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Nicotine Differentially Inhibits the Acoustic Startle Reflex in African American and Caucasian American Smokers

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Abstract

Research suggests that there are racial disparities in smoking behaviors, cessation rates, mortality, and morbidity. However, little is known regarding racial differences in affect regulation by smoking. The purpose of this study was to examine racial differences in the effects of nicotine deprivation and administration on smokers' startle responding to smoking and affective cues. 104 African American (AA) and Caucasian American (CA) smokers completed 4 laboratory sessions crossing nicotine deprivation (12-hour deprived vs. nondeprived) with nicotine nasal spray (active vs. placebo). Participants viewed affective (positive, neutral, and negative) and smoking slides while startle probes were administered. The results showed that relative to placebo, AA smokers given nicotine spray exhibited significantly lower startle responses when they were exposed to smoking cues and CA smokers given nicotine spray exhibited significantly lower startle responses when they were exposed to negative and neutral cues. Although nicotine suppresses startle responding in both AA and CA smokers, the effect is modulated by different cue conditions, suggesting that there may be racial differences in components of smoking motivation.

Keywords

African Americans; Caucasian Americans; nicotine; startle reflex

Approximately 23% of African Americans (AA) and 22% of Caucasian Americans (CA) living in the United States are cigarette smokers (Centers for Disease Control and Prevention, 2007). Despite having a similar prevalence of smoking, AA and CA smokers differ in smoking behaviors. For instance, AA smokers start smoking at a later age (Trinidad, Gilpin, Lee, & Pierce, 2004), have a shorter smoking history (Kabat, Morabia, & Wynder, 1991), smoke fewer cigarettes per day (Okuyemi, 2001), and are more likely to smoke high-tar/nicotine and mentholated cigarettes (Kabat et al., 1991) than CA smokers. Although AA smokers report stronger motivation to quit than CA smokers (Royce, Hymowitz, Corbett, Hartwell, & Orlandi, 1993), AAs are less successful than CAs at achieving abstinence (Giovino, Schooley, & Zhu,

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1994; Kabat et al., 1991; King, Polednak, Bendel, Vilsaint, & Nahata, 2004). Furthermore, AA smokers face a substantially higher risk of lung cancer and of other smoking-related health consequences than their CA counterparts (Harris, Zang, Anderson, & Wynder, 1993; Haiman et al., 2006).

Racial differences in nicotine metabolism may provide some clues as to why AAs consume fewer cigarettes than CAs. AA smokers take in more nicotine per cigarette (Perez-Stable, Herrera, Jacob III, & Benowitz, 1998) and metabolize nicotine and cotinine slower (Benowitz et al., 1999; Perez-Stable, Herrera, Jacob, & Benowitz, 2000) than CA smokers, thus making it possible for AAs to maintain a desired level of nicotine in the body with a lower daily rate of smoking. This racial difference in nicotine metabolism may be partially explained by some AA smokers' preference for mentholated cigarettes (Giovino et al., 2004), which have been shown to inhibit the rate of metabolizing nicotine into cotinine (Benowitz, Herrera, & Jacob, 2004).

Few studies have investigated factors that may explain the different cessation rates found between AA and CA smokers (e.g. Pederson, Ahluwalia, Harris, & McGrady, 2000; Royce et al., 1993). Okuyemi and colleagues (2006) used functional magnetic resonance imaging (fMRI) to examine brain activation in response to smoking cues and found that, compared to CA smokers, AA smokers exhibited significantly greater activation in response to cues in the medial prefrontal, the lateral orbitofrontal, and the ventrolateral prefrontal cortices. No such differences were found between AA and CA nonsmokers. The researchers surmised that AA smokers' increased attention to smoking cues may elicit a higher level of cue-induced craving that in turn, may contribute to their difficulty in achieving and maintain abstinence. This finding suggests that racial differences in cue responding may exist.

Smoking and negative affective cues often precipitate smoking (Shiffman et al., 2002), a lapse after quitting (Shiffman et al., 1996a; Shiffman et al., 1996b), and relapse (Shiffman, 1982). Postcessation negative affect (unpleasant emotions that include anxiety, anger, frustration, and depression) has been found to be a potent predictor of lapse and relapse (e.g. Kenford et al., 2002). Baker and colleagues (2004) hypothesized that interoceptive (e.g. symptoms of early withdrawal) and exteroceptive (e.g. environmental stressors) cues of negative affect signal the rise of unpleasant emotions, prompting smokers to respond with cigarette use, which quickly relieves smokers' aversive state. Smoking cues (e.g. smell of cigarette smoke) may acquire positive incentive value, through either positive (association with smoking and the appetitive effects of nicotine) or negative (association with smoking and the relief of negative affect) reinforcement, and signal that drug self-administration will be rewarded. Since the presence of smoking and negative affective cues may set the occasion for smoking, differential responses to these cues by AAs and CAs may account for differences in smoking behaviors and cessation success.

The current study uses the acoustic startle reflex (ASR) to study racial differences in nicotine's effects on smokers' responses to smoking and affective cues. The ASR, typically measured by the strength of the eyeblink response at the orbicularis oculi muscle, is a defensive reflex elicited in response to an unexpected auditory probe. The ASR is systematically modulated by the valence of foreground affective cues (Vrana, Spence, & Lang, 1988). The amplitude of ASR, which is augmented by negative cues that activate the defensive system and is inhibited by positive cues that activate the appetitive system (Cook, III, Hawk, Davis, & Stevenson, 1991; Cuthbert, Bradley, & Lang, 1996; Lang, 1995; Vrana et al., 1988), reflects the ebb and flow of the defensive and appetitive motivational systems (Lang, Bradley, & Cuthbert, 1990; Lang, 1995). Thus, ASR may provide a sensitive and reliable index of the processing of emotionally evocative stimuli.

Data on the effects of nicotine deprivation and administration on ASR during affective manipulation is mixed. Although our work (Cinciripini et al., 2006) showed that nicotine deprivation reduced ASR to smoking cues, others found no effect of nicotine deprivation on ASR (Geier, Mucha, & Pauli, 2000; Hogle & Curtin, 2006; Orain-Pelissolo, Grillon, Perez-Diaz, & Jouvent, 2004; Piper & Curtin, 2006). Regarding nicotine administration and ASR, our work (Cinciripini et al., 2006) showed that nicotine suppressed ASR to smoking and affective cues in smokers whereas another study found that nicotine has no effect on pulse-alone ASR (no affective cues, Kumari, Cotter, Checkley, & Gray, 1997). These findings suggest that while the effects of nicotine deprivation on ASR remain unclear, nicotine administration may suppress smokers' overall ASR. Only one study investigated ASR differences between AAs and CAs and found no racial differences in pulse-alone ASR (Brown, Bradley, & Lang, 2006). However, this study did not assess racial differences in startle responding to smoking or affective cues.

To the best of our knowledge, this study is the first to compare AA and CA smokers with respect to the effects of overnight deprivation and acute nicotine administration on the affective modulation of ASR. Specifically, participants completed four laboratory sessions that counterbalanced nasal spray (active vs. placebo) with deprivation (12-h deprived vs. nondeprived). During each session, acoustic startle probes were presented to smokers intermittently while they viewed affective and smoking pictures. We adopted a 12-hour deprivation period since studies that examined the effects of nicotine and nicotine withdrawal had suggested that these effects can be reliably observed after 6 to 12 hours of deprivation (e.g. Hughes, Higgins, & Hatsukami, 1990). Furthermore, since we were interested in studying the effects of acute nicotine administration, the current study chose nicotine nasal spray over other routes of administration like nicotine patch, which offers a steady infusion of the drug, or smoking, which included other sensory stimuli.

Method

Participants

This paper included a subsample of 104 smokers (56 AAs and 48 CAs) recruited from the Houston metropolitan area as part of a larger study (Cinciripini et al., 2006). Only healthy smokers who had no uncontrolled medical illness, were between the ages of 18 and 59 years, were fluent in English, and smoked at least 10 cigarettes per day were included in the study. Individuals were excluded if they were taking psychotropic medication, met the criteria for a current psychiatric disorder, reported hearing loss, or were involved in current smoking cessation activities. Table 1 shows the baseline characteristics of the participants.

Materials

Expired CO testing—Expired CO was measured before each of these sessions. Smokers attending the deprived sessions were expected to produce a CO level below 10 ppm. However, given that many participants were heavy smokers in whom a high baseline level of expired CO (e.g. >30 ppm) was routinely recorded, an exception was made where a CO above 10 ppm could be expected after a period of overnight deprivation. In this case, a value at or below 50% of their baseline CO was used as a cut-off point. Nonabstinent participants in the deprived sessions were rescheduled.

Affective slides—A total of 48 color slides were presented to participants. We selected 12 slides each from the low positively valenced/low arousal (neutral), high positively valenced/high arousal (positive), and high negatively valenced/high arousal (negative) categories of the International Affective Picture System (IAPS, Center for the Study of Emotion and Attention (CSEA-NIMH), 1995)¹. Previous studies have shown the amplitude of ASR is positively

related to the arousal intensity of the slides (Cuthbert et al., 1996). Therefore, the average arousal level of the positive slides was matched to that of the negative slides. The presentation also included 12 slides that contained smoking cues (e.g. a burning cigarette, people smoking alone) created by our laboratory and validated for reliability (Carter et al., 2006). A Pentium III computer running Psychology Tools' Eprime software (Pittsburgh, PA) was used to project a 91.5 by 122 cm image of the slides, through an In-Focus (Wilsonville, OR) LCD projector, onto a screen positioned approximately 1.5 m from the subject.

Startle probe—The acoustic startle probe consisted of a 50-ms, 100-dBA presentation of white noise with instantaneous rise time. The probes were generated and amplified using a Pentium III computer running Psychology Tools' Eprime software and were presented binaurally using Sennheiser (Wedemark, Germany) HD500 headphones.

Center for Epidemiologic Studies Depression Scale: The Center for Epidemiologic Studies Depression Scale (CES-D, Radloff, 1977) is a 20-item self-report measure developed to assess depressive symptoms in community (nonclinical) populations (Ross & Mirowsky, 1984). The CES-D was administered to measure smokers' depressive symptomatology at baseline and again at each of the laboratory sessions.

Nicotine nasal spray—Depending on the experimental condition, participants received either active nicotine or placebo nasal spray immediately before the test block. Participants were blind to the content of the nasal spray and were instructed to self-administer one spray (metered dose either 0 or 0.5 mg nicotine per spray) per nostril. Pharmacia & Upjohn, Inc. (Peapack, NJ) provided the nicotine and placebo sprays.

Saliva nicotine assessment—Two saliva nicotine samples were collected at each laboratory session. Sample 1 was collected 5 minutes after the administration of placebo spray at the beginning of the habituation block (approximately 15 minutes after participants finished smoking their last cigarette in the nondeprived condition) and represented the level of nicotine at the beginning of each experimental session. Sample 2 was collected 5 minutes after the administration of placebo or nicotine nasal spray at the beginning of the test block to assess nicotine exposure as a function of nasal spray as well as smoking deprivation. The samples were analyzed for nicotine using the high-performance liquid chromatography method of Hariharan & VanNoord (1991). The assay can detect nicotine concentrations of less than 1 ng/ml.

Procedures

Participants attended four 90-minute laboratory sessions (two nicotine deprived and two nicotine nondeprived) at approximately the same time of the day (either 9 am or 11 am) scheduled approximately three days apart. For the nicotine-deprived sessions, participants were instructed to refrain from smoking for at least 12 hours prior to attending the session. Compliance with the deprivation instructions was biochemically assessed using expired CO readings taken at the beginning of each session. For the nicotine-nondeprived sessions, smoking was unrestricted prior to the session. To control for ad-lib smoking prior to nondeprived sessions, we asked all participants to smoke one cigarette at the beginning of each of those sessions. Following expired CO assessment and cigarette smoking (nondeprived sessions only), the Center for Epidemiologic Studies Depression Scale (CES-D, see below) was administered to assess participants' depressive symptoms. A trained research assistant

ⁱThe following IAPS slides were used: Positive, 4220, 4652, 4658, 4659, 4660, 4670, 5621, 5629, 8030, 8370, 8490, and 8500; Neutral, 7000, 7010, 7020, 7030, 7040, 7050, 7060, 7080, 7090, 7100, 7150, and 7170; Negative, 3010, 3060, 3100, 3120, 3130, 3150, 3170, 3500, 6230, 6350, 6560, and 9410.

then attached sensors to the right orbicularis oculi region on the participant's face. Participants were instructed to rest for 5 minutes to allow for initial adaptation to the hook-up procedure and assessment of signal quality.

Each laboratory session consisted of two blocks of trials. The first was a habituation block used to acclimatize participants to the novel effects of the startle procedure, nasal spray administration, and general laboratory surroundings. The second was a test block used as the primary dependent measure in this study. The habituation and test blocks were similar to each other in terms of slides and startle probes presentation. Both the habituation and test blocks included 24 slide presentations (presentation of six slides from each of four valence categories; see "Affective slides" below), with each lasting 6 seconds and followed by a randomly determined intertrial interval that varied from 10 to 20 seconds. A startle probe was presented during 16 of the 24 slide presentations, at a randomly determined time of 2.5 to 5 seconds after slide onset, such that a probe was presented during 4 of the 6 slide presentations of each valence condition. To enhance unpredictability of the startle presentation, eight startle probes were presented during intertrial intervals in each block. Four separate slide orders, one for each session, were counterbalanced across subjects.

Nasal spray was administered twice at each laboratory session, once before the habituation block and once before the test block. Participants always received placebo spray prior to the habituation block, and either nicotine or placebo spray prior to the test block. A 5-minute absorption period was inserted between the administration of nasal spray and the commencement of the habituation or test block. Participants were instructed to rest quietly during the 5-minute period. At the end of the absorption period, the slide presentation and psychophysiological recording was initiated.

Startle acquisition and quantification

ASR was measured using electromyographic electrodes (Ag-AgCl) filled with saline gel that were placed over the right lower orbital portion of the orbicularis oculi muscle (Blumenthal et al., 2005; Fridlund & Cacioppo, 1986). This signal was acquired and amplified using a BIOPAC Systems (Goleta, CA) EMG100A module connected to a BIOPAC Systems MP100WSW bioamplifier sampled at 1,000 Hz. Data were recorded and displayed using BIOPAC Systems AcqKnowledge III data acquisition software installed on a Pentium III computer. ASR was rectified and integrated using a 10 ms time constant before it was manually scored in microvolts (μ V) using the AcqKnowledge III software. Peak startle amplitude was defined as the maximal electromyographic value recorded at the orbicularis oculi area within a time period of 20–120 ms following startle probe onset. Trials with clear movement artifact and trials where no blink response was elicited were rejected and excluded from analyses. There were no differences in the distribution of movement artifacts or zero responses as a function of valence, nicotine deprivation, spray condition, or race.

Large individual differences exist in absolute ASR and these variations can obscure the detection of the experimental phenomenon of interest. Several different methods have been proposed for standardization (see Blumenthal et al., 2005 for discussion). One way to minimize the variance due to individual differences and improve the probability of detecting the variance due to the experimental conditions is to use standard scores (Blumenthal et al., 2005; Bonnet, Bradley, Lang, & Requin, 1995; Cuthbert et al., 2003). In this study, we chose to standardize valence-related ASRs (i.e., ASRs elicited in the presence of foreground smoking and affective cues) in reference to the mean and standard deviation of each participant's pulse-alone ASRs (i.e., ASRs elicited during intertrial-intervals when no foreground cues were presented). The absolute peak startle amplitudes obtained under the four valence categories in the test block for each participant were converted to a standardized T score using the participant's own intertrial-interval (ITI) ASR distribution as the reference. That is, after we had calculated the

mean and standard deviation of all ITI ASRs across all four sessions for each participant, we applied the equation, $T \text{ score} = 50 + 10 * [(absolute \text{ valence-related ASR} - \text{mean of ITI ASR}) / \text{standard deviation of ITI ASR}]$, to all valence-related ASRs to convert the absolute amplitude to T score. A total of 16 condition means (deprivation status $\times$ nasal spray $\times$ slide type) were calculated across sessions using the standardized T scores.

Statistical analysis

The outcomes of interest in the current study are the differential effects of nicotine deprivation, nicotine administration, and affective cues on AA and CA smokers. Only the main effect of these factors and their interactions related to race are reported here. The main outcome and the gender differences findings are presented in Cinciripini et al. (2006) and Robinson et al. (2007) respectively. We used multilevel models analysis (PROC MIXED, SAS Institute Inc, Cary, NC, version 9.1, Littell, Milliken, Stroup, Wolfinger, & Schabenberfer, 2006) to examine the effects of Race (two levels: African American versus Caucasian American), Nicotine Deprivation (two levels: 12-hour deprived versus nondeprived), Nasal Spray (two levels: nicotine versus placebo), Slide Type (four levels: neutral, positive, negative, and smoking pictures), and Session (four levels: session one thru four) on standardized mean ASR from the test block. Psychophysiological researchers have increasingly applied multilevel models to analyze data in repeated measures designs (Bageilla, Sloan, & Heitjan, 2000; Kristjansson, Kircher, & Webb, 2007). Using likelihood functions rather than least squares approach to estimate effects (McCullagh & Nedler, 1989), multilevel models analysis has many advantages over the traditional repeated measures analysis of variance. Multilevel models estimates both fixed (group means) and random (individuals differences) effects, allows for estimation of variance and covariance components with unbalanced and nested data, and does not exclude from analysis participants with missing observation (Bageilla et al., 2000; Kristjansson et al., 2007). In the current analysis, the variable Race was modeled as between-subject fixed effect and the factors Nicotine Deprivation, Nasal Spray, Slide Type were modeled as within-subject fixed effects. We wanted to take into account individual differences (means and changes across session) in ASR within participants and therefore modeled both subject and session as random effects. Main effects and interactions terms of the fixed and random effects were examined.

Results

Expired CO

A significant Nicotine Deprivation main effect was found for expired CO, $F = 334.67$, $p < .01$, indicating that participants followed our instructions and had largely refrained from smoking before they attended a nicotine-deprived laboratory session. Nevertheless, we found that in some instances, participants who had smoked within 12 hours of their deprived sessions were mistakenly allowed to complete the sessions. Abstinence of 12 or more hours was reported on 94% of the deprived sessions. About 4.3% of the deprived sessions fell in the 10–12 hour range and were included in the analysis. Sessions in which participants reported less than 10 hours of deprivation were excluded from the analysis.

Saliva nicotine level

Table 1 shows the mean preexisting saliva nicotine levels for AA and CA smokers under both deprived and nondeprived conditions. Saliva nicotine has been found to be a reliable index in assessing overnight deprivation, with values ranging from 16 ng/ml to 40 ng/ml among deprived heavy smokers (Teneggi et al., 2002). The average saliva nicotine values collected at the beginning of deprived sessions were well within this range. However, the final analysis did include observations (approximately 5% of the total) where smokers' saliva nicotine values were above 40 ng/ml (range 42–94 ng/ml).

We also assessed whether or not a standard nicotine dose delivered via nasal spray resulted in differential saliva nicotine concentrations (i.e., Sample 2) between AA and CA smokers. Due to the positive skewness of the distributions for both saliva nicotine samples, nicotine values were logarithmically transformed before analysis. Controlling for the participants' preexisting saliva nicotine level (Sample 1), we failed to find a significant Race main effect or any interaction between Race and Nasal Spray or Nicotine Deprivation for Sample 2, indicating no racial difference in nicotine concentration following a standard dose of nicotine administration.

Acoustic startle eye-blink response

The purpose of this paper was to evaluate the differential effects of nicotine deprivation, nasal spray, and slide types on AA and CA smokers' startle responding. The main outcome findings from the entire sample were presented in Cinciripini et al. (2006). We used multilevel models analysis to examine standardized ASR obtained in the test block and found a significant Race $\times$ Nasal Spray $\times$ Slide Type interaction, $F = 2.61$, $p < .05$ (see Figure 1). AA smokers showed a significantly lower ASR to smoking slides, $F = 6.23$, $p < .05$, after they had received nicotine nasal spray than after they had received placebo nasal spray. There was no effect of nasal spray on ASR in response to smoking slides in CA smokers. CA smokers showed a significantly lower ASR to negative, $F = 3.97$, $p < .05$, and neutral slides, $F = 10.72$, $p < .05$, following nicotine nasal spray compared with placebo nasal spray. AA smokers' ASR to neutral and negative slides did not differ across nasal spray conditions. There were no additional significant interactions with race.

Preexisting demographic differences between the two racial groups included age, education, occupation, body mass index, cigarettes smoked prior to a session, and depressive symptoms (i.e., CES-D total score obtained at each session). To adjust for these preexisting differences between CA and AA smokers, we repeated the multilevel model analysis and included age, education, occupation, body mass index, cigarettes smoked prior to a session, depressive symptoms, sex, history of depression, and saliva nicotine level (a covariate that was found to be associated with ASR) in the analysis. Adding these covariates to the model did not significantly alter the results.

We did not find significant interactions between Nicotine Deprivation and either Race or Nasal Spray. However, as reported in our earlier paper (Cinciripini et al., 2006), we did find a significant Nicotine Deprivation $\times$ Slide Type interaction, $F = 4.43$, $p < .05$ that showed deprivation reduced ASR in the presence of smoking stimuli. We also found a significant main effect for Session, $F = 5.53$, $p < .05$, indicating that ASR habituated across sessions.

Discussion

The current study found that acute administration of nicotine, relative to placebo, significantly reduced ASR to smoking cues in AA but not in CA smokers. Conversely, nicotine administration attenuated CA smokers' ASR to negative and neutral stimuli but had no effect on ASR among AA smokers exposed to the same stimuli. These findings suggest that nicotine administration increases positive affect in AAs when they are exposed to smoking cues and decreases negative affect in CAs when they are exposed to negative affective cues.

The amplitude of ASR is suppressed when the appetitive motivational system is activated and augmented when the defensive motivational system is mobilized. (Lang et al., 1990; Lang, 1995; Lang, Bradley, & Cuthbert, 1997). Thus, one plausible implication of our findings is that nicotine is more potent in 1) activating appetitive mechanisms already triggered by smoking cues among AAs than among CAs, and 2) dampening the defensive system already triggered by negative cues among CAs than among AAs. Results from neuroimaging studies

have shown that nicotine increases dopaminergic transmission in the mesolimbic dopaminergic system, an important appetitive pathway in the brain for many drugs of abuse (DiChiara & Imperato, 1988), supporting the notion that nicotine enhances the activation of appetitive mechanisms. However, since no studies have linked nicotine to the suppression of defensive responses (e.g. modulating responses in central nucleus of the amygdala), the neuro-biological mechanism by which nicotine may influence the defensive pathway remains unclear.

Alternately, the findings may be explained by a hypothesis that nicotine activates the appetitive motivational system, under different conditions, in both AA and CA smokers. In AA smokers, nicotine enhances the activation of the appetitive system already triggered by smoking cues. In CA smokers, nicotine also activates the appetitive pathways, the effect of which is to reduce activation of the defensive system brought about by exposure to the negative stimuli. The net effect of this exchange results in a reduction of ASR.

The findings imply that motivational significance of nicotine may differ for AA and CA smokers. That is, among AA smokers, the incentive value and/or reinforcing effects of nicotine may be most apparent in the presence of smoking cues. Both negative (e.g. Baker, Piper, McCarthy, Majeskie, & Fiore, 2004) and positive (e.g. Stewart, de Wit, & Eikelboom, 1984) reinforcement drug models posit that drug (including smoking) cues signal drug availability and have positive incentive value. Thus, for AA smokers, positive affect enhancement may be a particularly important incentive associated with cigarette use. Among CA smokers, the incentive value and/or reinforcing nicotine is more readily observed when CA smokers are exposed to negative cues. Negative stimuli may signal the rise of negative affect, which prompts smokers to smoke in order to relieve the aversive affective states (see Baker et al., 2004). As such, negative affect reduction may be a particularly important incentive associated with cigarette use in CA smokers.

Racial differences in nicotine metabolism and associated behavioral learning history could explain a dissimilar motivational significance of smoking between AA and CA smokers. AA smokers have higher nicotine intake and slower nicotine and cotinine clearance per cigarette than CA smokers (Benowitz et al., 1999; Perez-Stable et al., 1998; Perez-Stable et al., 2000). For these reasons, AA smokers may be able to maintain an optimal level of nicotine, and thus its desired positive effect, for a longer period after each cigarette than do CA smokers. As nicotine level declines, smokers experience interoceptive withdrawal symptoms that prompt them to smoke, which relieves the aversive symptoms (Baker et al., 2004). Since CA smokers metabolize nicotine faster, they may experience not only more frequent bouts of nicotine withdrawal, but also more instances of smoking-induced withdrawal relief during a day than AA smokers. Consequently, while AA smokers may associate smoking more with the positive effects of nicotine, CA smokers' behaviors may be more contingent on the negative affective reduction effects of the drug.

This explanation does not imply that CA smokers do not seek nicotine for its positive effects, or that AA smokers do not smoke to reduce withdrawal symptoms. One potential implication of a differential motivational significance of nicotine for AA and CA smokers might be that relapse may be more likely to occur in the presence of smoking cues among AA smokers and in negative affective situations among CA smokers. Nicotine also suppressed ASR in CA smokers when they were exposed to neutral stimuli. As in our original analysis, the current racial analysis found a significant interaction between nicotine deprivation and slide types. However, no interaction between race and deprivation was found. Thus, the current finding adds to our earlier paper by showing that while nicotine deprivation reduces ASR similarly in both AA and CA smokers, acute nicotine administration reduces ASR in AA and CA under different circumstances.

The study is limited by the demographic differences between AA and CA smokers (e.g. AA smokers were older, heavier, and reported more depressive symptoms at baseline than CA smokers). Although we statistically controlled for these differences in our analyses, the possibility remains that one or more of these factors, not race, were responsible for the findings. It is also unclear if the findings will generalize to other routes of nicotine administration (e.g., cigarette smoking, nicotine patch). Furthermore, the current study examined a single nicotine dose and a fixed nicotine deprivation period. Future studies should include other routes of nicotine administration and test a wider range of nicotine doses and deprivation periods to examine the effects of race, nicotine deprivation and administration on ASR.

In summary, the current study represents some of the first reported results to compare AA and CA smokers with respect to nicotine's effects on affective modulation. We found that nicotine plays an active role in modulating ASR and that the specific pattern of modulation differs between AA and CA smokers. Future research is needed to replicate these findings and to examine if the current findings are related to racial differences in cessation success.

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Figure 1.

Top panel: Nicotine reduces acoustic startle reflex in AA smokers exposed to smoking cues. Bottom panel: Nicotine reduces acoustic startle reflex in CA smokers exposed to negative and neutral cues

Table 1**Participant Characteristics at Baseline**

Measures	AA (N=56)	CA (N=48)	p-value
Education (% high school education or less)	50	29	<.05
Employment in service or labor sector (%)	72	48	<.05
Positive history of depression (%)	12.5	18.8	ns
Gender (% female)	39	48	ns
Employed full or part time (%)	64	65	ns
	Mean (SD)		p-value
Body mass index	28.5 (6.2)	24.7 (4.9)	<.01
Age	40.9 (8.2)	33.8 (12.2)	<.01
CES-D total score	12.9 (10.2)	8.6 (6.1)	<.01
Years of smoking	21.6 (9.3)	17.8 (12.2)	ns
Cigarettes/day	23.9 (12.1)	20.9 (9.0)	ns
FTND total score	5.3 (2.2)	4.9 (2.1)	ns
Cigarettes smoked on the day baseline visit	4.2 (2.7)	4.7 (2.9)	ns
Expired CO at baseline visit	20.5 (8.7)	21.4 (10.0)	ns
Preexisting saliva nicotine level at nicotine- nondeprived sessions	494.1 (527.9)	381.6 (366.1)	ns
Preexisting saliva nicotine level at nicotine- deprived sessions	15.8 (17.8)	15.0 (32.6)	ns

CES-D, Center for Epidemiologic Studies Depression Scale; FTND, Fagerström Test for Nicotine Dependence.