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ORIGINAL INVESTIGATION

Appetitive nature of drug cues *re*-confirmed with physiological measures and the potential role of stage of change

Jared P. Dempsey · Lee M. Cohen · Valerie L. Hobson · Patrick K. Randall

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Abstract
Rationale Smokers report pleasant reactions to viewing cigarettes, suggesting that smoking cues may be appetitive in nature. Two studies have investigated this hypothesis through physiological assessment. The first study found that smoking cues were physiologically appetitive in nature, with dampened startle response to smoking pictures in comparison to neutral pictures. The second found that smoking pictures did not modulate the startle response, suggesting such cues may not be physiologically appetitive.
Objective The goal of the present study was to further investigate how participants' motivation to quit smoking might modulate responses to smoking cues.
Materials and methods Twenty-two nicotine-dependent smokers viewed standardized pleasant, unpleasant, neutral, and smoking pictures. Eleven of the subjects reported no intent to quit (precontemplators) and 11 reported planning to quit within the next 6 months (contemplators). Acoustic startle probes were randomly administered while subjects viewed the pictures, and eyeblink startle magnitude was measured with electromyography (EMG).
Results As a whole, participants exhibited dampened startle responses during smoking pictures, relative to unpleasant pictures. Precontemplators showed robust startle inhibition to smoking pictures, in comparison to both neutral and unpleasant pictures. Contemplators, however, showed blunted unpleasant picture augmentation and a lack of startle inhibition for pleasant pictures.
Conclusion These findings are consistent with the idea that smoking pictures are appetitive in nature. Furthermore, they suggest that smokers at a later stage of change may exhibit a lesser response.

Keywords Smoking cues · Affective modulation · Acoustic startle reflex · Nicotine · Stage of change · Transtheoretical · Drug cue

Introduction

In the addicted individual, drug cues appear to increase motivation to consume the addictive substance (Carter and Tiffany 1999). However, the nature of this motivation is controversial. It may be the result of negative reinforcement, reflecting the individual's desire to eliminate an aversive withdrawal-like state brought about by the cues (Siegel 1979). Alternatively, cue-induced motivation may reflect a positive state induced by conditioned cues (Stewart et al. 1984). Research to investigate the motivational nature of cue reactivity among individuals who smoke cigarettes has produced support for both aversive (Elash et al. 1995) and appetitive (Geier et al. 2000) motivation.

Smoking cue reactivity research has relied heavily on the subjective self-reports of participants' affective responses (e.g., McDermut and Haaga 1998; Mucha et al. 1999). Recently, several investigators have employed objective, psychophysiological indicators, such as the measurement of the startle reflex. The startle reflex is inhibited when an individual views a pleasant picture and is potentiated when an individual views an unpleasant picture, compared to

J. P. Dempsey (✉) · L. M. Cohen · V. L. Hobson
Department of Psychology, Texas Tech University,
P.O. Box 42051, Lubbock, TX 79409-4201, USA
e-mail: dempsey@b-med.net

J. P. Dempsey · P. K. Randall
Center for Drug and Alcohol Programs,
Medical University of South Carolina,
67 President Street, P.O. Box 250861,
Charleston, SC 29425, USA

neutral pictures (Lang et al. 1990). Thus, the magnitude of the startle response may be taken as an index of subjects' affective reaction to pleasant, unpleasant, and neutral stimuli (Center for the Study of Emotion and Attention 1995).

Two studies have investigated the affective modulation of the startle reflex to smoking pictures. In one study (Geier et al. 2000), smoking cues attenuated the startle response, consistent with a pleasant affective stimulus. Similarly, participants reported that they perceived smoking cues as pleasant. In contrast, a more recent study (Orain-Pelissolo et al. 2004) failed to find an inhibition of the startle response while smokers viewed smoking-related compared to neutral pictures.

It is important to note that the two studies mentioned above differed greatly in methodology. Specifically, Geier et al. (2000) utilized a sample of more highly dependent cigarette smokers and included the full range of standardized affective pictures (i.e., pleasant, unpleasant, and neutral pictures). Orain-Pelissolo et al. (2004), however, used smokers who were less nicotine-dependent and were shown only the neutral standardized pictures (see Mucha et al. 2006 for further discussion of these methodological issues). It seems plausible, therefore, that these methodological differences may have resulted in the null findings of the later study. Conversely, the appetitive drug cue reactivity documented by Geier et al. (2000) is consistent with prior research demonstrating that alcohol cues can inhibit startle responses among individuals suffering from alcohol use disorders (Heinz et al. 2003; Mucha et al. 2000). Neither smoking study, however, considered individual factors such as the desire to quit smoking. This motivational information may be useful, as previous research has documented subjective differences in smoking cue reactivity as a function of an individual's stage of change (e.g., a gauge of an individual's desire to change or stop a certain behavior; McDermut and Haaga 1998).

The present study assessed affective reaction to smoking cues among dependent cigarette smokers as a function of an individual's stage of change. Participants were initially screened for stage of change and were placed in either the precontemplator (i.e., not thinking about quitting smoking) or contemplator group (i.e., thinking about quitting smoking within the next 6 months). Acoustic startle probes were then administered while participants viewed standardized pleasant, unpleasant, and neutral pictures from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention 1995) and standardized smoking cue pictures utilized by Geier et al. (2000). The Self-assessment Manikin (SAM) was also utilized to collect self-reported affective responses (Bradley and Lang 1994).

It was hypothesized that significant startle attenuation would occur in response to smoking cue pictures, compared to neutral pictures, only for the precontemplator group. Such a finding would be consistent with prior research demonstrating that subjective reports of substance cues among cigarette smokers and social drinkers differ as a function of state of change (Mucha et al. 1999). Furthermore, it has been documented that as smokers transition from precontemplation to contemplation they become more cognizant of the negative implications of smoking (Velicer et al. 1985). Therefore, smokers in the precontemplator group, being less cognizant of the negative implications of smoking, were expected to show a stronger positive affective response to smoking cues (i.e., significant startle attenuation).

Cigarette smokers classified as contemplators continue to smoke despite increased recognition of the negative implications of their habit (Velicer et al. 1985). Thus, it seems reasonable that these individuals may experience ambivalent pleasant–unpleasant affective responses with regard to their cigarette use. Evidence for the dual experience of opposing emotional states has previously been documented (Larsen et al. 2001). Therefore, it was hypothesized that participants in the contemplator group would show significantly larger startle magnitudes when presented with pictures of smoking cues compared to standardized pleasant pictures. Conversely, this group was expected to show a significantly lower startle magnitude when presented with pictures of smoking cues compared to standardized unpleasant pictures (being similar to neutral pictures). Lastly, subjective emotional reactions (i.e., SAM ratings) were hypothesized to coincide with the hypothesized psychophysiological responses.

Materials and methods

Subjects

Twenty-two nicotine-dependent male smokers (11 precontemplators, 11 contemplators) participated in the current study. Smoking status was biologically verified, with a required carbon monoxide (CO) expired breath reading of ≥10 ppm and nicotine dependence was verified by self-report, with a required score of ≥4 on the Fagerström test of nicotine dependence (FTND; Heatherton et al. 1991). Participants were initially identified from a large multistudy screening survey administered to all *Introduction to Psychology* students. Further screening (i.e., CO level) was conducted on subjects agreeing to participate in the current study. No significant group differences were observed with respect to ethnicity, age, education, preexperiment CO level, or FTND score (see Table 1). Presentation order of experimental pictures was counterbalanced to control for potential order effects. Participant exclusion criteria included hearing difficulties, ongoing illicit substance use, and use of psychotropic medications. Four

Table 1 Demographic and screening variables of participants

	Precontemplator				Contemplator			
	n	Mean	SD	Range	*n*	Mean	SD	Range
Ethnicity								
Asian	1				2			
Caucasian	8				8			
Hispanic	1				1			
Other	1				0			
Age		21.91	2.91	9.00		24.82	5.46	18.00
Education		14.64	2.01	7.00		15.55	2.34	7.00
Carbon Monoxide		22.00	10.54	32.00		23.91	13.24	41.00
Fagerström		5.45	0.93	2.00		5.45	0.93	3.00

Fagerström is the Fagerström Test for Nicotine Dependence. Carbon monoxide is listed in parts per million. None of the values significantly differ by group.

participants were excluded from the current study, one for disclosed illicit drug use, one for falling asleep, and two due to equipment failure. No participants were dropped due to poor startle reflex.

Stage of change measure

The stages of change are based on the transtheoretical model, which postulates that behavior change occurs through a series of stages, rather than a singular event (Velicer et al. 1998). The smoking stage of change form is a set of three questions, which categorizes smokers into a discrete category, including the precontemplation stage, the contemplation stage, the preparation stage, the action stage, or the maintenance stage (DiClemente et al. 1991; Velicer et al. 1995). Given the substantial motivational differences between precontemplators and contemplators (i.e., not considering quitting vs considering quitting), and also given that these two groups comprise the vast majority of the smoking population (approximately 80%; Velicer et al. 1995), smokers included in this study were from one of these two groups. Previous research (Morera et al. 1998) has revealed that the stages of change model in smokers has sound psychometric qualities, having an adequate fit (χ^2= 6.33, p<0.79), an adjusted goodness of fit=0.98, stability ranging from 0.88 to 0.98, and reliability ranging from 0.69 to 0.76.

Self-assessment Manikin

The SAM is a picture-oriented instrument devised as a nonverbal assessment scale of pleasure, arousal, and dominance associated with the perception of an object or picture (see Bradley and Lang 1994). These three domains are assessed by the rater placing an "x" on, or in between, a character displaying a linear progression of pleasure, arousal, and dominance, allowing for a nine-point rating scale for each dimension. A replication study comparing a smaller sample of participant SAM ratings to the IAPS ratings of standardized pleasant, unpleasant, and neutral pictures (Center for the Study of Emotion and Attention 1995) showed a Pearson correlation of 0.99 for pleasure and 0.93 for arousal ratings. For the current study, participants rated only the pleasure scale on this instrument.

Fagerström test of nicotine dependence

The FTND (Heatherton et al. 1991) is a six-item self-report measure of nicotine dependence. Scores can range from 0 to 10, with increasing values suggesting higher levels of nicotine dependence. The FTND is an adaptation of the Fagerström tolerance questionnaire (Fagerstrom 1978) that has been shown to have improved internal consistency (α= 0.61) to its' predecessor (Heatherton et al. 1991).

Stimulus material and presentation

Pictures were presented on a 17-in. LCD computer monitor (Dell Ultrasharp 1703FPs). The 64 pictures included the 16 smoking pictures utilized by Geier et al. (2000) (available by request to Geier and colleagues), 16 IAPS (Center for the Study of Emotion and Attention 1995) neutral pictures (2840, 5534, 6150, 7000, 7002, 7006, 7010, 7034, 7050, 7090, 7150, 7217, 7025, 7030, 7040, and 7233), 16 IAPS pleasant pictures (1710, 4660, 5621, 5700, 5910, 7270, 7502, 8030, 8080, 8200, 8370, 8380, 8190, 8420, 5480, and 8470), and 16 IAPS unpleasant pictures (1300, 3060, 3102, 3170, 3530, 6212, 6230, 6313, 9410, 9570, 9910, 9921, 3000, 3150, 6560, and 9252). Consistent with Geier et al. (2000) the pictures were presented in two picture-type balanced sets of 32 pictures, in five pseudorandomized orders. Pictures were presented for 7–8 s, with interpicture intervals (black screen) of 17–26 s. For two third of the pictures, acoustic startle probes were presented approxi-

mately 4 s postpresentation of the picture (range of 3 to 5 s to control for expectancy). Acoustic probes were 95 dB (SPL A) white noise, 50 ms in duration, with instantaneous rise time (<1 ms), and were administered binaurally via Optimus Pro headphones (model 135).

Procedure and equipment

Upon arriving, participants completed initial measures (e.g., demographic questionnaire and list of current medications), and smoked a cigarette (to control for deprivation level). Next, electrodes were attached, verified for signal integrity, and a preprogrammed experimental session was administered using Coulbourn Instruments LabLinc V modular instrument system (Coulbourn Instruments, Allentown, PA, USA), in conjunction with Coulbourn Instruments Human Startle Software (version 5.100-00). Before administration of the experimental session, a habituation trial was conducted, including ten startle probes (Geier et al. 2000 included three habituating startle probes). The two-block preprogrammed experimental session was initiated. Between blocks, participants were instructed to rest for 3 min in their chair. After the completion of the experimental sessions, participants were shown paper-based photographs of the 64 experimental pictures and completed SAM ratings for each picture.

Physiological data acquisition

Probe placement sites were abraded with Nuprep (Weaver & Company). Ag-AgCl 4 mm surface electrodes (In Vivo Metric, E220-LS), filled with Microlyte Gel (Coulbourn Instruments), were placed in a bipolar configuration on the left *orbicularis oculi* (reference electrode: *mastoid process*). Electrodes were verified to have an impedance level below 10 kΩ via an electrode impedance meter (UFI Checktrode, model 1089mkIII). Raw electromyography (EMG) signal was collected using an amplification setting of 50,000 on a Coulbourn V75-05 Bioamplifier. The signal was then full-wave rectified using a bandpass filter setting of 8–150 Hz, and a time constant of 10 ms, on a Coulbourn V76-23 contour-following integrator. Integrated EMG signal was manually scored using Coulbourn Instruments Human Startle Software. Consistent with recent guidelines published by the Society for Psychophysiological Research (Blumenthal et al. 2005), eyeblink reflex magnitudes were calculated by taking the difference between baseline (data point just before response onset) and peak integrated EMG signal between 21 to 120 ms postprobe onset. Trial rejection criterion include (1) excessive noise (≥20 μV) during baseline or (2) nonstartle blink activity occurring at 0 to 21 ms postprobe onset.

Data analysis

EMG data was standardized within subject, and then averaged by picture type, consistent with other research groups (e.g., Blumenthal et al. 2005). Given that the SAM data are on the same scale across participants, scores were averaged by picture type. Primary analyses included mixed-design repeated measures analysis of variance (ANOVA). Family-wise error variance was utilized for all analyses. No alpha corrections were used for tests of a priori hypotheses. For exploratory analyses, a modified Bonferroni correction was used to control for alpha (Keppel 1991).

Results

Affective modulation of startle

A 2×4 (group, picture type) repeated measures ANOVA was conducted on EMG startle reflex magnitude. Test of picture type was significant, $F(2.71, 54.17)=10.59$, $p<0.001$, $\eta_p^2 = 0.346$. Test of picture type by group interaction showed a trend toward significance, $F(2.71, 54.17)=2.41$, $p=0.083$, $\eta_p^2 = 0.107$. Mean and standard deviation of EMG by picture and group are listed in Table 2.

Given the trend toward significance and medium effect size in test of interaction, contrast coefficients were conducted to explore potential differences. First, contrasts were conducted for picture type overall, collapsing across groups. This analysis was conducted to allow for comparison of previous nongrouped studies. Results indicated that startle reflex magnitude while viewing unpleasant pictures was significantly larger than while viewing pleasant, neutral, and smoking pictures [$F(1, 21)=12.92$, $p<0.05$, $\eta_p^2 = 0.44$; $F(1, 21)=8.67$, $p<0.05$, $\eta_p^2 = 0.303$; $F(1, 21)=41.38$, $p<0.001$, $\eta_p^2 = 0.676$, respectively]. Of the nonsignificant contrasts, one pair was particularly notable given the significance before modified Bonferroni adjustment. Specifically, EMG startle reflex showed a trend toward significance for smaller startle values while viewing smoking pictures, in comparison to startle values while viewing neutral pictures, $F(1, 21)=5.611$, $p=0.056$, $\eta_p^2 = 0.212$.

Table 2 Standardized electromyographic startle reflex magnitudes

	Precontemplator	Contemplator	Total
Pleasant (SD)	−0.23 (0.28)	0.02 (0.26)	−0.11 (0.30)
Unpleasant (SD)	0.38 (0.21)	0.18 (0.30)	0.28 (0.27)
Neutral (SD)	0.005 (0.13)	−0.003 (0.35)	0.001 (0.25)
Smoking (SD)	−0.15 (0.21)	−0.20 (0.17)	−0.17 (0.19)

EMG scores are presented in standardized *Z*-score form. Scores were standardized within participant.

Table 3 Contrast analyses for EMG startle magnitude by group

	df	Mean$_1$, Mean$_2$	*F*	Partial eta^2
Precontemplator				
Pleasant–Smoking	1, 10	−0.23, −0.15	00.39	
Pleasant–Neutral	1, 10	−0.23, 0.005	05.47	
Pleasant–Unpleasant	1, 10	−0.23, 0.38	20.35**	0.67
Smoking–Neutral	1, 10	−0.15, 0.005	04.37†	0.30
Smoking–Unpleasant	1, 10	−0.15, 0.38	32.75***	0.77
Neutral–Unpleasant	1, 10	0.005, 0.38	22.93**	0.70
Contemplator				
Pleasant–Smoking	1, 10	0.02, −0.20	04.87	
Pleasant–Neutral	1, 10	0.02, −0.003	00.02	
Pleasant–Unpleasant	1, 10	0.02, 0.18	01.27	
Smoking–Neutral	1, 10	−0.20, −0.003	02.21	
Smoking–Unpleasant	1, 10	−0.20, 0.18	12.77††	0.56
Neutral–Unpleasant	1, 10	−0.003, 0.18	01.11	

EMG values in *Z*-score form, standardized within participant. Larger values equal greater relative startle. Modified Bonferroni critical $F(1, 10)$: 6.94, *$p<0.05$; 12.83, **$p<0.01$; and 24.85, ***$p<0.001$. For directional a priori hypotheses, one-tailed standard critical *F* values were used: $^{\dagger}p<0.05$, $^{\dagger\dagger}p<0.01$, and $^{\dagger\dagger\dagger}p<0.001$

Contrast coefficients were also conducted separately for each group. Among precontemplators, EMG startle magnitude while viewing unpleasant pictures was significantly larger than while viewing pleasant, neutral, and smoking pictures. EMG startle magnitude while viewing smoking pictures was significantly smaller than while viewing neutral pictures. For contemplators, only one set of pair wise comparisons reached significance, with EMG startle magnitude while viewing unpleasant pictures being larger than while viewing smoking pictures (see Table 3 and Fig. 1).

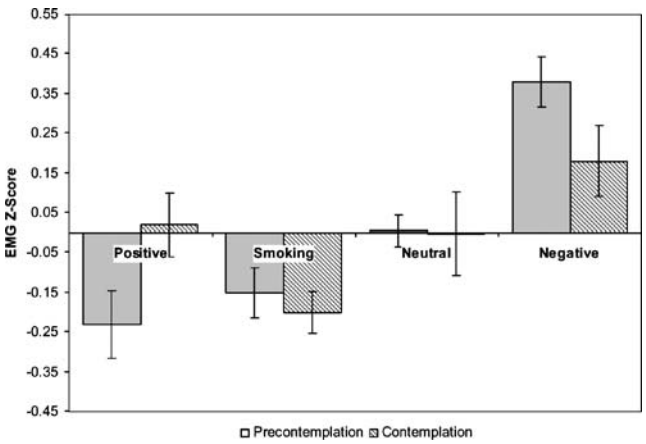

Fig. 1 EMG startle reflex magnitude. Standardized EMG startle magnitude, by picture type, with standard error *T bars*. Averaged nonstandardized microvolt values for all subjects, across tests was 0.10 (SD=0.08) for baseline and 0.78 (SD=0.80) for peak startle value. Groups did not differ in overall averaged microvolt baseline or peak startle values

For the first hypothesis, it was predicted that significant startle attenuation would be seen for smoking cues, for the precontemplation group only. As expected, the precontemplation group showed significantly lower EMG startle magnitude while viewing smoking pictures, compared to when they viewed neutral pictures, $F(1, 10)=4.37$, $p<0.05$, one-tailed. Also as expected, this same test for the contemplation group failed to reach significance, $F(1, 10)=2.21$, n.s. However, smoking pictures were significantly smaller than unpleasant pictures $F(1, 10)=12.77$, $p<0.01$.

For the second hypothesis, it was predicted that contemplators' startle magnitudes while viewing smoking pictures would be significantly smaller compared to unpleasant pictures, and significantly larger compared to pleasant pictures. This hypothesis was partially supported. Specifically, contemplators' EMG startle magnitude during smoking pictures was significantly lower compared to unpleasant pictures [$F(1, 10)=12.77$, $p<0.01$, one-tailed], but was not significantly higher compared to pleasant pictures [$F(1, 10)=4.87$, n.s., one-tailed].

Self-report Self-assessment Manikin data

A 2×4 (group, picture type) repeated measures ANOVA was conducted. Effect of picture type was significant [$F(2.31, 46.24)=72.28$, $p<0.001$, $\eta_p^2 = 0.78$], indicating that picture category significantly differed in self-report. Test of picture type by group interaction did not reach significance, [$F(2.31, 46.24)=0.85$, $p>0.05$], suggesting that participants in the precontemplation and contemplation groups rated picture pleasantness similarly. Means and standard deviation scores of SAM ratings by picture and group are listed in Table 4.

Contrast coefficients for picture-type overall, collapsing across groups indicated that all combinations of contrasts were significant, even when the more conservative adjusted alpha value was used. All findings were in the hypothesized direction, with pleasant pictures being rated significantly more pleasurable compared to smoking, neutral, and unpleasant pictures. Smoking pictures were rated significantly more pleasurable compared to neutral and unpleasant pictures. Lastly, neutral pictures were rated significantly more pleasurable compared to unpleasant pictures (see

Table 4 SAM ratings

	Precontemplator	Contemplator	Total
Pleasant (SD)	6.33 (0.98)	6.54 (0.85)	6.43 (0.90)
Unpleasant (SD)	2.87 (1.09)	2.36 (0.77)	2.62 (0.95)
Neutral (SD)	4.77 (0.81)	5.05 (0.41)	4.91 (0.64)
Smoking (SD)	5.54 (0.71)	5.49 (1.01)	5.52 (0.85)

Range of scores 1–9. A score of 5 indicates neutral affect, lower scores indicating negative affect and higher scores indicating positive affect.

Table 5 Contrast analyses for SAM ratings of pictures overall

	df	$Mean_1$–$Mean_2$	*F*	Partial eta^2
Pleasant–Smoking	1, 21	6.43–5.52	11.99**	0.36
Pleasant–Neutral	1, 21	6.43–4.91	056.18***	0.73
Pleasant–Unpleasant	1, 21	6.43–2.62	120.34***	0.85
Smoking–Neutral	1, 21	5.52–4.91	09.25*	0.31
Smoking–Unpleasant	1, 21	5.52–2.62	92.21***	0.82
Neutral–Unpleasant	1, 21	4.91–2.62	72.31***	0.78

Range of scores 1–9. A score of 5 indicates neutral affect, lower scores indicating negative affect and higher scores indicating positive affect. Modified Bonferroni critical $F(1, 21)$: 5.83, *$p<0.05$; 9.83, **$p<0.01$; and 16.57, ***$p<0.001$.

Table 5). Given the lack of significant group by picture type interaction, group-specific contrasts were not conducted.

Discussion

The present study was conducted to physiologically assess the affective reactions of nicotine-dependent participants to photographic smoking cues, taking into consideration the stage of change of the participant. The current study replicates past research (Geier et al. 2000), showing that physiological reactions to smoking cues are appetitive in nature among nicotine-dependent individuals. While these findings are in contrast to Orain-Pelissolo et al. (2004), there is some question as to the appropriateness of the methodology employed by this more recent study (see Mucha et al. 2006). Findings from the present study, along with the findings reported by Geier et al. (2000), are consistent with other research in the addiction field. For example, research involving cue reactivity with alcohol has also documented an inhibition of the startle reflex for drug-related stimuli (Heinz et al. 2003; Mucha et al. 2000).

A distinguishing aspect of the present study was that smoking groups were defined based upon their stage of change. It was hypothesized that those individuals with no desire to quit smoking (i.e., precontemplators) would demonstrate significant startle inhibition while viewing smoking pictures (suggesting that these pictures would be perceived as pleasant). As hypothesized, precontemplators showed significant startle inhibition to smoking pictures, in comparison to both neutral and unpleasant pictures. Furthermore, startle reflex during smoking pictures did not differ from standardized pleasant pictures. However, while precontemplators showed robust affective modulation in the expected direction for the standardized affective pictures, contemplators showed an atypical pattern. Specifically, contemplators' startle reflex values while viewing pleasant pictures were similar to values when viewing neutral pictures. This atypical pattern of affective modulation makes interpretation of hypotheses regarding contemplators less clear.

Given that smokers classified as contemplators were theorized as experiencing ambivalent affective reactions while viewing smoking pictures, it was hypothesized that the startle magnitude for smoking pictures would be most similar to neutral pictures. Specifically, it was hypothesized that startle responses while viewing smoking pictures would be significantly larger compared to pleasant pictures and significantly smaller compared to unpleasant pictures. Consistent with this hypothesis, smoking picture startle reflex values were significantly smaller compared to startle reflex values while viewing unpleasant pictures and did not significantly differ from neutral pictures. However, given the atypical affective modulation observed, smoking picture startle reflex values were not found to be significantly larger compared to pleasant pictures. These results suggest that smoking pictures may be perceived as pleasant, but not to the magnitude seen among the precontemplation group.

The atypical affective modulation, with startle magnitude for pleasant pictures being indistinguishable from neutral pictures, negates an appropriate gauge of affective modulation for the contemplation group. It is unclear as to why pleasant pictures were perceived more similar to neutral pictures. One possible explanation could be increased level of depression among participants planning to quit smoking. It has been suggested that quitting smoking could contribute to depression (Wilhelm et al. 2006). Furthermore, clinically depressed individuals show little to no modulation to pleasant stimuli (Kaviani et al. 2004). Thus, increased levels of depression among the contemplator group could potentially have contributed to the lack of modulation to standardized pleasant pictures in the current study.

Hypotheses for the self-report data were unable to be tested. Given the lack of a significant interaction between group and picture type, further within group testing would not be statistically appropriate. However, overall contrast analyses were consistent with previous research and in the expected direction. Specifically, smoking pictures were rated similar to pleasant pictures, and were rated significantly less pleasant than neutral and unpleasant pictures.

Theoretical and methodological implications

The current study lends support to the theory that drug cues engender positive affect, which is related to drug-seeking behavior (Stewart et al. 1984). Smoking pictures were found to be pleasant both physiologically and via subjective self-report. The current findings also suggest that the paradigm of the affective modulation of the startle reflex can be utilized to assess the appetitive nature of drug cues among addicted individuals. Given that the current study lends further support for drug cues modulating the startle reflex, the lack of significant results by Orain-Pelissolo et al. (2004) are unclear and may be an artifact of methodological factors (see Mucha et al. 2006). In summary, findings from this study further support the use of startle modulation as a viable tool in addiction research.

Although consideration of the stage of change model in nicotine-startle research has been suggested as a potentially fruitful area of research (Postma et al. 2001), no such studies could be found. Findings from the current study suggest that consideration of the stage of change model may be an important factor for physiological and subjective assessment of drug cue reactivity.

Limitations of current study

One of the major limitations of the current study is inclusion of only male participants. The two studies most closely related to the current study included female participants (Geier et al. 2000, 33%; Orain-Pelissolo et al. 2004, 56%). Neither of these studies, however, reported analyses regarding gender differences, which could provide important information regarding individual differences. This is particularly important given the well documented gender differences observed in physiological reaction to emotionally salient pictures (e.g., Bradley et al. 2001; Schupp et al. 1996).

Another limitation is the lack of biological verification of abstinence from illicit substance use. Illicit substance use was an exclusionary criterion, but information was collected via self-report only. Given that smoking is often ubiquitous among drug users (e.g., Frosch et al. 2000), it is possible that smoking pictures may prime the participant to another substance as well. Lastly, a larger sample size would allow for more detailed statistical procedures and would decrease the chance of sampling error.

Conclusion

The current study supports the theory that drug cues engender a positive effect, which is associated with drug-seeking behavior. The current study also replicated disputed findings of previous research, supporting the notion that affective reaction to smoking cues can be assessed physiologically. Stage of change was also found to play a role in the affective reactions to experimental stimuli. Specifically, those participants in the precontemplation stage showed robust affective modulation of the startle reflex and pleasant reactivity to smoking pictures. However, those participants in the contemplation stage showed atypical affective modulation of the startle reflex (pleasant pictures similar to neutral pictures) and smoking pictures showing a tendency toward pleasant reactivity. Overall, the current study demonstrates that affective modulation of the startle reflex is a viable paradigm for investigating nicotine dependence.

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