively greater amount of concentration needed to hold a scenario in mind, compared with looking at a photograph. Smokers were also more distracted on the first cue presentation, compared with the second cue presentation, regardless of type (smoking and neutral) or mode (imagery and photograph). This finding may reflect within-session practice effects.

Over the past decade, researchers have increasingly questioned the assumption that drug use behavior is driven by craving, as empirical evidence has been inconsistent (Tiffany, 1990; Tiffany & Conklin, 2000). Furthermore, several investigations specifically examining the relationship between CR and smoking behavior have found little or no relationship on measures of abstinence (e.g., Niaura, Abrams, Monti, & Pedraza, 1989; Shadel, Niaura, Rohsenow, Sirota, & Monti, 1998) and a generally modest relationship on latency to smoke (e.g., Carter & Tiffany, 2001). Likewise, we found no indication that exposure to smoking cues decreased the latency to smoke, compared with neutral cues. However, because participants logged, on average, only 56% of the cigarettes they reportedly smoked before the study, these results must be interpreted with caution.

In summary, the CREMA procedure successfully invoked strong cue-elicited craving for smokers, although CREMA trials spanned a wide range of contextual, situational, and temporal variables. The strength of these findings and their consistency with previous research are interesting to note considering that CREMA differed from both our laboratory procedure and past CR research in terms of the cue presentation procedure. During CREMA, each two-trial block of cues was matched in terms of type (neutral or smoking) and mode (photograph or imagery). In our laboratory sessions, all cue types and modes were presented within a single block of trials. This is similar to the methods used in previous laboratory-

based CR studies. Despite the fact that smoking trials and neutral trials were given at different times during the CREMA session, the craving effects were highly robust. These findings are promising, as the ecological study of craving should provide information not readily available from laboratory-based research. For example, several factors may serve to moderate CR in the real world, such as environmental settings, social situations, and/or stress levels. Our investigation only involved active smokers who had been smoking 15 or more cigarettes a day for at least 1 year and were not attempting to quit or restrict their smoking. Different patterns may emerge when investigating individuals who are contemplating quitting smoking. Furthermore, differences in CR and corresponding variables, such as mood, may look different at various stages of smoking. Overall, we believe that these preliminary results with the novel CREMA procedure illustrate its potential for more focused studies of CR in the daily lives of cigarette smokers.

Acknowledgments

This research was supported by a grant from the National Institute on Drug Abuse (DA01965301) awarded to Stephen T. Tiffany.

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Figure 1.

Average craving ratings (and standard errors of the mean) for the CREMA sessions for precue presentations (baseline) and postcue presentations divided by type (smoking, neutral) and mode (photos, imagery). CREMA = cue reactivity procedures combined with ecological momentary assessment.

Figure 2. Average craving ratings (and standard errors of the mean) for the average of the two laboratory sessions divided by type (smoking, neutral) and mode (photos, imagery).

Table 1

Means (and Standard Deviations) of Postcue Ratings for CREMA Trials

Measure	Smoking trials	Neutral trials
Craving		
Photographs order 1	2.98 (0.93)	2.02 (0.75)
Photographs order 2	3.09 (1.02)	1.96 (0.77)
Imagery order 1	3.04 (0.81)	2.28 (0.67)
Imagery order 2	3.15 (0.90)	2.33 (0.71)
Positive mood		
Photographs order 1	2.86 (0.92)	3.06 (0.90)
Photographs order 2	2.88 (0.92)	3.11 (0.87)
Imagery order 1	3.39 (0.72)	3.66 (0.68)
Imagery order 2	3.41 (0.69)	3.78 (0.68)
Negative mood		
Photographs order 1	1.86 (0.62)	1.67 (0.68)
Photographs order 2	1.90 (0.67)	1.62 (0.68)
Imagery order 1	1.74 (0.63)	1.54 (0.49)
Imagery order 2	1.78 (0.59)	1.46 (0.46)
Distraction		
Photographs order 1	1.50 (0.55)	1.64 (0.57)
Photographs order 2	1.48 (0.54)	1.50 (0.54)
Imagery order 1	1.68 (0.61)	1.76 (0.59)
Imagery order 2	1.68 (0.63)	1.70 (0.61)
Focus		
Photographs order 1	4.58 (0.52)	4.58 (0.47)
Photographs order 2	4.62 (0.48)	4.63 (0.43)
Vividness		
Imagery order 1	4.42 (0.49)	4.34 (0.60)
Imagery order 2	4.41 (0.53)	4.46 (0.60)

Note. Ratings were completed on a 5-point scale. All measures were rated in the positive direction (e.g., higher distraction scores indicate higher levels of distraction). CREMA = cue reactivity procedures combined with ecological momentary assessment.

Table 2

Means (and Standard Deviations) of Postcue Ratings for Laboratory Trials

Measure	Pre-CREMA session		Post-CREMA session	
	Smoking trials	Neutral trials	Smoking trials	Neutral trials
Craving				
Photographs	3.64 (1.21)	2.23 (1.05)	2.99 (1.05)	1.99 (0.92)
Imagery	3.63 (0.99)	2.75 (1.13)	3.15 (1.02)	2.13 (0.88)
Positive mood				
Photographs	2.53 (1.06)	3.02 (1.02)	2.97 (1.04)	3.21 (1.04)
Imagery	3.34 (0.96)	3.51 (0.83)	3.43 (0.88)	3.71 (0.85)
Negative mood				
Photographs	1.98 (0.92)	1.73 (0.83)	1.62 (0.73)	1.45 (0.75)
Imagery	1.79 (0.87)	1.57 (0.77)	1.63 (0.83)	1.45 (0.71)
Distraction				
Photographs	1.37 (0.56)	1.51 (0.66)	1.19 (0.48)	1.30 (0.69)
Imagery	1.58 (0.67)	1.50 (0.80)	1.24 (0.55)	1.20 (0.48)
Focus				
Photographs	4.66 (0.55)	4.56 (0.64)	4.85 (0.34)	4.80 (0.49)
Vividness				
Imagery	4.31 (0.76)	4.29 (0.75)	4.76 (0.44)	4.77 (0.43)

Note. Ratings were completed on a 5-point scale. All measures were rated in the positive direction (e.g., higher distraction scores indicate higher levels of distraction). CREMA = cue reactivity procedures combined with ecological momentary assessment.