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Exposure to Electronic Nicotine Delivery Device (ENDS) Visual Imagery Increases Smoking Urge and Desire

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Abstract

Use and awareness of electronic nicotine delivery systems (ENDS; also known as electronic cigarettes or e-cigarettes) has increased rapidly in recent years, particularly among young adults. As use of ENDS resembles traditional smoking in both hand to mouth movements and inhalation and exhalation behaviors, we determined whether exposure to e-cigarette use via video exposure would act as a cue to elicit urge and desire for a combustible cigarette. Young adult smokers (mean age 26.3 ± 4.1 years) were randomized to view a brief video montage of advertisements depicting either e-cigarette vaping ($n = 38$) or bottled water drinking ($n = 40$). Pre- and post-cue exposure assessments were conducted in a controlled laboratory setting without other smoking or vaping cues present or behaviors allowed. Primary outcomes included change from pre-exposure baseline in smoking urge (Brief Questionnaire of Smoking Urges) and desire for a combustible and e-cigarette (visual analogue scales). Results showed that relative to exposure to the bottled water video, exposure to the ENDS video significantly increased smoking urge ($p < 0.001$) as well as desire for a regular cigarette ($p < 0.05$) and an e-cigarette ($p < 0.001$). These findings provide preliminary evidence that passive exposure to video imagery of ENDS use may generalize as a condition cue and evoke urges for a combustible cigarette in young adult smokers. It remains to be determined whether such increases in urge and desire correspond to increases in actual smoking behavior.

Keywords

ENDS; Electronic Cigarettes (E-Cigarettes); Smoking Cues; Cue Reactivity; Urge

Electronic nicotine delivery systems (ENDS), also referred to as electronic cigarettes or e-cigarettes, deliver nicotine to the user via inhalable aerosol derived from a nicotine-

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containing solution rather than smoke from burning tobacco as in combustible cigarettes (Grana, Benowitz, & Glantz, 2014). Globally, the popularity of these devices has increased in recent years (Pepper & Brewer, 2013; Regan, Promoff, Dube, & Arrazola, 2013; Vardavas, Filippidis, & Agaku, 2014; Zhu, 2013). In the United States, ENDS use has increased substantially with 49.6% of current smokers reporting ever use of ENDS in 2014 (Giovenco, Lewis, & Delnevo, 2014), an increase from 11.4% in 2010 (Pearson, Richardson, Niaura, Vallone, & Abrams, 2012). While ENDS are perceived as less harmful than combustible cigarettes (Pearson et al., 2012), their risk and health effects remain uncertain (Bastian & Oncken, 2014).

Exposure to visual imagery depicting e-cigarette use via online and television advertisements has also increased rapidly in young adults (Duke et al., 2014; Durbin, 2014; Legacy Foundation, 2014; Pokhrel, Fagan, Kehl, & Herzog, 2015), among whom these advertisements have shown great appeal (Kong, Morean, Cavallo, Camenga, & Krishnan-Sarin, 2014; Pepper, Emery, Ribisl, Southwell, & Brewer, 2014; Trumbo & Kim, 2015). ENDS use shares many salient features of traditional cigarette smoking in terms of form and function, frequent hand to mouth movements, and inhalation and exhalation behaviors. As visual imagery of combustible cigarette smoking acts as a conditioned cue to elicit urges to smoke (McBride, Barrett, Kelly, Aw, & Dagher, 2006; Shmueli, Prochaska, & Glantz, 2010; Tong, Bovbjerg, & Erblich, 2007), it is possible that visual imagery of ENDS use could also generalize as a conditioned cue and elicit urges to smoke. Indeed, in our prior investigation, direct in-vivo observation of e-cigarette use evoked increases in young adult smokers' urge and desire for a regular cigarette as well as for an e-cigarette, regardless of their e-cigarette use history (King, Smith, McNamara, Matthews, & Fridberg, 2014). Research on smokers' exposure to e-cigarette use via television and internet advertisements has shown that viewers report urges to smoke (Kim, Lee, Shafer, Nonnemaker, & Makarenko, 2013), favorable product beliefs (Kim et al., 2013), and greater likelihood to smoke (Maloney & Cappella, 2015). While these online-based studies had large sample sizes, removal of other cues such as cigarettes, ashtrays, lighters, and smoking behavior during the assessments, was not possible.

Thus, the goal of the present study was to extend prior research by examining the effects of exposure to video imagery of e-cigarette use in a controlled laboratory setting and comparing such responses to those exposed to nonsmoking video imagery. Young adult smokers were randomized to one of two video cue conditions (ENDS or bottled water, and assessed for smoking urge and desire before and after the exposures. The video material was extracted from television and internet advertisements retrieved online (see Methods). It was hypothesized that exposure to the e-cigarette video would evoke increases in regular smoking urge and desire for a regular cigarette, in addition to increases in desire for an e-cigarette.

Method

Design

The study used a between-subjects design with the experimenter blind to assigned video cue condition. Participants were randomly assigned to view either an e-cigarette or a bottled

water video. They completed measures before and several times after the video cue exposure.

Recruitment and Screening

Participants were recruited via online advertisements with telephone screening verifying the following inclusion criteria: age between 18–36 years, daily smoking between 5–20 cigarettes/day, not currently attempting to quit smoking, and good general health. In order to minimize expectancy, candidates were informed that participation may include engaging in one of several tasks that included eating, drinking, smoking, engaging in conversation, or viewing visual materials. However, as per the study protocol, participants were not allowed to smoke and viewing a video was the selected task for all participants. Candidates who met inclusion criteria by telephone interview were invited to the laboratory for informed consent and additional screening. Before arrival, they were instructed to abstain from alcohol drinking for 24 hours with an alcohol breath test confirming recent alcohol abstinence (< 0.03 mg%) in all candidates. Candidates also completed demographic surveys, mood measures (Beck Depression Inventory [BDI]; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Spielberger Trait Anxiety Inventory [STAI-T] Spielberger, Gorsuch, & Luchene, 1970), and cigarette smoking inventories (Fagerström Test of Nicotine Dependence [FTND] Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; Rueger, Trela, Palmeri, & King, 2012; Online Timeline Follow-back [O-TLFB] Sobell, Brown, Leo, & Sobell, 1996). Candidates not meeting general inclusion criteria, exceeding standard clinical cut-offs on the BDI (> 29) or STAI (T score < 20 or > 80) or reporting non-daily smoking on the O-TLFB were excluded from study participation. Of the 84 in-person study candidates, 81 were deemed eligible (96%) with three ineligible due to age ($n = 1$) or smoking ($n = 2$) outside the range required for inclusion. The University of Chicago Institutional Review Board approved all study procedures.

Procedure

Participants completed the approximate one-hour testing session immediately after eligibility was confirmed. Sessions were conducted in a controlled laboratory environment resembling a comfortable living room with no smoking or vaping behavior allowed or cues present (e.g., ashtrays, lighters, regular or e-cigarettes). After the participant completed baseline subjective measures and had a five minute break, the research assistant loaded the randomly assigned video on the computer screen and then exited the room prior to the start of the video. The videos included instructions for the participant to view the video while “*imagining yourself in the situations presented.*” The video began at time T0, and subjective measures were repeated immediately after the video (T5) and fifteen minutes later (T15). Participants were then debriefed and received \$30 compensation.

Video Cues—The cues consisted of montages of television and internet video advertisements for ENDS or bottled water products downloaded from public video-sharing websites in July 2014. The ENDS video consisted of advertisement clips for first generation products including Blu[®], nJoy[®], and Green Smoke[®] (82% of total video time) as well as second-generation personal vaporizers such as eGo[®] (18% of total video cue time). The preponderance of first generation versus second generation products in the video montage

reflects their higher prevalence in currently available advertising (Duke et al., 2014; Luo, Zheng, Zeng, & Leischow, 2014; Richardson, Ganz, Stalgaitis, Abrams, & Vallone, 2014).

The control video cue featured advertisements for bottled water products such as Pure Life®, Poland Spring®, and Ice Mountain®. Water cues have been widely used as a control in prior cue reactivity studies (Carter & Tiffany, 2001; Drobles & Tiffany, 1997) and have the advantage of including frequent hand to mouth movements and consumptive behavior that is not associated with smoking or substance use (Drobles & Tiffany, 1997; Monti et al., 1987). Regular cigarette advertisements were unavailable and could not be used as they are banned in the U.S. and many other countries.

There was an average of 10 individual advertisement clips (21.9 ± 17.6 seconds each, range 6–72 seconds) in each video montage. Advertisements were edited to include visual imagery of actors using the products or close-ups of the products themselves (see Supplementary Material for details) with overt branding and product name close-ups omitted to reduce potential bias related to specific brands. Soundtracks and voice-overs were also replaced with freely-available instrumental background music (Zabriskie, 2010). The rationale for these modifications was to focus on elements of the visual imagery from a variety of advertisements and to avoid potential confounds of differential audio and brand effects. There were no differences between the ENDS and water videos on length of presentation (260 and 248 seconds respectively), scene depictions (urban recreation in 81% of scenes and work, residential or rural locales in 19% of the scenes), and mood/affect of actors (60% with interested or neutral affect, 40% with positive affect). Finally, product use representation was similar for the video conditions, averaging approximately 67% of the total running time.

Dependent Measures—Urge for a regular cigarette was assessed using the standard, validated version of the 10-item Brief Questionnaire of Smoking Urges (BQSU; (Cox, Tiffany, & Christen, 2001) which includes a total score and two sub-factor scores for regular cigarette urge (Factor 1: smoking for rewarding effects, Factor 2: smoking to relieve negative affect or withdrawal; (Cox et al., 2001). This was followed by visual analog scale ratings similar to those used in prior cue reactivity studies (Heishman, Lee, Taylor, & Singleton, 2010). All VAS items were anchored from ‘Not at All’ [0] to ‘Most Ever’ [100]). The main items were desire to smoke a regular cigarette (of participants’ preferred brand), desire to use an electronic cigarette and desire to drink water. Five additional dummy VAS items were included to mask the study purpose (i.e., desire for conversation, salty food, etc.). General mood was assessed by the 9-item Positive and Negative Affect Scale (Diener & Emmons, 1985). All subjective measures were given during pre-exposure baseline and then repeated 5 and 15 minutes after the onset of the videos. Data were summarized as change scores of each post-exposure rating subtracted from that measures’ baseline pre-exposure rating.

Statistical Analyses

Background and smoking characteristics between the groups were compared using Student’s *t*-test or chi-square tests, as appropriate. Session data were examined for normality and three outliers (2 e-cigarette group, 1 water group) were identified with extremely low desire and

urge ratings (± 2.25 SD) and excluded from analysis, thus yielding the final sample of 78 participants (e-cigarette group, $n = 38$; water group, $n = 40$). The primary outcomes were the BQSU total score and the VAS desire for a regular cigarette. Secondary outcomes were the BQSU sub-factor scores, VAS ratings of desire for an e-cigarette and water, and positive and negative affect (Diener & Emmons, 1985). Generalized estimating equation (GEE) analyses (Liang & Zeger, 1986) were used to examine the effects of Group, Time, and their interaction on outcomes. All analyses controlled for the baseline value for that measure, as the magnitude of the change scores may co-vary depending on the baseline level.

Results

Participants in the ENDS and water cue groups did not differ on the majority of socio-demographic, smoking, and e-cigarette use characteristics (Table 1). The overall average age was 26.3 ± 4.1 (SD) years, smoking averaged 9.2 ± 4.0 cigarettes per day with a mean FTND of 4.1 ± 2.3 , past year ENDS use was reported in 73% of the sample, and racial background was diverse (38% Caucasian, 45% African American, 17% other). Fifty-one percent of participants smoked their last cigarette within two hours of study arrival and 49% reported their last cigarette more than 2 hours prior to arrival. The ENDS and water cue groups did not differ on time since last cigarette and covarying for this variable did not change the main study findings. Education was the only background variable that differed between groups and this variable was included as a covariate in all analyses.

During the study, there was an increase in smoking urge and desire [BQSU Time: β (se) = 2.48 (1.18), $p < .05$, 95% CI (0.17, 4.79); VAS cigarette desire Time: β (se) = 5.21 (2.48), $p < .05$, 95% CI (0.35, 10.08)] and a decrease in positive mood [Time: β (se) = -6.07 (1.62), $p < .001$, 95% CI (-9.24, -2.90)]. These may reflect natural changes over time as smokers often show urge increases when cigarettes are not available, accompanied by decrease in positive mood (Zinser, Baker, Sherman, & Cannon, 1992). Confirming the salience and validity of the video cue types, exposure to the water video increased VAS ratings of desire for water [Group x Time: β (se) = 5.22 (2.39), $p = .029$, 95% CI (0.54–9.90)] (Figure 1A) and exposure to the ENDS video increased VAS ratings of desire for an e-cigarette [Group: β (se) = 27.18 (5.26), $p < .001$, 95% CI (16.87, 37.49)] (Figure 1B). Post-hoc tests of the interaction effect for water desire showed a group difference at the first post-video time point that lessened at the second timepoint (T5, T15 water cue > T5 ENDS cue, $ps < .05$).

Exposure to the ENDS video, relative to the water video, increased BQSU total [Group β (se) = 7.60 (2.09), $p < .001$, 95% CI (3.50, 11.69)] (Figure 1C) as well as VAS cigarette desire [Group: β (se) = 9.40 (4.15), $p = .023$, 95% CI (1.27, 17.53)] (Figure 1D). These urge and desire increases were evident at both post-exposure time points (T5, T15). Further examination showed that both BQSU sub-factors increased in the e-cigarette cue condition [Factor 1, $p < .001$; Factor 2, $p = .010$].

Effect sizes based on Cohen's f (Cohen, 1992) on the main outcomes ranged from small to large (VAS desire for a regular cigarette, $f = 0.16$; BQSU total, $f = 0.34$; VAS desire for an electronic cigarette, $f = 0.45$). Exploratory analyses examined whether past year ENDS use

affected study results and results showed that controlling for this variable did not affect the previously reported main effects or interactions ($ps < .022$).

Discussion

In this controlled study, exposure to ENDS visual imagery in an advertisement montage increased young adult smokers' urge to smoke and desire for a combustible as well as an e-cigarette. These findings extend those of our prior report, in a sample with similar characteristics to the present study, showing direct observation of e-cigarette use increased urge and desire for a combustible cigarette and an e-cigarette (King et al., 2014). The magnitude of the smoking urge and desire increases in the present study were comparable to those shown in our prior work (King et al., 2014), as well as those shown in other visual imagery studies (McDermut & Haaga, 1998; Tong et al., 2007).

The results also support two recent internet-based studies of e-cigarette advertisement effects on smokers' urges, positive thoughts about the product, and self-reported likelihood to smoke (Kim et al., 2013). Important aspects of the present study relative to prior work are the use of baseline assessments, randomization and experimenter blinding to video condition, as well as testing in an environment that eliminated smoking/vaping related cues and behaviors that might affect reactivity. While the other two studies in this area had larger sample sizes, the samples were not as diverse as the current study, environmental controls were not possible, and comparison conditions were either absent, confined to a no advertisement control, or an audio-only advertisement. Taking the results of all the studies together, there is a consistency of findings that ENDS imagery in video advertising affects a variety of outcomes, including increases in ratings of intention to smoke, positive feelings about the product, and desire and urges to smoke. The latter finding was observed in a racially diverse sample of young adult smokers suggesting that results are not confined to Caucasians, although future studies with larger sample sizes are needed for confirmation. Based on Pavlovian conditioning and the similarity of e-cigarettes to regular cigarettes in form and function, it is not surprising that passive exposure to the visual imagery of ENDS use may generalize as a cue to elicit desire for both electronic and combustible cigarettes. Overall, the body of work thus far on advertisement exposures, including the present study, suggests that the olfactory component of combustible smoke or aerosol from ENDS may not necessary to evoke such urges.

There were several strengths to the study and these include taking into account time-dependent effects, non-specific reactivity, and responses to a comparison control video for a product not associated with smoking. There are also several study limitations worth noting. First, modification of video advertisements was undertaken to focus specifically on the visual elements of product use as a cue and the order of ads was fixed for both conditions. These modifications may have reduced the external validity of responses to specific advertisements, but such detailed advertisement comparisons were outside the scope of the study. Second, the sample size was small and primarily comprised of moderate smokers, so it is unknown if the results would generalize to lighter, heavier or former smokers. Third, actual smoking behavior was not assessed. While combustible smoking cues have been shown to shorten smoking latency and increase smoking topography (Droungas, Ehrman,

Childress, & O'Brien, 1995; Hogarth, 2009; Payne, Schare, Levis, & Colletti, 1991), smoking urge increases do not always lead to smoking behavior (Drummond, 2000; Perkins, 2009; Sayette et al., 2000). Therefore, it has yet to be determined whether the increases in desire for a combustible or an e-cigarette observed in the current study would affect actual smoking and/or vaping behavior.

In sum, the present study results indicate that the exposure to visual imagery of ENDS use from a montage of television and internet video advertisements increases urge to smoke and desire for both combustible and e-cigarettes. We surmise that these findings are reflective of the salient features that ENDS products share with traditional combustible cigarette smoking to generalize as a conditioned cue to elicit smoking urge and desire. These results extend prior direct in-vivo observation findings as well as internet-based study findings of video advertisement responses. Increasing scientific evidence will aid in our understanding of passive exposures to ENDS as potential conditioned cues in smokers and whether these exposures affect smoking behavior.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Cue response values are mean ($\pm$ SEM) change scores from baseline to 5 and 15 minutes post onset of each video cue. Visual analogue scale (VAS) ratings on desire for water (A), desire for an e-cigarette (B), Brief Questionnaire of Smoking Urges (BQSU) total score (C), and desire for a regular cigarette (D). VAS scored on a 0–100 scale anchored from ‘not at all’ to ‘most ever’ and BQSU scored on a 10 point scale. Participants were randomised to either the ENDS cue group ($n=38$) or the water cue group ($n=40$). Statistical analyses were from Generalized Estimating Equations.

Table 1**Group Characteristics**

	Water Cue Group (n=40)	ENDS Cue Group (n=38)	<i>p</i>
Demographics and Background			
Age (yr)	26.2 (4.3)	26.3 (3.9)	<i>p</i> =0.88
Education (yr)	13.4 (1.5)	14.5 (2.0)	<i>p</i> =0.04
Sex (% Male)	48%	53%	<i>p</i> =0.66
Race			<i>p</i> =0.34
% Caucasian	40%	37%	
% African-American	43%	47%	
% Other	15%	18%	
Household Income			<i>p</i> =0.78
< \$20K	43%	45%	
\$20,000–39,999	31%	30%	
\$40,000+	26%	25%	
Beck Depression Inventory	6.2 (6.8)	6.8 (5.5)	
Spielberger Trait Anxiety (t-score)	59.4 (4.2)	59.7 (4.1)	
Alcohol drinks/week	10.3 (10.8)	12.2 (12.4)	<i>p</i> =0.48
Smoking			
Cigarettes/day	9.0 (4.3)	9.4 (3.7)	<i>p</i> =0.69
Fagerström Nicotine Dependence (FTND)	3.9 (2.4)	4.3 (2.1)	<i>p</i> =0.51
Past year ENDS use prevalence	70%	76%	<i>p</i> =0.54
Past month ENDS use prevalence	25%	29%	<i>p</i> =0.70
ENDS use days/month ^a	8.5 (8.8)	6.6 (9.5)	<i>p</i> =0.88
Other Tobacco Product Use ^b			
Cigars	55%	47%	<i>p</i> =0.51
Smokeless Tobacco (dip, snuff, chew)	18%	11%	<i>p</i> =0.38
Hookah	50%	66%	<i>p</i> =0.16
Pipe Tobacco	26%	11%	<i>p</i> =0.10
Cloves	8%	16%	<i>p</i> =0.26
Baseline Ratings			
Average baseline CO (ppm)	11.0 (8.7)	8.2 (6.4)	<i>p</i> =0.11
Percent baseline CO 15 ppm	85%	87%	<i>p</i> =0.82
BQSU	37.2 (12.2)	41.8 (21.9)	<i>p</i> =0.10
Regular Cigarette Desire (VAS)	64.3 (20.6)	72.4 (21.9)	<i>p</i> =0.10
E-cigarette Desire (VAS)	19.5 (23.9)	26.5 (28.1)	<i>p</i> =0.24
Water Desire (VAS)	65.6 (19.6)	66.5 (25.1)	<i>p</i> =0.86

Note. Values are Mean (SD) or %, as indicated. All variables were compared between groups with t-test or Chi-Square as warranted.

^a Average e-cigarette days of use pertains to those participants who reporting past month ENDS use, i.e., water cue, n=10; ENDS cue, n=11.

^b Other tobacco product use pertains to participants using each product in the past year.