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Visual Attention to Antismoking PSAs: Smoking Cues Versus Other Attention-Grabbing Features

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Abstract

This study examines how addicted smokers attend visually to smoking-related public service announcements (PSAs) in adults smokers. Smokers' onscreen visual fixation is an indicator of cognitive resources allocated to visual attention. Characteristic of individuals with addictive tendencies, smokers are expected to be appetitively activated by images of their addiction—specifically smoking cues. At the same time, these cues are embedded in messages that associate avoidance responses with these appetitive cues, potentially inducing avoidance of PSA processing. Findings suggest that segments of PSAs that contain smoking cues are processed similarly to segments that contain complex stimuli (operationalized in this case as high in information introduced) and that visual attention is aligned with smoking cues on the screen.

Some antismoking public service announcements (PSAs) have smoking cues as a part of the ad. The way smokers process these cues in antismoking contexts may affect their ability to encode and later retrieve surrounding information (e.g., Due, Huettel, Hall, & Rubin, 2002; Meinke, Thiel, & Fink, 2006).

A smoking cue is an image related to smoking. These can include a cigarette, a smoker smoking, a pack of cigarettes, and so on. Smokers have a greater attentional bias toward smoking cues compared with other objects; that is, smokers spend more time looking at information containing smoking cues than other information in still photographs (Ehrman et al., 2002) and they are aware of them faster than other objects (Yaxely & Zwaan, 2005). Even smoking words create an attentional bias in heavy smokers in contrast to neutral words when completing an attentional blink task (Waters, Heishman, Lerman, & Pickworth, 2007).

In addition, attending to this information may induce an urge to smoke (e.g., Lee et al., 2007; Tiffany, Carter, & Singleton, 2000). Individual differences can moderate the effect of smoking cues on urge (e.g., Doran, Cook, McChargue, Myers, & Spring, 2008; Waters, Shiffman, Bradley, & Mogg, 2003).

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The relationship between smoking cues and smoking urge exists even in complex mediated contexts. In a study of antismoking PSAs, researchers found that smoking urge in response to ads with smoking cues goes up but only when there is a weak argument against smoking employed in the ad (Kang, Cappella, Strasser, & Lerman, 2009). These data suggest that smokers' visual attention while watching antismoking ads may be directed more at the smoking cues present than at other images more pertinent to the ad's antismoking purposes. This article uses eye tracking as a way to address questions of visual attention and smoking cues for smokers.

Eye tracking is a well-developed procedure that has been used effectively in research for more than a century (Duchowski, 2003). It allows researchers to determine how visual attention is allocated to a stimulus. As Thornson (1994, p. 80) suggests,

> EOS [eyes on screen] is . . . one of several tools for measuring attention to television . . . EOS is strongly related to memory, as most theories of learning would lead us to expect. It is also related to measures of liking what is viewed.

Research and neurological evidence have confirmed the link between where the eye is focused and how cognitive effort is being allocated. Much of the same cortical system activated by overt attentional processing is activated by covert attentional processing, which is situated largely in the visual and motor areas of the brain (Ohlendorf, Kimmig, Glauche, & Haller, 2007).

Research has used eye tracking to determine eye scanning path and visual salience (Itti, 2006; Rutishauser & Koch, 2007), explore the tradeoff between visual attention and working memory (Droll & Hayhoe, 2007), and understand the effect motivational relevance has on processing (Balcetis & Dunning, 2006). What subjects look at should undergo enhanced encoding and be more accessible later for retrieval, with acceptance potentially enhanced.

Smokers may be more likely to encode information containing smoking cues. They look at the cues more frequently than other pieces of information because the smoking cues have been paired often over long periods with a nicotine-based reward (e.g., Field & Cox, 2008; Hogarth, Dickinson, Hutton, Elbers, & Duka, 2006; Lee et al., 2007). Indeed, if smoking cues activate the appetitive system, it is likely that they will be better encoded (Lang, 2006a; Lang, Chung, Lee, Schwartz, & Shim, 2005; Lang, Chung, Lee,& Zhao, 2005). Appetitive activation encourages an organism to move toward an object, thus improving encoding (Cacioppo & Gardner, 1999). In contrast, aversive stimuli are those that encourage an animal to avoid or move away from an object (Cacioppo & Gardner, 1999). Research in the addiction and smoking literature supports the notion that smoking activates the appetitive processing system and thus the presence of smoking cues, which are paired repeatedly over time with smoking, also activates the appetitive system (Dempsey, Cohen, Hobson, & Randall, 2007; Ehrman et al., 2002; Mogg, Bradley, Field, & De Houwer, 2003; Mogg, Field, & Bradley, 2005). These effects may be moderated by quit attempts (Bradley, Mogg, Wright, & Field, 2003) and exacerbated by lower levels of nicotine in the system (Field, Mogg, & Bradley, 2003).

Although smoking cues likely activate the appetitive system, it is still possible that smokers may be overloaded by the smoking information in the message. If overload occurs, subjects should look away from the smoking cue and perhaps from the PSA itself (Anderson, Colombo, & Shaddy, 2006). Additionally, in anticipation of PSAs containing information directed toward changing their behavior, providing information they do not want to hear and thereby creating a form of aversive activation, smokers may avoid antismoking PSAs or at least reduce their attentional resources in some way (Jones & Owen, 2006; Kavadas, Katsanis, & LeBel, 2007). In summary, the negative context (i.e., an antismoking PSA) in which a smoking cue is contained may induce aversive activation even while the smoking cues themselves should be appetitive.

If smoking cues are very strong activating cues for smokers, then smokers' visual attention should be directed at the smoking cues more than at other parts of the PSA. However, the aversive nature of the information being presented mixed with the appetitive nature of the smoking cue, producing coactivation between the two systems, could create different responses for physiological and cognitive systems—for example, for attention or cognitive effort (e.g., heart rate) or memory (e.g., free recall or forced choice recognition). However, we expect that visual attention to smoking cues will compete well for smokers' visual attention regardless of other features of the PSA due to the long-term pairing of smoking with activation of the appetitive system in heavy smokers. Thus, smokers will spend more time visually attending to a PSA when it contains more frequent smoking cues or ones of greater duration.

Gaze fixation should vary both by PSA overall (i.e., for an entire PSA that contains a smoking cue) and for particular segments of a PSA that contain smoking cues. This is because there should be at least some level of excitation transfer (Ramirez, Bryant, & Zillmann, 1982) from the short-term exposure to the smoking cue to the rest of the PSA that contains the smoking cue. Excitation transfer occurs when an emotional state (such as appetitive activation) is activated. The duration of the activation of the emotional state may not be limited to the short period around the eliciting stimulus. Thus, the emotional state may affect the processing of later stimuli.

> H1: Smokers will have higher fixation duration on a PSA segment if it contains smoking cues than on a PSA if it does not contain smoking cues.

The above hypothesis compares PSA fixation duration for PSAs that contain smoking cues to those that do not. Of course, there are a myriad of factors that could affect eyes on screen, including sensation seeking, level of addiction, gender, and structural features of the PSA. For purpose of the current study, sensation seeking, level of addiction, and biological sex of the subject are treated as moderator variables because they can affect an individual's visual attention to both the PSAs and the PSA segments with smoking cues.

Antismoking PSAs are complex stimuli with many features to attract smokers' visual attention beyond smoking cues themselves. To begin to understand these other competitive attention-getting features of ads, we focus on information introduced (II; Lang, Park, Sanders-Jackson, Wilson, & Wang, 2007). II is a measure of information on screen after each camera change. The camera change is an example of an orienting eliciting structural feature (OESF) and has specific effects on processing of the information contained in the message. An OESF should elicit a viewer's orienting response, a reaction that affects processing. An orienting response is a precognitive automatic allocation of cognitive resources to processing. The response is associated with elevated skin conductance response (Lang, Chung, Lee, & Zhao, 2005), decrease in heart rate (Wise & Pepple, 2008), and decreased electroencephalogram (EEG) alpha frequency (Lynn, 1966).The amount of II during an OESF affects cognitive load.

II is a coded measure of structural features of a message. Lang (2006b) defines II as a measure of how many resources are required to process a message. Coding is triggered by a camera change and what follows, including "(a) emotionally different, (b) a new focal object, (c) new to this message, (d) expected or related, (e) closer to the camera, (f) seen from a new perspective, or (g) presented in a different form" (Lang et al., 2007, p. 326). Thus, high-II segments should increase resources automatically allocated to the processing of the PSAs (until overload) (Lang et al., 2007) because of the effects of OESFs on

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processing load. II should be particularly sensitive to increased resource allocation to visual information due to its visually heavy nature. If smoking cues induce appetitive activation, they should induce visual behavior that is similar to any other component of II. That is, they should increase resources automatically allocated to processing the PSA until overload.

Both smoking cues and high-II segments should increase allocation of visual attention and cognitive resources. The concept behind II is that human beings are limited capacity processors. Thus, if too much information is presented too rapidly in a mediated message, especially images or sounds that should elicit an orienting response, then there will not be enough resources to effectively process the message (Lang et al., 2007). This overload has been shown in a number of contexts including processing of television messages (Fox et al., 2004; Lang, Chung, Lee, & Zhao, 2006) and processing of radio messages (Potter, 2000). However, prior to overload, an increasing number of structural features should actually improve message processing. Appetitive stimuli should reduce the likelihood of overload as they increase processing resources available for encoding of new information (Cacioppo & Gardner, 1999). It is unclear if the structural features of PSAs are equivalent to smoking cues in their effect on cognitive load. Although we would predict both high-II segments and smoking cue segments should increase visual attention, it is not clear which will increase visual attention more—high-II segments or the presence of smoking cues. Thus the following research question is proposed:

> RQ1: Will II or the presence of a smoking cue most affect gaze fixation duration?

Gender, sensation seeking, and level of addiction could moderate visual attention to smoking cues. Level of addiction may affect how people process smoking-related cues (Smolka et al., 2006) and sensation seeking may be related to how interested they are in the feeling of arousal created by the smoking-related cues (e.g., Palmgreen et al., 1991; Palmgreen, Stephenson, Everett, Baseheart, & Francies, 2002). So we pose the following research question:

> RQ2: Will the relationship between II and the presence of a smoking cue be moderated by sensation seeking and Fagerstrom Test of Nicotine Dependence scores?

In addition, it is possible that there are gender differences in how smokers process antismoking PSAs. Males and females may have biologically based differences in their underlying addictive systems along with different socialization (Becker, 2009) and have differentiated processing effects of exposure to cigarette smoke prenatally (Schuetze, Lopez, Garner, & Eiden, 2008) and during adolescence (Jacobsen et al., 2007). Kang et al. (2009) found significant differences in processing of smoking cues by gender—such that males experienced larger decreases in skin conductance when viewing smoking cues than females, who showed little change. Thus, males and females may process smoking cues differently based on differences in underlying motivational and processing systems that interact with their addiction. So we propose the following research question:

> RQ3: Will there be a difference for gaze fixation duration on smoking cue segments between males and females?

Method

Overview

This study is a secondary analysis of data from a study of visual attention to anti-smoking PSAs that differed in terms of their strength of argument against smoking and their structural features measured in terms of their "message sensation value" (e.g., Palmgreen et al., 1991; Stephenson & Palmgreen, 2001). Argument strength is a rated measure of how effective an argument is for a particular audience (Petty & Cacioppo, 1986). Arguments that are of higher strength are generally associated with attitude change (e.g., Hosman, Huebner, & Siltanen, 2002).

The original study was not designed to assess visual attention to smoking cues. The current study evaluated the PSAs for the presence of smoking cues and selected PSA segments differing on smoking cues and other structural features (II) described below.

Subjects

Eighty-four individuals participated in the study. They were recruited from a large U.S. metropolitan area using Craigslist, print advertisements, and word of mouth. In total, 44 were male, 47 were African American, 1 was Asian, and 27 were Caucasian, with the remainder listing "Other." Subjects ranged in age from 18 to 65 years of age with a mean age of 36.9 years (*SD* = 13.3). Subjects began to smoke on average at 14.7 years with a range of smoking initiation between 8 and 26 years. In the original study, subjects were randomly assigned to one of four conditions, each of which contained half of the stimuli as described in the design subsection. They were paid $40 for their participation. Individuals who were undergoing smoking cessation treatment were not included in this study.

Apparatus

The *Eye Movement Data Collection System*, the Applied Science Laboratories Model 504, measures pupil diameter and point of gaze on a visual display system. Recorded data include time, *x* (horizontal) and *y* (vertical) eye position coordinates, and pupil diameter. One display system was used for presentation of stimulus materials: a large flat panel PC color monitor (19″) chosen to most closely mimic the common interfaces that adults would likely use to increase the ecological validity of the project. The flat panel PC resolution quality is similar to flat panel TV systems.

Data imputation

Of the original 84 participants, 71 subjects were retained in this study. The rest were dropped because 20% or more of their data were missing for each of the eight PSAs they were asked to view or due to the fact that their (visual attention) scores were three standard deviations or more beyond the mean of scores. Missing data resulted from equipment error and noncompliance with the task. In addition, some of the subjects who were retained for the analysis generally were not used in all analyses for a group of segments as some of these subjects had no valid data for one of the four categories of segments (high-II no cue, low-II no cue, high-II cue, or low-II cue).

After subjects were dropped for excessive missing data, data imputation occurred for the remaining subjects for applicable segments. Data imputation only occurred for a segment if a subject had less than 20% missing data in the PSA containing that segment. Data were imputed if the space between two data points was at or greater than 0.02 seconds (because those data should have collected at roughly 0.017 seconds). The amount of data imputation varied by subject with a mean percentage of data imputed at 10.9% (*SD* = 4.3%) across subjects and PSAs. The last collected data point was used as a likely value for subsequent data points. The assumption behind this, which is the same assumption for estimating gaze pattern, is that the gaze does not vary significantly over data collection points. To verify this assumption, the data on eight PSAs for 10 randomly selected subjects were analyzed, piece by piece, for the amount of space between one gaze segment and the next. Little difference was found over the 0.018-second increment at which the data imputation was set to occur. This is expected given the relative stability and lack of rapid gaze change found in a number

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of previous eye tracking studies even dating back to the beginning of the method (Buswell, 1935).

In addition, two subjects had incomplete data for sensation seeking and six subjects had incomplete Fagerstrom Test of Nicotine Dependence data. Missing data were replaced on an item-by-item basis within each scale with the mean from other subjects being used for the response on the missing item.

Procedure

Subjects entered a small room and were asked to sit in a comfortable chair in front of a computer screen. They were then fitted with a head apparatus prior to being trained on the equipment described above. Following the fitting procedure, participants provided demographic, smoking, and sensation seeking information. Each subject viewed 8 of 16 PSAs. Two orders were created for one set of PSAs and two orders for the other set. Participants then completed additional questionnaires and free and cued-recall tests.

Coding of segments

Smoking cues were operationally defined using three categories and consensus coded by two trained coders. The three categories were smoking artifact, smoking action, and active smoking. Smoking artifact included the presence of items that could be used for smoking but are not being used at that moment. For example, this category would include a pack of cigarettes unopened or a cigarette in an ashtray. Smoking action pertained to the holding and handling of cigarettes (Hutchinson et al., 1999; Hutchinson, LaChance, Bryan, & Smolen, 2002). If within 2 seconds after the smoking action began the cigarette was lit and puffed, this was no longer categorized as a smoking action. Rather, it was placed into the third category of active smoking.

Selection of segments that do not contain smoking cues—To compare visual attention to PSAs with and without smoking cues, we selected segments of PSAs to compare. First, segments with smoking cues were chosen. Across the ads, 42 segments with smoking cues occurred; all were included. Smoking cue segments had a mean duration of 1.84 seconds and a standard deviation of 2.05 seconds.

Segments that did not contain smoking cues were chosen based on three criteria. The first was absence of a smoking cue. That is, there were either no smoking cues in the entire PSA from which the segment was taken or there was no smoking cue anywhere in the PSA *preceding* the chosen segment. This criterion was used to prevent the effects of viewing a smoking cue from affecting the processing of the control segments that did not contain smoking cues. If a smoking cue preceded a noncue comparison segment, there could be residual attention from the smoking cue directed to materials following.

Duration was the second criterion for selection of a smoking segment. We tried to match the duration distribution between high-II and low-II nonsmoking cue segmentswiththedistributionforsmoking cuessegments.Thisattemptwasonlypartially successful. There is no significant difference between the high-II group and the smoking cues in terms of duration of segment, $t(41) = 0.89$; however, there is a significant difference between the low-II group and the smoking cues, $t(41) = 2.74$, $p < .01$, such that smoking cue segments have significantly higher durations than low-II segments.

The third criterion was II. II is measured after camera changes. For every camera change that occurred, there were seven categories of information that were coded by comparing the current scene to the scene immediately preceding it. Lang, Chung, Lee, and Zhao (2006) and

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Lang et al. (2007) define II as a measure of how many resources are required to process a message. Coding categories triggered by a camera change include "(a) emotionally different, (b) a new focal object, (e) new to this message, (e) expected or related (i.e, does something after the change violate expectations of what should have been there), (e) closer to the camera, (f) seen from a new perspective, or (g) presented in a different form" (Lang et al., 2007, p. 326). An example of presenting something in a different form is a scene changing from black and white to color. If the answer to the category questions (above) is yes, then a "1" was added to the coding sheet for that category and scene; if the answer is no, then a "0" was coded for that category and scene. II intercoder reliability for two trained coders using Krippendorff's α was .92. II was used as a measure of the structural complexity of the segment. This measure allows control of message segments for competing targets of visual attention. Other structural features of the message (measured as a part of II) may create comparable levels of attention to smoking cues, due to their attention-grabbing nature.

Design

In the original study, each of the 16 PSAs was viewed by one half of the subjects. After the selection of cue and noncue segments, the design became a two II (high and low) by two smoking cue (cue and no cue) with repeated measures on segments. A total of 126 segments were distributed as follows: 42 segments for each of the high- and low-II no cue conditions, 31 segments for high-II cue condition, and 11 segments for the low-II cue condition. The asymmetry in the number of cue segments is the result of the selection criteria employed; otherwise, all possible smoking cue segments were retained.

Dependent variable

The dependent variable is the fixation duration of gaze on a section of the PSA. A longer gaze indicates more visual attention. Fixation duration is the amount of time a subject is looking at a particular x,y coordinate on the screen. Fixation data by x,y location was collected every 1/60th of a second. For analytic and descriptive purposes, the viewing screen was divided into a 7 × 7 grid (creating 49 viewing blocks overlaid conceptually on each PSA). An additional area that surrounds the PSA in black on the screen that does not include the PSA was also identified as a location for visual attention, obviously "off-ad." The more often a viewing block contained a fixation, the more likely individuals are to have the information in that area available for processing as informative (e.g., Buswell, 1935; Mackworth & Morandi, 1967; Yarbus, 1967). Coordinate data (x and y positions of a visual fixation) were aggregated into one of the 7 × 7 viewing blocks for each subject across each PSA segment viewed.

As not all subjects saw all PSAs, a method needed to be devised to compare across low-II, high-II, and smoking-cue segments for each subject. That is, each segment needed a unique value measuring the distribution of gaze fixations across the three types of segments. A statistical measure of uncertainty or variation of gaze fixation across the 7 × 7 grid was employed. The following equation from Krippendorff (1986, p. 13) provides a good measure of uncertainty in the spatial distribution of visual attention:

$$\text{Uncertainty} = \log_2 \quad N_A - \log_2 \quad N_a$$

$$N_a = \sum_{j}^{i} p_{ij} \quad \log_2 \quad p_{ij}$$

where N_A is a measure of the probability of viewing the alternatives available (in this case, the 49 viewing blocks of the PSA) at baseline (i.e., at chance) is $\log_2(1/49)$, which equals 5.61. N_a is a measure of the actual probability distribution of the viewing. P_{ij} is the proportion of looking at the *i,j* cell averaged segments by viewer. Thus, a lower level of uncertainty indicates a greater focus on a particular location on screen (less spatial variation). Conversely, a higher level of uncertainty indicates more distributed viewing across the 7×7 grid.

The method for calculating uncertainty for each individual segment is as follows. First, fixation duration for each of the 49 matrix blocks was calculated for each segment. Then, the fixation duration was divided by the total amount of time the segment was viewed. Next, the fixation duration that was divided by time was averaged across matrix blocks for the segment across person to create a single measure of uncertainty.

Moderator variables

Level of addiction to smoking is operationally defined by the Fagerstrom Test of Nicotine Dependence Scale from 0 to 10 ($M_{Fagerstrom} = 4.71$, $SD = 2.13$) with higher values indicating a higher level of addiction (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). Owing to the limited size of our data, analysis using the 11 groups established by the Fagerstrom Test of Nicotine Dependence (score from 0 to 10) would diminish statistical power; moreover, examination of the distribution of addiction showed patterns that were consistent with fewer levels of addiction obtained by grouping similar scores together. We determined that three levels of addiction—low dependence (Fagerstrom Test of Nicotine Dependence from 0 to 4), medium dependence (Fagerstrom Test of Nicotine Dependence of 5), and high dependence (Fagerstrom Test of Nicotine Dependence from 6 to 10)—best captured these patterns and provided better statistical power for our analysis.

Sensation seeking is operationalized using the eight-item sensation seeking scale (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002; Stephenson, Velez, Chalela, Ramirez, & Hoyle, 2007). Subjects were divided into high and low sensation seeking groups by a median split because the majority of sensation seeking research divides subjects into these categories. Biological sex was also used as a moderator variable.

Analysis strategy

For H1 (the only PSA level hypothesis), mean fixation duration was calculated by averaging across subjects for each PSA and completing an analysis of variance (ANOVA) to compare PSAs that contained smoking cues and those that did not. An uncertainty statistic was not computed for the first hypothesis due to its aggregate nature over both time and space. The remainder of the analysis was completed on a segment-by-segment basis with the uncertainty score averaged within each subject within condition—allowing for individual differences to be used as between-subjects factors.

For RQ_1, RQ_2, and RQ_3, a repeated measures ANOVA with sensation seeking, Fagerstrom Test of Nicotine Dependence score, and subject gender (depending on the research question) as between-subjects variables and uncertainty in conditions—smoking cue—present or absent and II—high II or low II—as the within-subjects variables was completed.

Results

Hypothesis 1 was not supported. There was no effect of the presence of smoking cues on eyes onscreen versus offscreen, $t(14) = 1.58$, $p = .37$.

Research Question 1 asked if II or the presence of a smoking cue would most affect gaze fixation duration. There is a statistically significant main effect of II $F(1,60) = 27.94$, $p \leq .001$, $\eta_p^2 = .32$) such that viewing high-II segments is associated with lower levels of uncertainty ($M = 0.06$, $SE = .02$) than viewing low-II segments ($M = .18$, $SE = .01$). There is

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also a statistically significant main effect of smoking cues, $F(1,60) = 9.47$, $p = .003$, $\eta_p^2 = .14$, with segments containing smoking cues ($M = 0.09$ $SE = .01$) having less uncertainty (that is, more focused) in viewing than segments without smoking cues ($M = 0.16$, $SE = .02$). Though there were no significant interactions between II and presence of cues on uncertainty, the direction of the results is intriguing (Table 1).

Research Question 2 asked whether any of the findings above were moderated by either sensation seeking or Fagerstrom Test of Nicotine Dependence scores. Sensation seeking and Fagerstrom Test of Nicotine Dependence score were added to the repeated measures ANOVA. Individuals were divided into high, medium, and low sensation seekers and high, medium, and low Fagerstrom Test of Nicotine Dependence groups.

The main effects for cue type, $F(1,38) = 4.41$, $p = .04$, $\eta_p^2 = .10$, and II, $F(1,38) = 39.29$, $p < .001$, $\eta_p^2 = .51$, remained significant when sensation seeking and Fagerstrom Test of Nicotine Dependence were added to the model. There was no significant interaction between sensation seeking and cue, $F(2,38) < 1.00$, $p = .63$, $\eta_p^2 = .02$, or sensation seeking and II, $F(2,38) < 1.00$, $p = .57$, $\eta_p^2 = .03$. There was also no significant interaction between Fagerstrom Test of Nicotine Dependence and II, $F(2,32) = 2.22$, $p = .12$, $\eta_p^2 = .11$, though it approached significance. There was a marginally significant interaction between Fagerstrom Test of Nicotine Dependence and II, $F(2,32) = 2.49$, $p = .10$, $\eta_p^2 = .12$. The interaction between II and Fagerstrom can be found in Figure 1.

Research Question 3 asked whether men and women would have different gaze durations on smoking cues. There was no significant interaction between sex and presence/absence of cues, $F(1,59) < 1.00$, $p = .64$, $\eta_p^2 < .01$.

Decomposing uncertainty for smoking cue segments

The reduced variation in visual attention for the smoking-cue segments in comparison to the low-II segments does not tell us whether the localization of visual attention is in fact increased visual attention to smoking cues. To assess where visual attention is being directed in the smoking-cue segments, a separate analysis was carried out. A method for comparing the parts of the screen that contained smoking cues to the parts that did not contain smoking cues was based on research by Van der Lans, Pieters, and Wedel (2008). They compared spatial distributions of salient stimuli to investigate eye movement during a search task. We chose to use a measure of correlation for the smoking segments between the position of smoking cues on the screen and visual attention by viewers on the 7 × 7 PSA grid.

For each smoking-cue segment, the position of the smoking cue on the 7 × 7 grid was coded as close to every 0.16 seconds as was possible given the quality of the videos and the Gazetracker software.[1] An estimate of the approximate percentage of each grid block that was occupied by a smoking cue from 0% to 100% in increments of 10% was made. For example, if a cigarette pack occupied 50% of frame (3,3) for the whole duration of the segment, then frame (3,3) would have a value of 0.50 while all other cells of this video segment would be zero. These values were then averaged across each smoking segment for each grid block. This procedure provided a single 7 × 7 matrix for each smoking-cue segment representing the extent to which the smoking cue was distributed across the array for the duration of the segment.

For each smoking-cue segment, the two 7 × 7 distributions were compared—one for subject gaze duration and the other for smoking-cue distribution. The two distributions were

[1]To do this, PSAs were divided into 7 × 7 grids within Gazetracker. A trained coder estimated the percentage of a smoking-related cue that was contained in each grid at each time point available.

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compared using the Pearson correlation between the smoking cue's presence in the (*i*,*j*) cell and visual fixation in that cell over the duration of the segment.[2]

Pearson's correlation was carried out between the 49 cells for each smoking segment associating smoking cue position to proportion of visual attention. Matrix grid blocks were averaged across subjects for each segment and compared to the percentage of the grid block containing a smoking cue for that segment.

The mean value for Pearson's $R = .39$, $SD = 0.32$, $Min. = -0.26$, and $Max. = 0.97$. Twenty-six segments had correlations greater than .25 ($p < .05$); four correlations were negative with two at or near significance (r –.21, –.26).

The variation in correlation between smoking cue and viewing indicates that smokers do not simply fixate on smoking cues. We sought to explain some of this variation in visual attention to smoking cues. First, Pearson's *r* was transformed to Fisher's *Z*. The variation in Fisher's *Z* was explored in terms of the characteristic of each of the 42 segments including the kind of smoking cue present, the strength of the antismoking argument in the segment, and the level of II.

Three factors were explored: active versus passive smoking cues, argument strength, and II and the interaction between cues and argument strength. Smoking artifacts and "holding and handling cigarettes" were combined and compared with active smoking. The latter should draw more attention. A smoking-addiction-related craving is produced by pairing an external stimulus, such as holding a cigarette, with access to nicotine (e.g., Niaura, Abrams, Demuth, Pinto, & Monti, 1989). Active smoking should be closer to the exposure of the smoking cue to nicotine than either handling a cigarette or other passive cues, thus eliciting a greater craving. Strong arguments should reduce attention to smoking cues compared with weaker arguments consistent with the direction of findings by Kang et al. (2009). II should compete with smoking cues so that low-II segments will produce greater smoking cue–visual attention associations.

Main effects for these three factors and one interaction between type of smoking cues and argument strength were explored with Fisher's *Z* for the correlation of cue presence and visual attention as the outcome measure. A significant main effect for type of cue, $F(1,37) = 6.35$, $p = .016$, argument strength, $F(1,37) = 2.05$, $p = .002$, and a significant interaction for cue type by argument strength, $F(1,37) = 7.06$, $p = .012$, were obtained. No effects were seen for II, $F(1,37) = 0.44$, $p = .513$. The direction of effects is interesting, with associations between cue and visual attention stronger in active smoking segments ($M_{active} = 0.63$, $M_{passive} = 0.42$), when arguments are weak ($M_{weak} = 0.59$, $M_{strong} = 0.34$), and for the combined effects of weak arguments and active smoking cues ($M_{active\times weak} = 1.31$, $M_{others} = .33$ to .47). Although these findings are based on a very limited number of observations ($N = 42$ smoking segments), they do explain 28% (20% adjusted) of the variance in the viewing-cue correlations and they are consistent with expectation and prior literature. That is, more "eyes on the smoking cue" occurs with active smoking, embedded in weaker antismoking arguments.

[2]This analysis was also completed using Moran's *I*, a measure of spatial-auto correlation (e.g., Li, Calder, & Cressie, 2005). The advantage of the Moran's *I* analysis is that it takes spatial adjacency into consideration as part of the calculation of the relationship between one look zone and another. However, results for the Moran's *I* and Fisher's *Z* analysis were similar though not identical and the space required to explain the complexity of the Moran's *I* analysis is beyond the scope of this article. The Spearman's ρ correlation between Moran's *I* and Pearson's *R* is $\rho = .72$, $p < .001$.

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Discussion

Variation in visual fixation is reduced when smoking cues are present. In addition, the localization of visual attention does seem to center mostly—but not exclusively—on the smoking cues themselves more so when the cues involve active smoking by the characters and weak arguments against smoking.

Results generally supported earlier findings by Due et al. (2002), Hogarth et al. (2006), and Meinke et al. (2006) that individuals who have chemical addictions are more likely to attend visually to objects associated with their addiction—particularly those who are most heavily addicted. Whether this increased visual attention to smoking cues is problematic for increasing smoking urge or for interfering with the effectiveness of antismoking PSAs must await additional research. Studies by Kang et al. (2009) suggest that ads with smoking cues and with weak arguments increase smoking urge versus ads with strong arguments but we are unable to test that finding in these data nor test the effectiveness of the ads in achieving belief or intention change. Smoking cues do gain visual attention but whether this advances the ad's intention to reduce smoking behavior or retards it remains for future research.

Not all segments exhibited positive correlations between the smoking cue and visual fixations. Indeed, some were negative. We examined the ads with the negative associations, finding in the most negative case the smoking cue interspersed with highly negative, visceral images of a lung decaying and being filled with smoke. These negative images are likely to produce aversive activation that might lead the viewer to look away or to overload. The sample in this study included too few ads and segments to explore this possibility except in a cursory way.

It is also possible that the size of the smoking cue or its movement may play a role in the processing of the smoking cues. Additional research needs to be completed to understand which types of smoking cues increase fixation duration most. This work should control for the movement of the smoking cues themselves.

The results generally suggest that the inclusion of smoking cues within a PSA increases resources allocated to processing the PSA. This may improve memory and persuasion both through the association of smoking cessation information with an appetitive stimulus. Also, this may be because of an underlying increase in encoding due to appetitive activation. It is also possible that increased allocation of cognitive resources to segments that contain smoking cues (and perhaps to the smoking cues themselves) may detract from processing of other pertinent information in the message (such as information about how to quit smoking or the costs of continuing to smoke). Further research needs to be completed to address the effect of smoking cues not only on visual attention but also on important memory and persuasion tasks that may be affected by the strong draw that smoking cues offer smokers.

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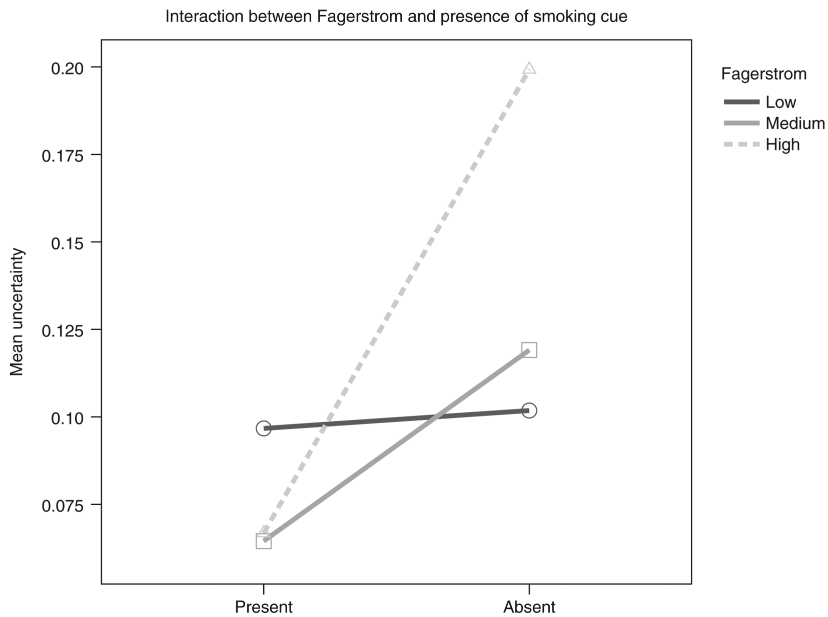

Figure 1.
Interaction between Fagerstrom Test of Nicotine Dependence and presence of smoking cues on uncertainty.

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Table 1

Average Uncertainty in Visual Fixation Across II and Smoking Cues

	Cue Present			Cue Absent		
II	***M***	***SE***	***N***	***M***	***SE***	***N***
Low II	0.13	0.01	11	0.24	0.03	42
High II	0.05	0.02	31	0.08	0.03	42