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Visual Attention to Tobacco-Related Stimuli in a 3D Virtual Store

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Abstract

We used eye tracking to measure visual attention to tobacco products and pro- and anti-tobacco advertisements (pro-ads and anti-ads) during a shopping task in a three-dimensional virtual convenience store. We used eye-tracking hardware to track the percentage of fixations (number of times the eye was essentially stationary; F) and dwell time (time spent looking at an object; DT) for several categories of objects and ads for 30 adult current cigarette smokers. We used Wald F-tests to compare fixations and dwell time across categories, adjusting comparisons of ads by the number of each type of ad. Overall, unadjusted for the number of each object, participants focused significantly greater attention on snacks and drinks and tobacco products than ads (all $P < 0.005$). Adjusting for the number of each type of ad viewed, participants devoted significantly greater visual attention to pro-ads than anti-ads or ads unrelated to tobacco ($P < 0.001$). Visual attention for anti-ads was significantly greater when the ads were placed on the store's external walls or hung from the ceiling than when placed on the gas pump or floor ($P < 0.005$). In a cluttered convenience store environment, anti-ads at the point of sale have to compete with many other stimuli. Restrictions on tobacco product displays and advertisements at the point of sale could reduce the stimuli that attract smokers' attention away from anti-ads.

Introduction

The point of sale (POS) is a central focus of tobacco company advertising. In 2016, the tobacco industry spent $51.9 million on POS materials, including ads and colorful displays of products (Federal Trade Commission, 2018). Tobacco advertising and promotions at the POS increase youth tobacco initiation (Feighery, Henriksen, Wang, Schleicher, & Fortmann, 2006; Weiss et al., 2006), undermine quit attempts by current smokers (Siahpush et al., 2016b), and encourage relapse among recent quitters (Paynter & Edwards, 2009). Tobacco companies also use the POS to target at-risk populations by placing greater amounts of POS tobacco advertising in low-income and African American communities (Balbach, Gasior, & Barbeau, 2003; Henriksen et al., 2008; Lavack & Toth, 2006; Lee, Henriksen, Rose, Moreland-Russell, & Ribisl, 2015; Perry, 1999; Siahpush et al., 2016a).

In recent years, tobacco control efforts have attempted to educate consumers about smoking cessation by placing anti-tobacco ads (anti-ads) at the POS (Coady et al., 2013; Food and Drug Administration, 2018). Between December 2009 and June 2010, as a result of a new tobacco control law, New York City placed mandatory graphic ads in convenience stores. These ads highlighted the potential negative consequences of smoking (Coady et al., 2013). However, the anti-ads were removed after the law was overturned in December 2010. Cross-sectional intercept studies conducted before and during the placement of the anti-ads showed that consumers reported noticing tobacco warning signs at the POS more while the anti-ads were in place than before the anti-ads were in place, and those who reported noticing the anti-ads were more likely to report thinking about the health risks of smoking (Coady et al., 2013). In addition, the national campaign Every Try Counts was launched by the US Food and Drug Administration Center for Tobacco Products in January 2018 (Food and Drug Administration, 2018) and as of December 2019 consisted of supportive pro-cessation ads placed in and around convenience stores.

Although anti-ads at the POS have the potential to reach smokers at a pivotal moment of decision making and dissuade them from purchasing tobacco products, anti-ads also have to compete for consumers' attention in a visually cluttered retail environment. As a result, knowing where smokers focus their visual attention in convenience stores may inform strategic development and placement of anti-ads. In addition to providing information about which objects are viewed in the POS, visual attention to tobacco-related stimuli has been associated with predictors of tobacco use behavior, such as the recall of stimuli (Klein et al., 2015; Peterson, Thomsen, Lindsay, & John, 2010). Two studies found a significant relationship between visual attention to warning labels and warning message recall (Klein et al., 2015; Peterson et al., 2010). Recall of tobacco-related stimuli has in turn been associated with tobacco use behaviors. Specifically, one study found that recall of anti-smoking ads from the *Tips from Former Smokers®* (*Tips®*) campaign was associated with quit attempts among cigarette smokers (McAfee et al., 2017).

Eye tracking provides an objective measure of information acquisition in the form of visual attention (Dutra et al., 2018a; Higgins, Leinenger, & Rayner, 2014). Visual attention is a precursor to information processing, which tends to influence decision-making processes (Meernik et al., 2016), recall, and other processes (Klein et al., 2015; Meernik et al., 2016). Eye tracking is less likely to be biased by recall than self-reported measures of attention (Higgins et al., 2014), has been validated through research (Wedel & Pieters, 2008), and has proven useful for tobacco control research (Meernik et al., 2016).

Two common measures of visual attention that eye tracking captures are dwell time, which is the amount of time an individual looks at a specific object, and fixations, which are the number of times an individual looks at an object. Eye-tracking research using two-dimensional (2D) images (e.g., words and images on paper) has revealed information about visual attention to objects in the POS, including anti-ads. A previous study conducted by the authors (Dutra et al., 2018a) used 2D eye tracking to examine visual attention to anti-ads among current smokers. The study identified differences in visual attention to anti-ads based on ad placement (whether the anti-ad was shown alone or next to a cigarette ad, tobacco

display, or drink cooler) but not by ad type (e.g., graphic, emotive, supportive). In addition, both dwell time and fixations have been associated with recall of 2D tobacco warning labels (Crespo, Cabestrero, Grzib, & Quiros, 2007; Fischer, Richards, Berman, & Krugman, 1989; Klein et al., 2015; Krugman, Fox, Fletcher, Fischer, & Rojas, 1994; Strasser, Tang, Romer, Jepson, & Cappella, 2012).

Although 2D eye tracking has revealed important insights about visual attention, three-dimensional (3D) eye tracking more closely approximates actual eye movements in a 3D space (such as a brick-and-mortar store) and visual attention to 3D objects in these spaces, even if the 3D space is viewed on a computer monitor (Dutra et al., 2018a; Wang, Koch, Holmqvist, & Alexa, 2018). Bansal-Travers et al. (2016) used 3D eye tracking to examine visual attention to tobacco products and advertising in brick-and-mortar convenience stores among young adult smokers. The study found high levels of attention to power walls (large, colorful displays of tobacco products) regardless of participant smoking status. However, this experiment and other 3D eye-tracking studies have not included anti-ads, a potential method of discouraging tobacco purchases at the POS.

To fill this gap in the literature, we used 3D eye tracking to examine how much visual attention current cigarette smokers paid to different types of pro-tobacco and anti-tobacco stimuli in a virtual convenience store called RTI iShoppe®. Virtual stores provide a flexibility in ad placement that may not be possible in physical convenience stores. Previous research has demonstrated the ability of virtual convenience stores to provide information about consumer behavior (van Herpen, van den Broek, van Trijp, & Yu, 2016).

We calculated fixations and dwell time for the following categories of visual attention in the store: (1) attention paid by product type (e.g., snacks and drinks, tobacco products, ads) during the shopping task, (2) attention to anti-ads out of attention to all types of ads, and (3) attention to anti-ads by location in the store. This study has the potential to reveal information about attention to pro- and anti-tobacco media in the tobacco retail environment.

Methods

Sample

In August 2016, a convenience sample of 32 adult (aged 18 years or older) current cigarette smokers (defined as smoking cigarettes on "some days" or "every day") in Raleigh, North Carolina, participated in the study. Two did not complete the survey after completing the eye-tracking task and were dropped from the analysis, resulting in 30 participants. Participants were recruited by First In Focus (FIF), a market research firm in North Carolina. FIF maintains a database of adult current smokers who have participated in their previous research studies. Through phone or email, an FIF staff member contacted adult current smokers in their database and, if eligible, invited them to participate in the study. Participants had to be 18 years or older, current smokers, and living in the Raleigh area at the time of the screening. Participants who wore bifocals, progressive lenses, or hard contact lenses were excluded because the eye-tracking hardware does not accurately record visual attention for individuals wearing these types of visual aids. FIF scheduled eligible participants to complete the experiment onsite at FIF.

Study Procedure

Upon arrival to FIF, participants provided informed consent. The consent form described the shopping task, which involved viewing a 3D virtual convenience store while the participant's eye movements were tracked with an eye-tracking device, and, afterward, completing a survey. The form stated that the purpose of the study was to collect information from 30 adults on their opinions about pro-tobacco and anti-tobacco images. After consenting, participants were seated in front of a laptop equipped with the automated contact-free SensoMotoric Instruments (SMI) Mobile Remote Eye-Tracking Device, version 7.2, a black rectangular box that sits at the interior hinge of the laptop where the monitor and keyboard meet. Before entering the virtual store, we gave participants a viewing task (e.g., look at Xs on a screen) to calibrate the eye-tracking hardware. The laptop had a 22-inch monitor with a resolution of 1680 × 1050 pixels.

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After we calibrated the eye-tracking device, we loaded the 3D iShoppe virtual convenience store. Additional information about iShoppe, which was developed in Unity, has been described in previous publications (Dutra et al., 2019; Dutra et al., 2018a; Dutra, Nonnemaker, Taylor, & Kim, 2018b; Guillory et al., 2019; Kim et al., 2017; Kim et al., 2013a; Kim et al., 2013b; Kim et al., 2014). The version of iShoppe that we developed for this experiment (Figure 1; online multimedia supplement) included 7 anti-ads, 25 pro-tobacco ads (pro-ads), 3 promotions, 14 other ads (i.e., for non-tobacco products), tobacco products, and non-tobacco products like drinks and food. We chose the number of each type of ad and placement of the ads based on the proportion of each ad type found in actual convenience stores we visited in the Raleigh area. Pro-ads hung from the ceiling and were placed around the checkout, on and near the gas pumps, on the e-cigarette display next to the checkout, on exterior windows and walls of the store, and on the entrance door. Pro-ads for popular cigarette brands were obtained from Kantar Media (Kim et al., 2017). Inside the store, anti-ads hung from the ceiling and were placed above the checkout counter, on the entrance door, and on the floor near the store entrance (ad clings placed on the floor). Outside the store, anti-ads were placed on an exterior window and above the gas pumps. Anti-ads included supportive and graphic ads from *Tips* with the Centers for Disease Control and Prevention logo removed and the national quitline phone number placed at the bottom to make sure that the ads were uniform (Dutra et al., 2019). Price promotions were placed on the tobacco display between rows of cigarette packs and displayed prices for and discounts on tobacco products. Ads for non-tobacco products were also placed around the gas pumps, on the floor of the store, by soda displays, on the ice cream cooler, and above the checkout.

Once the store environment loaded, participants followed on-screen instructions to complete a shopping task. Participants were instructed that they had a budget of $15 and to select items of their choice. Participants were able to explore the interior and exterior of the virtual store as desired; they did not have to take a specific path inside or outside of the store. Participants were permitted to spend a maximum of 10 minutes in the store before the virtual store program closed.

Figure 1. Store exterior, interior, and checkout counter

Exterior

Interior

Checkout counter

The software for the eye-tracking device was linked to the iShoppe Unity application using a custom software interface via a dynamic link library file (DLL). Unity ran at a speed of 60 frames per second (or 60 Hz on the computer monitor) during the experiment. Eye movements were recorded at a sampling rate of 120 Hz. The data from the DLL contained an event log that included timestamps and object identifiers, enabling us to identify visual attention to specific objects.

The eye-tracking device used a video camera pointed toward the participant's eyes to record video of the participant's eye movements while the participant viewed the computer screen (Wang et al., 2018). Then,

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eye-tracking software identified the location and movement of the pupil in the recorded video footage and drew a vector from the pupil of the participant's eye to the visual field to determine whether the end point of that vector laid in an area of interest (Wang et al., 2018). Before participants viewed the virtual store, we defined areas of interest for the store by outlining these objects in Unity. We created borders around the areas of interest to isolate them from the rest of the visual field.

Upon completing the task, participants were asked to complete a brief survey. They received a $50 cash payment for their participation. At this time, the researcher informed participants that they would not receive any of the goods selected in the virtual store. RTI is not authorized to distribute tobacco products; therefore, we could not provide the selected products because many participants chose to purchase tobacco products. The study was approved by the RTI International Institutional Review Board.

Measures

Fixations: We defined a fixation as at least two consecutive data points of eye-tracking data for the same object on the screen. However, we excluded observations of objects not of interest in our experiment that occurred between two observations for objects of interest. These data points would occur, for example, when a participant glanced at a shelf in the store in between two observations for an anti-ad. These observations are likely to be saccades, rapid reorienting eye movements in between blinks or fixations. In complex and crowded 3D environments, saccades often occur between fixations because of distraction. These saccades also commonly occur when objects in the visual field (here, the store) collide with the frame (or outline) of the store (in this case, the edge of the monitor) as the participant moves through the store (Vater, Kredel, & Hossner, 2017). After excluding these observations, we converted raw fixations into percentage of fixations attributable to a given object or area of the store to account for differences across participants in total number of fixations (and time) while in the store. We divided the number of fixations for that object or area by the total number of fixations recorded for a given participant during the shopping task.

Dwell time: The dwell time for a given object was defined as the difference between the first timestamp for an object and the last timestamp for that object in seconds. This method ensured that both fixations and saccades would be included in our measure of dwell time, which is consistent with the definition of dwell time in the literature. To account for differences across participants in the total dwell time recorded during the experiment, we converted raw dwell time into the percentage of dwell time attributable to a given object or area of the store. We divided the dwell time for a given object or area by the total dwell time recorded for a given participant during the shopping task.

Visual attention variables: We first expressed fixations and dwell time as the percentage of total visual attention in the store devoted to anti-ads, pro-ads, promotions, other ads, tobacco products, and non-tobacco products. For this comparison, we did not adjust by the number of ads and products included in the store because the small size of the products (e.g., cigarette packs on the display) makes it difficult to determine how many objects of a certain type the participant viewed. In addition, because of the large number of products in the store, calculations divided by the number of certain types of products (e.g., packs of cigarettes) would have been difficult to interpret as fixations (because they would likely be fractions of a second). We did adjust for the number of ads of each type when we examined the percentage of visual attention in the store devoted to each ad type (anti-ads, pro-ads, and other ads) and the percentage of visual attention devoted to anti-ads by location. We divided the percentage of total dwell time or fixations for each ad type by the number of ads of the type that the participant viewed. For example, if eye-tracking data indicated that a participant viewed 23 of the 25 pro-ads in the store, we divided the percentage of fixations and dwell time for pro-ads by 23. We also measured the percentage of participants who fixated on the tobacco display to facilitate comparisons with previous publications.

Cigarette cravings: We examined cigarette cravings as a potential correlate of visual attention paid to tobacco-related stimuli. Cravings were measured by the question "On a scale of 0 to 100, rate your urge

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to smoke cigarettes after shopping in the virtual convenience store with 0 being 'no urge' and 100 being 'strongest urge I have ever experienced.'"

Analysis

We used Stata MP version 15.1 to conduct all analyses. First, we produced descriptive demographic statistics for the sample. Then, we used mean percentages to describe dwell time and fixations (and standard errors), and we used adjusted Wald F-tests (which adjust confidence intervals for small samples) (Agresti & Coull, 1998) to identify significant differences in percentage of visual attention by object type, ad type, tobacco-related stimuli type, and location. F-tests can only be used to compare pairs of categories. As a result, multiple comparisons were needed when comparing values across variables with more than two values; we used a Sidak adjustment for multiple comparisons. We also used linear regression models to determine whether there was an association between cravings to smoke and percentage of visual attention (both dwell time and fixations) devoted to pro-ads, anti-ads, and tobacco products.

Results

Participant Demographics

The average age for the sample was 40.53 years (SD = 14.21; Table 1). The sample was split approximately evenly between women (46.7%) and men (53.3%). The sample was primarily non-Hispanic white (63.3%). Most of the sample (86.2%) had some college education or greater, and a large portion of the sample reported high income (33.3% had an income over $75,000).

Bivariate Analyses of Visual Attention Within Each Category of Variables

Percentage of Visual Attention by Object Type

In the virtual store, unadjusted by the number of objects and types of ads in the store, non-tobacco products like snacks received the greatest amount of visual attention (F: 31.36%, DT: 27.72%), followed by tobacco products (F: 14.80%, DT: 10.26%), pro-ads (F: 4.86%, DT: 4.47%) other ads (F: 1.44%, DT: 1.17%), anti-ads (F: 0.90%, DT: 0.83%), and promos (F: 0.65%, DT: 0.52%). All comparisons were significant for fixations and dwell time ($P < 0.005$) except for anti-ads versus price promotions (F: $P = 0.103$, DT: $P = 0.074$). In addition, for dwell time, there was not a significant difference between anti-ads versus other ads ($P = 0.127$).

Table 1. Demographic characteristics of thirty participants in the 3D iShoppe virtual convenience store shopping experiment

Demographic characteristic	*n*	Mean/%
Age	30	40.53
Gender		
Female	14	46.7%
Male	16	53.3%
Race		
Non-Hispanic white	19	63.3%
Non-Hispanic black	6	20.0%
Hispanic	1	3.3%
Non-Hispanic other race	2	6.7%
Missing	2	6.7%
Education		
High school degree	4	13.8%
Some college	13	44.8%
College plus	12	41.4%
Income		
Less than $25,000	4	13.3%
$25,000–$49,999	8	26.7%
$50,000–$74,999	6	20.0%
Greater than or equal to $75,000	10	33.3%
Missing	2	6.7%

Percentage of Visual Attention by Ad Type (Ads Only)

Adjusting for the number of ads of each type viewed by each participant in the virtual store, pro-ads received significantly greater visual attention (F: 4.92%, DT: 5.07%) than other ads (F: 3.61%, DT: 3.30%; all $P < 0.001$; Table 2) or anti-ads (F: 3.32%, $P = 0.001$; DT: 3.50% $P = 0.011$), which did not differ significantly from each other (F: $P = 0.534$, DT: $P = 0.757$; Table 2). All participants (100%) had at least one fixation on the tobacco display.

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Table 2. Percentage of visual attention devoted to different types of objects in iShoppe

	% fixations (SE)	% dwell time (SE)
Percentage of visual attention by object type (entire store)		
Anti-tobacco ads	0.90 (0.65)[bdef]	0.83 (0.74)[bdef]
Pro-tobacco ads	4.86 (2.67)[acdef]	4.47 (1.93)[acdef]
Price promotions	0.65 (0.54)[bdef]	0.52 (0.55)[bdef]
Other ads	1.44 (0.58)[abcef]	1.17 (0.52)[abcef]
Tobacco products	14.80 (6.77)[abcdf]	10.26 (5.65)[abcdf]
Non-tobacco products (i.e., snacks)	31.36 (6.46)[abcde]	27.72 (8.24)[abcde]
Percentage of visual attention by tobacco stimuli type (display only)		
Pro-tobacco ads	12.20 (8.99)[ce]	15.74 (10.17)[ce]
Price promotions	4.21 (2.93)[be]	4.58 (3.97)[be]
Tobacco products[k]	83.59 (9.18)[bc]	79.68 (10.80)[bc]
Cigarettes	76.63 (16.21)[hij]	78.48 (16.53)[hij]
Cigars	8.48 (8.84)[g]	6.00 (8.03)[gi]
Smokeless tobacco	10.76 (7.32)[g]	11.31 (8.37)[ghj]
E-cigarettes[l]	4.13 (6.05)[ghij]	4.21 (6.19)[gi]
Percentage of visual attention by ad type (ads only) Unadjusted for number of ads viewed by the participant for each ad type		
Anti-tobacco ads	12.37 (6.87)[bd]	12.84 (9.82)[bd]
Pro-tobacco ads	66.27 (11.77)[ad]	68.52 (13.49)[ad]
Other ads	21.36 (8.77)[ab]	18.65 (7.85)[ab]
Adjusted for number of ads viewed by the participant for each ad typem		
Anti-tobacco ads	3.32 (2.12)[b]	3.50 (3.04)[b]
Pro-tobacco ads	4.92 (1.32)[ad]	5.07 (1.39)[ad]
Other ads	3.61 (1.44)[b]	3.30 (1.66)[b]

Note: SE = standard error; 30 participants were included in the analyses; all figures are unadjusted by the number of ads and objects of each type, except where indicated.

[a] Significantly different from "Anti-tobacco ads" ($P < 0.050$).

[b] Significantly different from "Pro-tobacco ads" ($P < 0.050$).

[c] Significantly different from "Price promotions" ($P < 0.050$).

[d] Significantly different from "Other ads" ($P < 0.050$).

[e] Significantly different from "Tobacco products" ($P < 0.050$).

[f] Significantly different from "Non-tobacco products" ($P < 0.050$).

[g] Significantly different from "Cigarettes" ($P < 0.050$).

[h] Significantly different from "Cigars" ($P < 0.050$).

[i] Significantly different from "Smokeless tobacco" ($P < 0.050$).

[j] Significantly different from "E-cigarettes" ($P < 0.050$).

[k] Measures for types of tobacco products are percentage out of all tobacco products, not of display; significant differences between all types of tobacco products at $P < 0.050$ for fixations and dwell time except for fixations for cigars versus smokeless tobacco.

[l] Does not include Blu e-cigarettes because they were on a separate stand in front of the counter, not on the display itself.

[m] To create comparability across ad types, we divided visual attention for each ad type by the number of ads of that type that the participant viewed while in the virtual store.

Percentage of Visual Attention to Anti-Ads by Location

Adjusting for the number of each type of ad, anti-ads received a significantly greater amount of attention when placed on an external wall of the store (F: 26.79%, DT: 27.64%) or hung from the ceiling (F: 28.56%, DT: 27.41%) than when placed in the area by the gas pump (F: 9.51%, DT: 9.63%; all $P < 0.001$) or on the floor of the store (F: 11.32%, DT: 9.16%; all $P < 0.005$; Table 3). There were no significant differences in visual attention between the external wall and hanging (F: $P = 0.727$, DT: $P = 0.369$) or the gas pump and floor (F: $P = 0.657$, DT: $P = 0.651$).

Table 3. Percentage of visual attention by location, within each ad type in iShoppe

	% fixations (SE)	% dwell time (SE)
Anti-tobacco ads		
External wall	26.79 (17.88)[de]	27.64 (20.86)[de]
Hanging	28.56 (21.19)[de]	27.41 (22.79)[de]
Pump area	9.51 (13.48)[ac]	9.63 (17.15)[ac]
Floor	11.32 (17.83)[ac]	9.16 (18.01)[ac]
Pro-tobacco ads		
External wall	5.57 (2.93)[dfh]	4.42 (3.35)[dfh]
Hanging	4.35 (5.74)[fgh]	3.36 (4.95)[dfgh]
Pump area	3.87 (1.97)[afgh]	9.14 (7.69)[acg]
Display	9.12 (4.39)[acd]	9.14 (5.62)[acg]
Door	7.19 (3.57)[cdh]	5.87 (3.47)[cdf]
Counter	10.22 (6.34)[acdg]	7.79 (6.94)[ac]
Other ads		
Internal wall	6.10 (7.41)[cdeh]	9.75 (14.17)
Hanging	18.60 (18.60)[be]	17.88 (20.45)
Pump area	12.53 (11.32)[bh]	15.08 (14.56)
Floor	11.22 (8.52)[bch]	10.79 (11.26)
Counter	19.68 (10.97)[bde]	15.34 (10.68)

Note: SE = standard error; 30 participants were included in the analyses; all figures are adjusted by the number of ads of each type viewed by participants.

[a] Significantly different from "External wall" ($P < 0.050$).

[b] Significantly different from "Internal wall" ($P < 0.050$).

[c] Significantly different from "Hanging" ($P < 0.050$).

[d] Significantly different from "Pump area" ($P < 0.050$).

[e] Significantly different from "Floor" ($P < 0.050$).

[f] Significantly different from "Display" ($P < 0.050$).

[g] Significantly different from "Door" ($P < 0.050$).

[h] Significantly different from "Counter" ($P < 0.050$).

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Bivariate Analysis of Cravings and Visual Attention

We found no significant relationship between cravings and any of the outcome variables. *P* values for these analyses ranged from a low of 0.125 for the relationship between cravings and percentage of dwell time for tobacco products (out of visual attention for the tobacco display) to a high of 0.934 for the relationship between cravings and the total percentage of fixations for pro-ads overall.

Discussion

We conducted a virtual shopping experiment to identify aspects of the POS that most attracted consumers' attention. Through eye tracking, we measured visual attention to products and advertisements typically available at the POS. Results showed that participants, who were 30 cigarette smokers obtained via convenience sample in Raleigh, North Carolina, spent most of their visual attention in the store focused on products (snacks and drinks or tobacco), resulting in less visual attention to advertising. Out of visual attention to ads, pro-ads received significantly greater visual attention than anti-ads. One potential explanation for this finding is that pro-ads garner more visual attention than anti-ads. Pro-ads are appealing, tend to be colorful and attractive, and elicit positive feelings and responses. In contrast, anti-ads tend to contain graphic images that elicit avoidance (Crespo et al., 2007; Fischer et al., 1989; Maynard et al., 2014). Another potential explanation is that pro-ads appeared larger than anti-ads when viewed by participants in the store, therefore gathering more attention because of their larger size. Although the pro-ads loaded into the virtual store were on average smaller in size than the anti-ads, we cannot measure the exact size of the ad when viewed by participants, making it impossible to adjust for the size of the ads. The appearance (i.e., shape and size) of the object changes as the participant moves through the store, and it is not possible to determine where the participant was located in the store when viewing each image. As a result, we cannot exclude the possibility that these differences were caused by the size of the ads. However, one study suggests that size may not matter. Klein et al. (2015), in an eye-tracking study of tobacco warning labels, found no difference in attention to the graphic image portion of a tobacco warning label based on the size of the image.

The anti-ads placed externally on the store windows or hung from the ceiling in the middle of each aisle garnered the most visual attention out of all anti-ads in the store. One potential reason for this finding is that the anti-ads attracted more visual attention when placed in these locations, possibly because of fewer competing visual stimuli in these locations compared with when the ads were placed on gas pumps or on the floor of the store.

Comparison with Previous Literature

Our results are consistent with but not equivalent to those of the only other study that used 3D eye tracking to measure visual attention to tobacco products (Bansal-Travers et al., 2016). Bansal-Travers et al. (2016) randomly assigned young adults who smoked cigarettes or who were vulnerable to smoking cigarettes to purchase a candy bar only, a candy bar and a specific brand of cigarettes, or a candy bar and their cigarette brand of choice in a brick-and-mortar convenience store while wearing an eye-tracking device. Bansal-Travers et al. (2016) found that 28% of dwell time was dedicated to tobacco ads and products in their study. In the current study, 16% of dwell time was dedicated to pro-ads, tobacco price promotions, and tobacco products. Both studies found that most participants fixated on the tobacco power wall, but the percentage of attention devoted to this aspect of the store differed between studies. Bansal-Travers et al. (2016) found that 72% of participants in their study fixated on the tobacco power wall during the shopping task, whereas 100% of participants in our study fixated on the tobacco power wall while in the virtual store. The difference between these two figures may be because of differences in participant characteristics and shopping task instructions, and differences in the environments (physical store versus virtual store).

Limitations

This study has several limitations that should inform interpretation of the results. Because we used a virtual environment and not a brick-and-mortar store, it

is unclear whether our results are generalizable to behavior in physical stores. However, our use of products and ads that closely resembled those found in physical stores increases the likelihood that our results are generalizable. For some comparisons, we were unable to adjust for the number of stimuli. It is possible that our results may have been different had we been able to do so. We were also unable to adjust for the size of any of the ads or objects in the store.

Additionally, because only current smokers were included in this study, the results may be limited and not generalizable to people who are former smokers or who have never smoked. In addition, the sample size was small, which potentially limits statistical power, and there is potential bias from using a convenience sample. However, large sample sizes are usually not feasible for eye-tracking studies because of the cost and time commitment involved, and the size of our sample is consistent with previous eye-tracking studies (Meernik et al., 2016). We also did not collect information about hunger or thirst, which may have affected participants' attention to stimuli related to food and beverages.

Conclusion

The results of this study, which was a convenience sample of 30 adult cigarette smokers in Raleigh, North Carolina, suggest that smokers in the POS environment may devote more visual attention to tobacco products and advertisements than anti-ads. These findings are important because of the established relationship between visual attention and recall (Crespo et al., 2007; Fischer et al., 1989; Klein et al., 2015; Krugman et al., 1994; Strasser et al., 2012). Organizations and government agencies should be mindful that anti-ads at the POS will have to compete with many other stimuli in a cluttered convenience store environment. Restrictions on tobacco product displays and advertisements at the POS could reduce the stimuli that attract smokers' attention away from anti-ads.

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