

Effects of Visual Exposure to IQOS Use on Smoking Urge and Behavior

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Objectives: In this study, we examined whether visual exposure to the heated tobacco product (HTP) IQOS, which was authorized for sale by the US Food and Drug Administration in 2019, acts as a cue to increase cigarette craving and smoking behavior among smokers. **Methods:** Young adult smokers (N = 105) were randomly assigned to view a video depicting use of either IQOS or bottled water. Main outcomes were changes in cigarette and e-cigarette desire and latency to smoke between the groups. We also examined participants' attitudes about the actors using IQOS and drinking water in the videos. **Results:** Exposure to the use of IQOS acutely increased observers' ratings of smoking urge and desire for a cigarette and an e-cigarette. The IQOS cue, compared with the water cue, also produced a marginally significant shorter latency to smoke. Participants perceived actors as less likeable and friendly when using IQOS than when drinking water. **Conclusions:** Results showed that exposure to IQOS produced smoking urge and behavior in young adult smokers, implicating IQOS use as a smoking and vaping cue. As HTPs gain popularity, product impact on passive observers should be included in their risk-benefit profile.

Key words: heated tobacco products; electronic nicotine delivery systems (ENDS); IQOS; cue reactivity; heat-not-burn

Tob Regul Sci.™ 2021;7(1):31-45

DOI: doi.org/10.18001/TRS.7.1.3

Electronic nicotine delivery systems (ENDS) have continued to rise in both popularity and variety since competing brands were introduced to western markets in 2010.¹⁻³ The prevalence of ENDS, namely e-cigarettes, varies by country and age group. For example, approximately 3.2% of adults in the United States (US), including 7.6% of young adults (age 18-24) and 4.2% of adults aged 25-44, report current use of e-cigarettes with rates substantially increasing globally during 2014-2018.^{4,5} Heated tobacco products (HTPs) are similar to ENDS, yet they differ from e-cigarettes in several important ways. First, HTPs use a battery-powered system that heats tobacco leaf to produce a nicotine-contain-

ing aerosol, whereas e-cigarettes aerosolize a liquid that may or may not include nicotine.⁶ Second, HTPs use heat-pressed tobacco sticks resembling short cigarettes instead of the e-liquids or pods used in vape products. Third, current generation HTPs are relatively new products compared to e-cigarettes as the HTP global market leader IQOS⁷ was first introduced to the market in Japan in 2014. However, similar to e-cigarettes, HTPs have seen rapid adoption and are available in over 50 countries worldwide and have been approved for sale in the US since 2019.

Beyond differences between HTPs and ENDS in product constituents and availability across certain markets, they also share similarities, particularly in

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their resemblance to traditional cigarette smoking in the hand-to-mouth motions involved in inhalation and exhalation behavior and their visible, exhaled aerosol that mimics combustion. This may be important as stimuli paired with smoking have been shown to serve as conditioned cues and evoke subjective and objective responses in smokers.⁸⁻¹⁰ As e-cigarette use resembles smoking, our group and others have found that exposure to vaping products not only elicits interest in ENDS products¹¹⁻¹³ and desire to vape,¹⁴⁻¹⁷ but also cross-generalizes as a smoking cue and increases smoking desire¹⁴⁻¹⁹ similar to that produced by a cigarette cue. To our knowledge, as HTPs are relatively novel, no studies have examined whether they act as a vaping or smoking cue.

As in other countries, an accelerated proliferation of HTPs is likely in the US, particularly among young adults, as their point-of-sale, design, and marketing tactics may specifically appeal to this demographic.²⁰ In Japan, HTP use is higher in smokers aged 20-39 than in middle-aged or older smokers.²¹ Currently, few people in the US have been exposed to the use of HTPs since there has not yet been widespread adoption due to its limited availability in select cities; as such, this presents a unique opportunity for examining their cue salience in young adult smokers with minimal confounding influence of prior exposure. Thus, we conducted a randomized laboratory study to examine visual exposure to the use of the HTP IQOS to determine if it affects smoking and vaping desire as well as smoking behavior among young adult smokers. We predicted that visual observation of its use, compared with a nonsmoking control cue, would elicit urge and desire for both combustible and electronic cigarettes, and produce shorter latency to smoke in a smoking lapse paradigm. We also explored whether observing IQOS use would affect participants' ratings of product interest and curiosity and the likeability of its users.

METHODS

Design

We used a between-subjects design with participants equally randomized by a computer number generator to exposure to the use of an HTP (active cue) or bottled water (control cue). Testing took place from July 2019 to January 2020 at the Clini-

cal Addictions Research Laboratory at the University of Chicago.

Procedure

Recruitment and screening. Candidates were recruited via flyers and online advertisements for a study described as examining "moods, behaviors, and social interactions." This description was chosen to mask the study purpose and minimize expectancy, as used successfully in prior studies.¹⁴⁻¹⁷ During a brief telephone screening, candidates were interviewed to assure they met the basic inclusion criteria: age between 18-35 years, daily smoking (5-30 cigarettes per day at least 5 days per week), no intention to quit smoking, never participated in a prior study at our laboratory, fluent in English, and no major physical or mental disorders or disabilities (eg, hearing or visual impairments) that would preclude participation. Candidates were eligible regardless of their ENDS use status. This was done to avoid attention on vaping and alternative tobacco products that might have affected responses in study sessions; all participants were assessed on ENDS history during an end of session survey.

The candidates who met the basic criteria were invited to an in-person screening. They were instructed to abstain from recreational drugs and alcohol for 24 hours and smoking for at least one hour prior to arriving to the visit. After the participant provided informed consent and presented a state-issued photo ID to verify their age and identity, they underwent the screening session that included explanation of study procedures and objective and subjective measures. Breath alcohol readings were required to be ≤ 0.003 mg% (Alco-Sensor III, Intoximeter, MO, USA). Expired-air carbon monoxide levels were used as a general indicator of smoking status and time since last cigarette (ie, 90% of candidates had carbon monoxide levels consistent with being a smoker (> 5 ppm) with the remainder reporting 6 or more hours since last cigarette). Surveys included the Beck Depression Inventory,²² Spielberger Trait Anxiety Inventory,²³ and the Timeline Followback calendar²⁴ for past month smoking and alcohol use. This was followed by an interview with the Structured Clinical Interview for DSM-IV research version²⁵ including screening items for major psychiatric disorders

(schizophrenia, bipolar, etc). Candidates were excluded if they had survey scores outside standard clinical thresholds for severe depression or anxiety or had a major untreated psychiatric disorder. Of the 120 candidates screened, 108 (90%) were deemed eligible and agreed to participate in the 1- to 1-1/2-hour study session that followed screening. The 12 candidates who were ineligible did not meet age ($N = 2$) or smoking ($N = 6$) criteria, or arrived to screening with a positive breath alcohol reading ($N = 4$). The latter were given a car service ride home to assure safety. Three participants were outliers on primary outcomes and were excluded from analyses (see “Data Analysis” for details).

Experimental session. The session began with the participant completing baseline surveys on the computer. Then the participant was instructed to view and focus on a video approximately 5 minutes long as they would be asked later to answer questions about its general content. Depending on randomization, the video included content depicting use of either the active HTP cue or the control cue of bottled water drinking (for details, see “Cues” section). Before the video began, the research assistant left the room to assure they were blind to study condition. After the video ended, the participant completed a repeated set of surveys. This was followed by a short rest break and a wash-out task (the digit symbol substitution task).²⁶ The participant then completed a final set of surveys approximately 20 minutes after the onset of the video. These surveys concluded with an open-ended item asking the participant: “*In your opinion, what was the purpose of the study?*” Responses to this item indicated that our masking was successful as only 15% (16/105) correctly deduced the study’s purpose.

After this cue phase, the final 50 minutes of the session included the smoking latency portion of the Smoking Lapse Paradigm.^{27,28} The research assistant presented the participant with a cigarette of their preferred brand, a lighter, an ashtray, and a buzzer. The participant was informed they could choose to smoke at any time else receive \$0.20 for every 5 minutes of refraining from smoking. No other activities were allowed, ie, no reading or use of smartphone/watches and there was no clock in the room. This procedure has been used successfully in prior studies of young adult smokers.^{16,17,19,29} After this portion, the participant completed ques-

tionnaires on their history of ENDS use; these were not administered earlier to avoid focus on ENDS and reduce expectancy. Once all measures were completed, the participant was paid \$100 for participation. A full debriefing was provided to all participants after study enrollment was completed.

Cues. The videos were presented on a 60-centimeter (cm) computer monitor with the participant seated approximately a half meter from the monitor. The HTP cue was a white IQOS device, 9 cm long by 1.2 cm wide, and attached to a 4.5 cm long white HEET stick inserted inside the holder. The brand logo of 3 vertical lines on the HEET sticks was not visible to the viewer as there were no product close-ups. This device was consistent with what was approved and available in the US at the time we conducted the study. The control cue was a standard 16.9 oz. clear bottle of water with a label but with brand name obscured. Bottled water was chosen as the control cue as it is a consummatory behavior with hand-to mouth motions but neutral in terms of associations to smoking.^{9,14,16,19}

The videos were created by a pre-professional videographer and edited with Adobe Premiere Pro. The acting, cinematography, and editing were identical for both videos such that the only difference between them was the product used by the actors (Figures 1 and 2). Scenes were filmed on the same day with one cue scene filmed immediately followed by filming of the other cue. The same 3 racially diverse, young adult actors were included in both videos, ie, one Asian woman, one White woman, and one Black man -- all were current smokers and vapers with prior acting experience. Background noise and voice sounds were edited out of the scenes and the videos were overlaid with an identical ambient soundtrack using freely available instrumental music³⁰ as used in our prior study.¹⁵

The videos included 29 9-10 second duration scenes including single-person or 2- or 3-person interactions (76%, 17%, and 7%, respectively; Table S1). Two-thirds of the video depicted outdoor environments with the actors sitting or talking in parks or in front of residences, walking and conversing on sidewalks, driving, or viewing park or lakefront scenery (Table S1). The other one-third of scenes were shot in indoor settings resembling an apartment living room or home office. Of the 29 scenes, 27 included hand-to-mouth movements

Figure 1
Example of Visual Stimulus as Cue – Water Cue Excerpt



Figure 2
Example of Visual Stimulus as Cue – IQOS Cue Excerpt



Note.

The top image is an excerpt from the water video (a) and the bottom image is from the IQOS video (b). This was the 14th scene at 2:33 of the 5-minute video. The actual video was displayed in full color.

Table 1
Group Characteristics

	Water (N = 53)	IQOS (N = 52)	p
Demographics and background			
Age (years)	29.5 (0.6)	27.7 (0.6)	.03
Education (years)	13.5 (0.2)	13.2 (0.2)	.27
Sex ^b (Percent male)	26 (49.1%)	25 (48.1%)	.99
Race			.47
White	27 (51%)	20 (39%)	-
Black	16 (30%)	22 (42%)	-
Other	10 (19%)	10 (19%)	-
Sexual Orientation			
Percent Heterosexual/Straight	37 (70%)	44 (81.5%)	.28
Beck Depression Inventory	8.8 (1.0)	11.1 (1.1)	.14
Spielberger Trait Anxiety (<i>t</i> -score)	59.7 (0.7)	60.0 (0.6)	.75
Alcohol drinks/week	13.1 (2.2)	9.5 (1.6)	.19
Smoking patterns and use			
Days smoked (of past 28 days)	27.7 (0.2)	27.9 (0.1)	.42
Cigarettes smoked per smoking day	9.7 (0.7)	10.1 (0.7)	.71
FTCD (nicotine dependency, 0-10)	3.4 (0.3)	3.9 (0.3)	.23
Hours since last reported cigarette ^a	4.3 (0.7)	4.7 (0.6)	.34
CO (ppm) ^a	14.8 (1.4)	15.2 (1.4)	.89
Previous ENDS use			.47
Naïve ENDS user (never used ENDS)	10 (19%)	11 (21%)	-
Lifetime ENDS user (no past month use)	23 (43%)	25 (48%)	-
Current ENDS user (past month use)	20 (38%)	16 (31%)	-
Other tobacco use in the past year:			
Hookah	9 (17%)	16 (31%)	.10
Cigars	17 (32%)	15 (29%)	.63
Other (Smokeless, Pipe, Cloves, etc)	8 (15%)	7 (13%)	.81
Baseline Urge and Desire Ratings			
BQSU ^c	38.8 (1.8)	40.6 (1.7)	.46
Regular Cigarette desire ^d	51.1 (3.4)	48.8 (3.0)	.61
Vape Pen/Mod desire ^d	12.3 (3.0)	10.3 (2.4)	.62
JUUL desire ^d	9.7 (2.8)	10.1 (2.7)	.90

Note.

Values are Mean (SEM) or N (%), as indicated. Variables were compared between groups with Student's *t*-test or chi-square as appropriate.

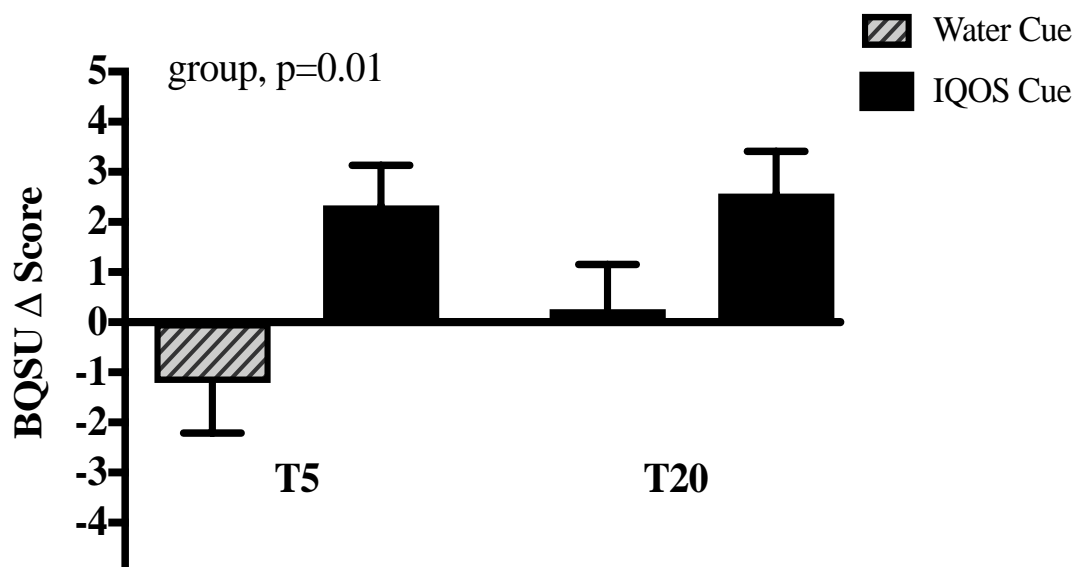
^a CO and hours since last reported cigarette values are medians due to non-normal distribution, and compared via Mann-Whitney U test.

^b Participant's biological sex.

^c Total score range: 10-70.

^d Range: 0-100. CO = carbon monoxide; ENDS = electronic nicotine delivery systems; FTCD = Fagerström Test for Cigarette Dependence; BQSU = Brief Questionnaire of Smoking Urges.

Figure 3
Smoking Urge



Note.

Data are mean \pm SEM. Subjective ratings of smoking urge represented as change scores from the baseline rating. Ratings were total scores on the 10-item Brief Questionnaire of Smoking Urges (BQSU). T represents time after exposure to the cue, with T5 = 5 minutes after cue exposure and T20 = 20 minutes after cue exposure.

of product use while 2 scenes showed the product held stationary in hand (Table S2). One single product (ie, one bottled water or one HTP) was displayed in each scene (see Supplement for more details; videos available upon request).

Measures

Primary dependent measures were the total score on the 10-item Brief Questionnaire of Smoking Urges (BQSU)³¹ and scores on 100mm visual analog scale (VAS) items scored from 0 (not at all) to 100 (most ever) on desire for a regular cigarette, an e-cigarette (separate items for a mod/vape pen and a JUUL), and water. Additional visual analog scale (VAS) items, eg, desire for conversation, salty foods, etc were imbedded in the surveys to mask the study purpose. The primary variable from the smoking behavior phase was median latency to smoke (in minutes). As in prior research,^{17,28,29,32}

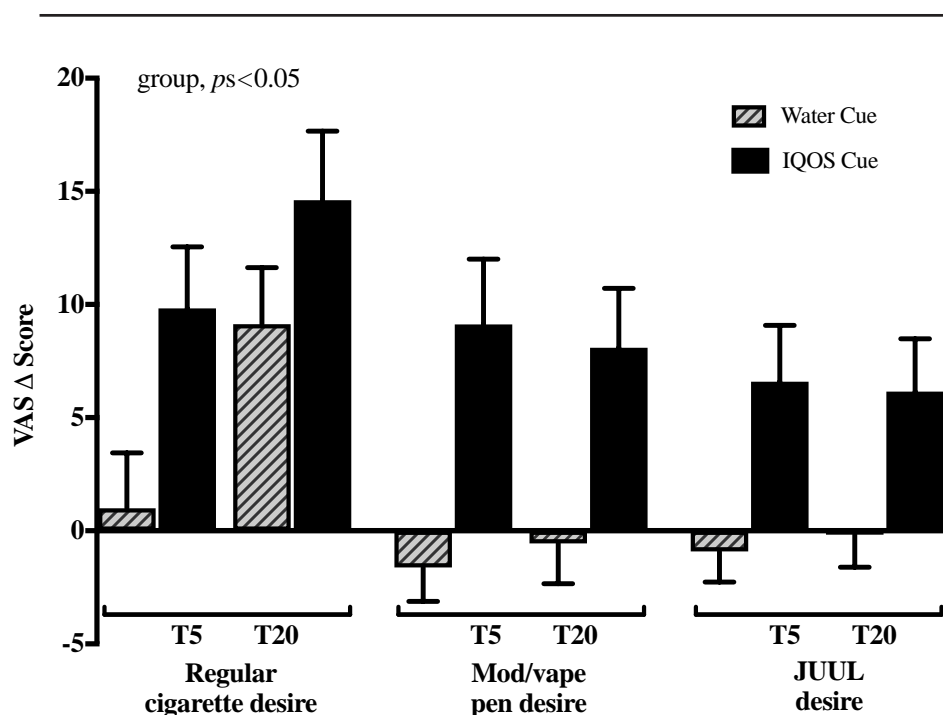
values for persons who did not choose to smoke ($N = 39/108$, 36%) were coded as 50 minutes and median values were examined as the data demonstrated a bimodal distribution.

Secondary measures included VAS items that were based on previous studies on vaping advertisements,^{11,33,34} and likability of a target individual.³⁵ These items included rating liking of the actors in the video (“The people in the video appeared to be likable.” and “The people in the video appeared to be friendly.”) and curiosity about (“I am curious about the product in this video.”) and interest (“I would like to use the product in this video.”) in using the product. The participant also rated overall liking of the video (“Did you like this video?” and “Would you like to watch more of this video?”).

Data Analysis

Primary data were examined first for normality.

Figure 4
Desire for Cigarette, Mod/vape Pen and JUUL



Note.

Data are mean \pm SEM and represent change scores from the baseline rating on 100mm visual analog scales scored from 0 (not at all) to 100 (most ever) for ratings of desire for a regular cigarette, mod/vape pen, and JUUL. T represents time after exposure to the cue, with T5 = 5 minutes after the initiation of cue exposure and T20 = 20 minutes after initiation of cue exposure. There was a significant group effect for each variable, all $ps < .05$.

There were 3 outliers identified (3% of sample; 2 in the IQOS group, one in the water group) who had urge or desire ratings > 2 SD from the mean, and thus, were excluded from analysis. This resulted in a final sample size of 105 participants ($N = 52$ IQOS group, $N = 53$ water group). As in our prior studies, ratings for each measure were summarized as change scores, ie, ratings at each time point minus the baseline score.

We compared demographic and smoking characteristics between groups using t-tests and chi-square tests, as appropriate. We analyzed outcomes using Generalized Estimating Equations (GEE) with an exchangeable correlation matrix and identity link function. Baseline measures were included as a covariate in all models as values that are very

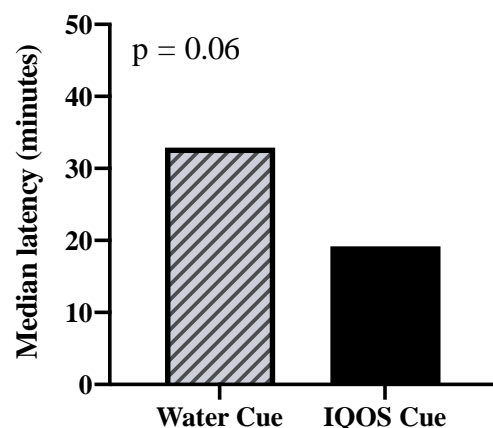
high or low at baseline can impact outcomes. We examined statistically significant effects by post-estimation contrasts with Bonferroni corrections for multiple comparisons. We used Mood's median test to examine group differences in smoking latency.³⁶ We ran separate GEE models to examine cue responses by ENDS use status (naïve, lifetime, and past month use). We repeated all analyses with relevant covariates, including age, sex,³⁷ cigarettes smoked per day, and ENDS use status.

RESULTS

Sample Characteristics

The average age of the sample was 28.6 ± 4.4 (SD) years (51% female), and the racial background was

Figure 5
Latency to Smoke in Choice Phase



Note.

Data are median latency. During the 50-minute Smoking Lapse Paradigm, the participant was informed they could choose to smoke at any time else receive \$0.20 for every 5 minutes of refraining from smoking. All participants who did not choose to smoke were counted as the duration of the task, ie 50 minutes. There was a trend for a significant group effect, $p = .06$.

diverse (45% white, 36% black, 19% other). The groups did not differ on most sociodemographic characteristics with the exception of age (Table 1); results did not change when age was included as a covariate. Participants averaged smoking 9.9 ± 5.0 cigarettes per day with a mean FTCD of 3.6 ± 2.1 , indicating moderate nicotine dependence, and 73% preferred mentholated cigarettes. Lifetime use of ENDS was common (80% of the sample) with over one-third (34%) reporting past month use, and prior use of IQOS was rare, with only 6 participants (5.7%) reporting ever use of this product. The groups did not differ on any smoking or ENDS use characteristics.

Study Outcomes

For the main study measures, the IQOS (vs water) cue produced significant increases in BQSU smoking urge and desire for a cigarette, a mod/vape pen, and a JUUL (group, all p s < .05; Figures 3-4 and Table S3). For those exposed to IQOS, within-

subject comparisons between desire for cigarettes, a mod/vape pen, and JUUL were not statistically significant ($p = .096$). As expected, the water cue (vs IQOS) elicited a greater desire for water (group, $p = .04$). In the smoking behavior task, 65.7% of the total sample chose to smoke during the task, with 71.2% and 60.4% in the IQOS and water groups, respectively, choosing to smoke. The IQOS cue group had a marginally significant shorter latency to smoke than the water cue group [median latency: 19.2 vs 32.9 minutes; $\chi^2(1,105) = 3.44$, $p = .06$; Figure 5]. The most commonly endorsed reasons for choosing to smoke were “I wanted to smoke” (94% agreement) and “I was bored” (82% agreement; Table S4). All aforementioned results did not change with the inclusion of covariates.

Despite the videos being identical except for the product used, participants who viewed the IQOS (vs water) cue rated the actors as significantly less likable ($p = .003$) and friendly ($p = .04$) and the product as significantly less desirable ($p = .002$). There were no differences between groups on ratings of product curiosity, overall liking of the video, or wanting to watch more. Table 2 shows the full details.

Responses to the cues by ENDS use status (past month, lifetime, and naïve users) revealed that, as expected, past month ENDS users, relative to lifetime and naïve users, reported higher baseline desire for both a mod/vape pen (baseline desire 21.6 compared with 5.6 and 1.5 for lifetime and naïve users, respectively) and a JUUL (baseline desire 20.9 compared with 3.1 and 0.8 for lifetime and naïve users, respectively). The IQOS cue (vs water) produced significantly higher increases in desire for a mod/vape pen [mean change scores of +10.5 and +14.2 in past month and lifetime users, respectively, compared with +0.7 in naïve users; group \times ENDS status, Wald $\chi^2(5) = 14.92$, $p < .05$]. ENDS use status did not significantly affect smoking urge, cigarette desire, or desire for a JUUL (all p s > .05).

DISCUSSION

In this study, we examined the cue salience of HTPs to determine whether the novel product IQOS generalizes as a cue for smoking and vaping in a group of young adult daily smokers. Visual imagery depicting the use of IQOS, but not water, resulted in statistically significant increases

Table 2
Video Perception Mean Ratings

Response item	Water (N = 53)	IQOS (N = 52)	p
Actor Perception			
The people in the video appeared to be likable.	74.5 (2.5)	60.4 (3.8)	.003
The people in the video appeared to be friendly	75.9 (2.7)	66.8 (3.3)	.04
Product Interest			
I would like to use the product in this video.	55.0 (4.3)	34.2 (5.0)	.002
I am curious about the product in this video.	38.0 (4.5)	43.7 (5.2)	.40
Video Liking			
Did you like this video?	47.5 (3.9)	40.3 (4.0)	.20
Would you like to watch more of this video?	29.1 (4.1)	27.3 (4.0)	.75

Note.

Values are Mean (SD). Each item was rated on a 100mm visual analog scale ranging from 0 (not at all) to 100 (most ever). Group differences on mean ratings were analyzed via Student's t-test.

in smoking urge and desire for a cigarette, a mod/vape pen, and JUUL. Further, exposure to visual imagery of IQOS use (vs water) produced shorter smoking latencies versus receiving a monetary reinforcer. On the other hand, visual imagery depicting the use of water (vs IQOS) increased ratings of desire for water, further confirming the validity of the exposures to induce craving for the cue depicted in each video. These findings suggest that the HTP IQOS, similar to first-to-fourth generation ENDS, elicits both smoking and vaping craving in young adult smokers.

The findings show that HTPs, similar to ENDS, cross-generalize as cues for smoking. Whereas HTPs are marketed as products that can help smokers abstain from cigarette smoking, there may be some population-wide trade-offs in the adoption of this product. Although manufacturers market HTP products as viable options in the harm reduction continuum for smokers,⁷ the features and use of these products closely resemble smoking³⁸ which may play a role in their cue salience. Importantly, in our US sample, most participants had not yet been exposed to IQOS use, but they still had statistically significant increases in smoking urge, desire, and behavior after exposure to its use, implicating the cross-generalization of this

product even among young smokers not yet familiar with the product. A small minority of 6 participants (5.7% of sample) endorsed having used an HTP. Visual aids were provided for all device types, but there was no interview conducted to ensure participants were not confusing an HTP with a vape pen or other ENDS device. Because IQOS was available in 39 countries and 2 US cities (but not Chicago) at the time of data collection, it is possible they were exposed to the product via one of these routes. Despite differences between HTPs and ENDS, the magnitude of craving responses to the HTP cue was similar to that shown to be elicited by ENDS^{16,17} and traditional cigarettes,^{14,19} and smoking latency was comparable to that observed in prior work with a variety of ENDS cues.^{17,19}

Interestingly, despite the fact that the same actors appeared in each video, they were rated as less likable and less friendly when they used IQOS than when they drank water. Although survey data suggest growing awareness and interest in using IQOS among youth³⁹ our study showed that, when observing direct use of the product, user judgments seem to arise, curiously among young adults who smoke. Furthermore, participants exposed to IQOS reported less interest in using the product shown despite reporting cigarette craving. We speculate

that our study participants' negative judgements of IQOS users related to the effects on craving in a situation where an immediate opportunity to smoke or vape to assuage those urges was not available, thereby creating a negative mental state that affected impressions of the actors and of HTP use in general. Another possibility is that participants formed a negative attribution of the product used to resolve the cognitive dissonance⁴⁰ of experiencing conflicting desire to use while at the same time being aware of the possible product harms and lung injury.^{41,42} Whereas further research is needed, it is certainly the case that the cue salience of novel tobacco products is not without some emotional responses in young adult smokers who may be receiving conflicting messages about non-combustible tobacco products from a variety of sources ranging from health authorities to social media influencers.

The strengths of this study include the use of a randomized design with cue exposure in a controlled laboratory setting and standardized cues allowing for a range of real-life exposures between groups to be identical besides the product shown. Despite these strengths in design and ecological validity, there are some limitations to note. First, the sample consisted of young adult daily smokers in a between-subjects design. Our sample was split somewhat evenly between those aged 18-29 (53%) and 30-35 (47%), encompassing a relatively wide age range for a young adult sample. Young adults were chosen because they report the highest rate of ENDS use and at the age range most likely to be exposed to ENDS in their social environments ie, parties, social media, school, etc.^{5,43} It is unknown if the findings would generalize to older or former smokers, nondaily smokers, or to sole e-cigarette users, or whether a cross-over design would have produced different results. Future studies could investigate differences in cue reactivity among different product users (ENDS-only users, dual users, former users, etc). Second, inherent in video cue exposure is the lack of sensory aspects one would encounter if the product were to be used in their presence. However, the magnitude of the increases in smoking desire were similar to that found in our prior research with direct confederate-delivered product use cues.^{16,17,19}

Finally, the videos were created for the purpose of this study and were not actual video portrayals that

smokers regularly encounter, ie, as in television or Internet advertisements. However, advertisements were not possible with IQOS as video advertising for tobacco products varies substantially by country due to differences in regulations; in the US, the Food and Drug Administration tightly regulates the depiction of tobacco product use in advertising. The advantage of our study's videos were that they to portrayed IQOS use across diverse racial/ethnic actors, from a variety of angles, and settings mimicking real-life exposures rather than using advertisements that showcase product use to increase sales.

IMPLICATIONS FOR TOBACCO REGULATION

The present investigation is the first to show that exposure to the use of the novel HTP IQOS increases smoking and vaping craving as well as smoking behavior in young adult daily smokers. Thus, it appears that HTPs, similar to a variety of e-cigarettes, generalize as a cue for smoking. Despite these findings, those in the IQOS group rated the actors in the video as less likeable, friendly, and the device itself as less desirable. Although it is currently unclear how HTPs such as IQOS will fare in the variable regulatory climates across countries, this study is timely for our understanding of how their proliferation might impact susceptible groups such as young adult smokers who are targeted as the next generation of regular tobacco users, whether for combustible or newer alternative products. These observer effects should be weighed against the possible mitigation of health risks in adults smokers who are able to stop using combustible cigarettes by switching to use of HTPs, although notably, long-term benefits of HTPs have not been determined. However, our findings raise further consideration of where and how IQOS and other HTPs are marketed and designed. As novel tobacco products are continuously developed, it is possible that reducing their resemblance to traditional cigarettes could help tip the risk/benefit ratio to enhance public health and consider effects for society at large.

Human Subjects Approval Statement

This study was approved by the University of Chicago Institutional Review Board.

Conflict of Interest Disclosure Statement

No conflicts to disclose

Acknowledgements

Appreciation is extended to Dingcai Cao for assistance with statistical analysis and to Martin Awano for video production. This research was supported by NIDA (R01-DA044210). Salary support for EIB was provided by National Institutes of Health (T32-DA043469).

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SUPPLEMENTARY METHODS AND RESULTS

Video Scene Details

A more detailed description of the proprietary video cues is included in this supplementary material as this level of detail was outside of the scope of the main manuscript. The videos used for the water and IQOS cues were created by a pre-professional videographer from the University of Chicago. Along with lab staff members, the videographer was able to create 2 identical videos depicting 3 actors using bottled water or IQOS.

The majority of scenes depicted one actor, though several scenes involved 2- and 3-person interactions (Table S1). A diverse group of actors (black male, Asian female, white female) were selected to help ensure that the demographics in the video were somewhat representative of the study sample. The solitary scenes consisted of an individual using or holding the product while appearing to walk, sit, or drive a vehicle, and engage in reading, concentrating, daydreaming, or listening to music on earphones. The 2- and 3-person interaction scenes showed the individuals engaging in generally pleasant back-and-forth. A series of nondescript locations, where one might naturally encounter people people using a tobacco product or drinking water, were selected to serve as settings for the shoot.

The videos were filmed on 2 partly sunny days in May 2019 to avoid differences in background weather. Scene types were also selected with reference to how many individuals were in the frame, how tight the framing would be to the person(s), and who in the scene would be using the product (Table S2). For each of these scenes, the goal was to capture a hand-to-mouth movement while showing the person using it. Scene types were designed to capture ordinary use as would be typical in naturalistic settings as opposed to shots specifically highlighting product features or its use. The IQOS was used in the video in a conventional manner with it held between thumb and fingers and inhaled in a motion similar to smoking. The bottled water was used in the standard method of holding it in hand between thumb and fingers with hand-to-mouth motions for ingestion. To ensure that all scenes were identical with the exception of product used, they were filmed on the same day, one after another (eg, a scene with IQOS was filmed and then the same scene with bottled water was filmed immediately after, and visa-versa).

Videography Specifications

The video was shot with a Sony A7S camera with a E-mount FE i.8 50mm lens. The camera was mounted on a Ikan 7" articulating arm to stabilize the camera. The camera settings were consistent from scene to scene with the exception of aperture, which was recalibrated to maintain good exposure depending on how the environment was lit. The shutter speed was set to 1/125, the ISO was set to 100, the white balance was set to automatic, and the stabilizer's motor was set to a power level of medium ("M").

GEE Results

For the main study measures, the IQOS (vs water) cue produced significant increases in BQSU smoking urge and desire for a cigarette, a mod/vape pen, and a JUUL (main effects of group, all p s < .05). As expected, the water (vs IQOS) cue elicited a greater desire for water (group, p = .04). Table S3 displays full GEE results.

Smoking Choice Reasons

Table S4 describes reasons for choosing to smoke during the Smoking Lapse Paradigm among those who chose to smoke within the 50-minute timeframe. Participants were able to express agreement with all or none of the provided reasons (eg, they were not limited to agreeing with one response option).

SUPPLEMENTARY TABLES

Table S1: Number of one-, 2-, and 3-person scenes by setting location in the active and control video. Actors appeared in scenes either alone, with one other person, or 2 other people. Setting locations included indoor scenes (31%) and outdoor scenes (69%).

Table S2: Displayed hand-to-mouth movement by actor race/gender and type of shot. Scenes were broken down by different types of shots. The camera captured the actors using the product through a wide shot, close-up shot, work/study shot (actor seen reading or looking at a computer), or a social shot (2 or 3 actors appearing to have a neutral conversation).

Table S3. GEE results on urge and desire change scores.

Main effect and interactions results for BQSU smoking urge and desire for a cigarette, mod/vape pen, JUUL, and water.

Table S4: Reasons for choosing to smoke in latency task of the Smoking Lapse Paradigm. Agreement was rated on a one to 7 scale, with higher values indicating higher levels of agreement.

Table S1
Scenes by Indoor and Outdoor Setting Types and One-, 2-, and 3-Person Scenes (Active and Control)

	One-person	2-person	3-person	Total
Indoor				
Study room	7	2	0	9 (31%)
Outdoor				
Lakefront	3	0	0	3 (10%)
Park	5	2	2	9 (31%)
Streetside	6	1	0	7 (35%)
Car	1	0	0	1 (3%)
Total:	22 (76%)	5 (17%)	2 (7%)	29 (100%)

Note.

Values are N (%). The IQOS and water videos were identical on the number of actors portrayed and the scene locations.

Table S2
Hand-to-Mouth Movements by Actor and Scene Shot Types

	Wide	Close-Up	Work/Study	Social	Total
Black Male	1	4	1	2	8 (30%)
Asian Female	1	5	0	1	7 (26%)
White Female	1	6	1	4	12 (44%)
	3 (11%)	15 (56%)	2 (7%)	7 (26%)	27 (100%)

Note.

Values are N (%). The IQOS and water videos were identical on the number of hand-to-mouth movements, actors, and scene shot types.

Table S3
GEE Results on Urge and Desire Change Scores

	Group		Time		Group x Time	
	Wald χ^2	p	Wald χ^2	p	Wald χ^2	p
Smoking urge (BQSU)	6.25	.01	4.32	.04	2.27	.13
Desire for						
Cigarette	4.05	.04	27.02	.00	1.83	.18
Mod or Vape Pen	10.32	.00	0.00	.99	1.09	.30
JUUL	6.93	.01	0.03	.86	0.47	.50
Water	4.19	.04	1.70	.19	3.60	.06

Note.

Data are Wald χ^2 and p-value for GEE tests for group, time and their interactions on the main outcomes. All analyses included baseline score as a covariate.

Table S4
Participants' Reasons for Choosing to Smoke During Latency Portion of the Smoking Lapse Paradigm

	Percent Agreement
I wanted to smoke	94.2%
I was bored	81.2%
I wanted to feel stimulated	68.1%
I wanted to reduce tension/stress	56.5%
The money wasn't worth it	42.0%
I thought it was cool to smoke in the building	31.9%
I saw someone else smoking/vaping	18.8%

Note.

Values are shown as percentages of sample that agreed with the stated reason for lapsing. The IQOS and water groups reported similar agreement across items with the exception of "I saw someone else smoking/vaping," which was 28.9% in the IQOS group compared with 6.5% in the water group.