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Visual Attention Patterns Differ by Pictorial Health Warning Label Features

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Abstract

Objectives: In this study, we sought to determine how smokers allocate their attention when viewing the 9 cigarette pictorial warning labels (PWLs) proposed by the Food and Drug Administration (FDA), and identify PWL attributes associated with increased attention.

Methods: Using eye-tracking data from an exploratory within-subject study, we examined smokers' attention (latency, latency duration, and dwell time) to areas of interest (image vs textual warning) for each PWL among 95 daily, non-treatment-seeking smokers (62.1% male, 48.4% white, mean [SD] age = 32.98 [10.14], mean [SD] cigarettes/day = 15.51 [8.43]). We also compared attention measures by PWL message congruency, textual warning location, and participant rankings of effectiveness.

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Human Subjects Statement

Study procedures were approved by the University of Pennsylvania Institutional Review Board (#814839).

Conflict of Interest Statement

All authors have no conflicts of interest to disclose.

Results: Attention measures differed significantly among PWLs ($ps < .001$) and by features and self-reported effectiveness rankings ($ps < .001 - .039$). Congruent PWLs, those displaying text across the warning label, and those ranked most effective were associated with sustained attention to image, whereas incongruent PWLs, those displaying left text, and those ranked least effective, were associated with faster and sustained attention to text.

Conclusions: Smokers allocated their attention differently across PWLs. Formats and participant effectiveness rankings of PWLs were associated with visual attention patterns, suggesting the importance of these features to the design of potential future PWLs.

Keywords

cigarette; congruency; eye-tracking; health warning; labeling; laboratory methods

The 2009 Family Smoking Prevention and Tobacco Control Act authorized the US Food and Drug Administration (FDA) to regulate tobacco products.¹ The Act also allowed the FDA to require pictorial images on extant textual warnings on combustible cigarettes,¹ a strategy advocated by the World Health Organization's Framework Convention on Tobacco Control² and implemented in numerous other countries.³ Efforts to mandate pictorial warning labels (PWLs) in the US, however, were contested by the tobacco industry as a violation of free speech rights under the First Amendment.⁴ Federal courts upheld this decision, arguing that PWLs elicit emotional responses rather than convey factual information.⁴ Although the fate of PWL implementation in the US is unclear, research is needed to strengthen the evidence base that the FDA may use to either challenge court rulings or propose improved or novel PWLs.⁵

PWLs have been theorized to reduce smoking behavior through eliciting greater attention to health-risk information. Increased attention then leads to encoding and processing of risk information and eventually promotes behavior change.⁵ Several review articles support this theory by indicating that PWLs increase smokers' knowledge of tobacco-related health risks and may encourage cessation.⁶⁻⁹ Furthermore, one randomized controlled trial¹⁰ demonstrated that using cigarette packages affixed with PWLs increased odds of abstinence compared to using cigarettes affixed with currently available textual warning labels. These studies provide critical evidence of how PWLs ultimately may influence quitting behavior. Yet, further data are needed to connect how smokers engage with the content and format within PWLs to improve understanding of how to increase PWL effectiveness.

Eye-tracking is an innovative, method used to assess visual engagement (ie, attention) that is commonly employed in communication research (eg, to inform design of product advertisements, nutrition information labels).¹¹⁻¹³ Because attention is necessary to process and recall information, detailed, direct measures of attention are informative for determining PWL components most salient to behavior change. Although the proposed PWLs were defeated as a group in the courts, using eye-tracking methods to examine differences in attention to each of the 9 PWLs may identify individual PWLs or features and formats that are objectively engaging and ultimately effective in reducing cigarette use. We previously used eye-tracking methods to understand how the attribute of congruency, the extent to which visual and textual information convey the same message, affects attention to and

recall of content within the FDA-proposed PWLs.^{14,15} These studies demonstrated that whereas incongruent PWLs elicited greater attention to textual information, the content of congruent PWLs was recalled better, suggesting that health-risk messages conveyed by congruent PWLs may require less initial effort to process.^{14,15} These findings, however, utilized between-subject comparisons following exposure to either a single PWL or single PWL condition. No eye-tracking studies have exposed smokers to all 9 of the proposed PWLs, which would provide an opportunity to assess visual engagement across an array of PWLs while accounting for individual differences.

Additionally, few studies have examined how PWL attributes other than label size affect attention.¹⁶ Because both the tobacco industry and the public health community have accepted text-only warnings as a reasonable way to convey factual information to consumers since the 1980s, we sought to understand how they are viewed when accompanied by images in varying formats. Given that previous research has demonstrated that smokers rate PWLs as more effective in making them want to quit when compared with text-only warnings,^{10,17} we also examined self-reported rankings of PWL effectiveness as an attribute that could affect attention.

Thus, in this study, we aimed to: (1) determine how smokers allocate their attention when viewing the FDA's proposed PWLs (Figure 1); and (2) identify PWL features and formats associated with increased attention. To address these aims, we analyzed eye-tracking data from the second session of an experimental study examining the effects of message congruency in PWLs on attention and recall.¹⁴

METHODS

Participants

Participants were daily, non-treatment seeking smokers recruited from the greater Philadelphia area from May through November 2012 using media advertisements and through contacting previous study participants. All completed a telephone interview to determine initial eligibility. Those eligible were aged 21–65, were fluent in English, reported smoking at least 5 cigarettes per day (CPD), were not pregnant/lactating, were not trying to quit or had no plans to quit smoking in the next 3 months, had no currently diagnosed or history of mental or health problems, reported consuming < 25 alcohol-containing drinks per week, and provided an initial carbon monoxide (CO) sample > 5 ppm (ie, biochemical verification of smoking status).

Procedures

This exploratory, within-subject study utilized data from the second session of a 2-session randomized laboratory-based trial examining the effects of PWL message congruency.¹⁴ In the full trial, smokers provided written informed consent and completed computer-based demographic, smoking history, and nicotine dependence questionnaires during an initial laboratory visit (ie, Day 1). They were then randomly assigned to view a set of 4 congruent or incongruent PWLs (ie, a between-subject manipulation consisting of only 4 PWLs). Smokers returned for a second laboratory visit 5 days later (ie, Day 5) to assess recall of the

previously viewed PWL set, having not seen them since Day 1. Smokers then viewed all 9 of the FDA-proposed PWLs (ie, a within-subject manipulation) and ranked their effectiveness. The present study examines data from this second (ie, Day 5) session only.

Immediately after arriving at the laboratory for the Day 5 session, smokers provided a CO sample to assess recent smoking. They then smoked a single cigarette to standardize time since last cigarette across participants, providing a CO sample afterward. Smokers next completed a computerized questionnaire where they described what they could recall of the PWL set from Day 1.¹⁴

Participants were next seated in front of the eye-tracking equipment. Staff calibrated the equipment for the participant and administered the same PWL sequence to all participants (ie, order was not counterbalanced): (1) dead body, (2) diseased lungs, (3) cartoon baby, (4) man wearing an “I quit” shirt, (5) tracheotomy, (6) diseased mouth, (7) woman crying, (8) man wearing an oxygen mask, and (9) toddler surrounded by smoke. Each PWL was displayed for 20 seconds and separated by a 15-second grey cross-hair located in the center of the screen; the overall task lasted 5 minutes. After the task, participants provided their rankings of the top 3 PWLs most effective and top 3 PWLs least effective at making them want to quit smoking. Participants received up to \$100 as compensation for completing the full study.

Measures

Attention.—PWLs were displayed to participants using Gazetracker software (v. 07.243.128, Eye Response Technologies; Charlottesville, VA). An Eye-Trac 6 control unit with an R6 pan/tilt optics system and a video head tracker (Applied Science Laboratories; Boston, MA) recorded participants’ eye movements; data were linked with the Eye-Trac 6 User Interface Program (v.1.30.8.0). For each PWL, an area of interest (AOI) was created to reflect the portions of the warning label containing the image and textual warning. For AOI text and AOI image, we recorded attention measures of latency (the time until first view in the AOI), latency duration (the length of the first view), and dwell time (total time spent viewing the AOI) in seconds (s). Thus, there were 6 outcome measures of visual attention. Latency was used to characterize how quickly smokers’ attention was drawn to an AOI,¹⁸ latency duration was used to describe how long a smoker attends to the first area they view; and dwell time was used to characterize overall viewing allocation during full exposure, accounting for viewing the same AOI multiple times.¹⁸

PWL Categorizations

PWL features.—We selected attributes that represent format features that may potentially affect how smokers engage with PWLs, as described below.

Congruency.—Three independent raters determined congruency between the textual and visual information conveyed within each PWL; these methods are detailed elsewhere.¹⁴ The PWLs depicting a dead body, diseased lungs, cartoon baby, and man wearing an “I quit” shirt were categorized as having congruent information; those depicting a tracheotomy, diseased mouth, woman crying, and man wearing an oxygen mask were categorized as

having incongruent information (Figure 1). Categorizations excluded the image of a toddler surrounded by smoke due to low agreement among raters. It is important to note that incongruent PWLs do not have incorrect information; rather, they simply contain visual and textual information that convey different health risk messages.

Text location.—Text location categorizations were based on the 3 text placement formats used by the FDA-proposed PWLs (ie, they were not manipulated experimentally): (1) left-justified on the left portion of the label (ie, PWLs depicting man wearing “I quit” shirt, tracheotomy, woman crying, man wearing an oxygen mask, and toddler surrounded by smoke); (2) centered across the top of the label (ie, cartoon baby); and (3) centered across the bottom of the label (ie, dead body, diseased lungs, cartoon baby, diseased mouth). Because only one PWL used the second format, we reduced these categorizations to 2 location formats: across the label (including above or below) versus on the left portion of the label.

Ranked effectiveness.—After viewing the PWLs, smokers were shown a 3×3 grid depicting all 9 PWLs (Figure 1) and were asked: “Which warning is the [most, second most, third most] effective at making you want to quit smoking?” and “Which warning is the [least, second least, third least] effective at making you want to quit smoking?” to identify their top 3 most and least effective PWLs, respectively. Thus, these rankings represent a personalized effectiveness ranking for each participant. As Table 1 illustrates, participants most commonly ranked the PWLs depicting a tracheotomy, dead body, and diseased lungs as the top 3 most effective PWLs, and the PWLs depicting a man wearing an “I quit” shirt, cartoon baby, and woman crying as the top 3 least effective PWLs.

Data Analysis—Analyses were conducted using IBM SPSS Statistics v24. Summary attention measure variables were created by taking the mean latency, latency duration, and dwell time for each AOI (1) across the 9 PWLs (eg, overall image latency), (2) across the 4 congruent and 4 incongruent PWLs, (3) across the 4 PWLs displaying text across and the 5 PWLs displaying text to the left, and (4) across smokers’ top 3 most and least effective PWLs.

Paired samples t-tests were used to examine differences between each AOI (image vs text) for overall latency, latency duration, and dwell time.

Six repeated measures analysis of variance (RM-ANOVA) models were used to assess differences in each attention measure (ie, one model specific to each outcome) by individual PWLs. PWL was the repeated measure with 9 levels. Huynh-Feldt and Greenhouse-Geisser corrections were applied for violations with epsilon values > 0.75 and < 0.75 , respectively.¹⁹ Significant main effects were examined using Bonferroni-corrected pairwise comparisons.

Prior to conducting RM-ANOVAs, we conducted 6 multivariate regression analyses (ie, per attention measure for AOI image and AOI text) to determine covariate inclusion for subsequent analyses. Models regressed each attention measure on predictor variables of age, sex, race, nicotine dependence (as measured by the Fagerstrom Test of Nicotine Dependence),²⁰ quit interest (assessed using a contemplation ladder²¹), and PWL

assignment during previous session.¹⁴ Because no variables were associated with any of the attention measures at $p < .05$, none were included as a covariates in subsequent analyses.

Finally, paired samples t-tests were used to examine differences in attention separately by PWL message congruency (congruent vs incongruent), text location (across vs left), and self-reported effectiveness rankings (top 3 most effective vs top 3 least effective).

RESULTS

Sample Characteristics

We previously reported sample characteristics for the 120 smokers enrolled in the larger trial.¹¹ Overall, 108 participants returned for the second session 5 days later. Of those individuals, eye-tracking data were lost for 13 participants, resulting in an analytic sample of 95 individuals. On average, the sample was 32.98 years old ($SD = 10.14$), self-reported smoking 15.51 CPD ($SD = 8.43$), had a session onset CO of 20.12 ppm ($SD = 10.4$), had smoked regularly for 15.80 years ($SD = 9.83$), and was moderately nicotine dependent ($M = 4.36$; $SD = 2.26$). Most were male (62.1%), white (48.4%) or black (43.2%) and had completed some college or professional training as their highest level of education (40.0%).

Differences in Attention to Individual PWLs

Consistent with our previous findings,¹⁴ overall latency (ie, averaged across all 9 PWLs) was shorter for the image AOI ($M = .29$ s, $SE = .05$) than the text AOI ($M = .84$ s, $SE = .07$), $t(94) = -6.72$, $p < .001$, and overall dwell time was greater for the image ($M = 11.48$ s, $SE = .27$) than text ($M = 5.30$ s, $SE = .20$), $t(94) = 15.02$, $p < .001$. In contrast to our previous results,¹⁴ overall latency duration was shorter for the image ($M = .73$ s, $SE = .06$) compared to text ($M = .91$ s, $SE = .05$), $t(94) = -2.44$, $p = .017$.

Table 2 provides descriptive statistics for latency, latency duration, and dwell time for both AOIs for each PWL. Within individual PWLs, latency was shorter for image versus text for all PWLs except the woman crying, in which image latency was greater than text [$t(94) = 4.05$, $p < .001$]. Latency duration was longer for the image versus text for the PWLs depicting a dead body [$t(94) = 3.88$, $p < .001$], diseased lungs [$t(93) = 2.26$, $p = .026$], and diseased mouth [$t(94) = 3.86$, $p < .001$]; latency duration was shorter for the image versus text for all other PWLs [$t(92 - 94)$, $ps < .001 - .044$]. Dwell time was longer for the image versus text for all PWLs [$t(92 - 94) = 3.15 - 18.14$, $ps < .001 - .002$], except the woman crying, where image and text dwell times did not differ [$t(94) = -.57$, $p = .572$].

Latency to image [$F(4.25, 390.81) = 8.75$, $p < .001$] and text [$F(4.28, 381.17) = 6.04$, $p < .001$] AOIs differed significantly among the 9 PWLs (Table 2). Image latency was an average of .73–.96 s ($SEs = .15-.21$) longer for the PWL depicting a woman crying than all other PWLs ($ps < .001-.027$). Text latency was significantly shorter for the PWL depicting a woman crying compared to those depicting a dead body ($p = .015$), diseased lungs ($p = .011$), and diseased mouth ($p = .01$), and for the PWL depicting a toddler versus diseased lungs ($p = .04$).

Latency duration for image [$F(4.33, 389.46) = 6.86, p < .001$] and text [$F(4.75, 427.10) = 20.20, p < .001$] AOIs also differed significantly by individual PWLs (Table 2). The PWL depicting a dead body had a significantly longer latency duration for image than the cartoon baby ($p = .003$), tracheotomy ($p = .003$), woman crying ($p = .027$), man wearing oxygen mask ($p = .002$), and toddler ($p = .001$) PWLs. The PWL depicting a diseased mouth had a significantly longer latency duration for image compared to the tracheotomy ($p = .025$) and toddler ($p = .038$) PWLs. Latency duration for text was longer for the PWL depicting a man wearing an “I Quit” shirt compared to all others ($ps < .001-.023$). The PWLs depicting a man wearing an oxygen mask and a toddler had longer text latency duration compared to those depicting a dead body, diseased lungs, and diseased mouth ($ps < .001$). The PWL depicting a man wearing an oxygen mask also had longer latency duration for text compared to the tracheotomy PWL ($p = .042$). The PWL depicting a diseased mouth had shorter text latency duration compared to all others ($ps < .001-.045$) except the dead body ($p = 1.00$) and diseased lungs ($p = .356$).

Finally, dwell time for image AOI [$F(7.35, 675.87) = 38.50, p < .001$] and text AOI [$F(6.77, 602.77) = 59.30, p < .001$] differed significantly among PWLs (Table 2). Image dwell time was longer for the dead body, diseased lungs, tracheotomy, and diseased mouth PWLs than the cartoon baby, man wearing an “I quit” t-shirt, woman crying, man wearing oxygen mask, and toddler PWLs ($ps < .001-.017$). The PWL depicting the woman crying had a significantly shorter image dwell time than all others ($ps < .001-.002$). Text dwell time was significantly longer for PWLs depicting a man wearing an “I quit” shirt, woman crying, man wearing oxygen mask, and toddler compared to the dead body, diseased lungs, tracheotomy, and diseased mouth PWLs ($ps < .001$). The PWL depicting a cartoon baby had a longer text dwell time compared to the dead body, tracheotomy, and diseased mouth ($ps < .001-.027$), but shorter text dwell time compared to the man wearing an “I quit” shirt, woman crying, and man wearing oxygen mask ($ps < .001-.002$). The PWL depicting a toddler had shorter text dwell time compared to the man wearing an “I quit” shirt and crying woman ($ps < .001$). The PWL depicting a woman crying had a longer text dwell time than the man wearing an oxygen mask ($p < .001$).

Differences in Attention by PWL Attributes and Ranked Effectiveness

Congruency.—All attention measures for the text and image AOIs differed significantly by congruency (Table 3). Compared to incongruent PWLs, congruent PWLs had .33-s ($SE = .09$) shorter image latency [$t(94) = -3.50, p = .001$] and .33-s ($SE = .10$) longer text latency [$t(94) = 3.16, p = .002$]. Congruent PWLs had longer latency duration than incongruent PWLs for both image ($M_{diff} = .19$ s, $SE = .09$; $t(94) = 2.10, p = .039$) and text ($M_{diff} = .17$ s, $SE = .07$; $t(94) = 2.30, p = .024$). Finally, image dwell time was .67 s ($SE = .18$) longer, and text dwell time was .64 s ($SE = .18$) shorter for congruent vs. incongruent PWLs [$t(94) = 3.63$ and -3.62 , respectively, $ps < .001$].

Text location.—Location of textual warnings significantly impacted all attention measures except latency to image [$t(94) = -1.17, p = .246$]. As Table 3 shows, compared to PWLs that displayed text on the left, those displaying text across the warning label had .56-s ($SE = .14$) longer text latency [$t(94) = 4.14, p < .001$], .42-s ($SE = .09$) longer image latency duration

[$t(94) = 4.63, p < .001$], and .59-s (SE = .08) shorter text latency duration [$t(94) = -7.33, p < .001$]. PWLs with text across the warning label also had a 2.35-s (SE = .23) longer image dwell time [$t(94) = 10.06, p < .001$] and a 2.71-s (SE = .20) shorter text dwell time compared to those with text on the left [$t(94) = -13.66, p < .001$].

Ranked effectiveness.—Smokers' rankings of the top 3 most effective and least effective PWLs significantly affected all attention measures except latency to image [$t(94) = .07, p = .941$] (Table 3). Compared to the 3 PWLs ranked least effective, the 3 ranked most effective demonstrated more sustained viewing of the image AOI, ie: .26-s (SE = .13) longer latency [$t(94) = 2.03, p = .045$], .41-s (SE = .10) shorter latency duration [$t(94) = -4.03, p < .001$], and 2.16-s (SE = .28) shorter dwell time [$t(94) = -7.65, p < .001$] for the text AOI, and .24-s (SE = .09) longer latency duration [$t(94) = 2.68, p < .009$] and 1.95-s (SE = .29) longer dwell time [$t(94) = 6.65, p < .001$] for the image AOI.

DISCUSSION

Placing PWLs on cigarette packaging is one potential means to accurately inform and remind smokers and non-smokers of the risks of cigarette smoking at opportune moments (eg, point-of-sale, when reaching for a cigarette). Accordingly, over 100 countries have adopted PWLs as a reasonable means to effectively communicate risk information.³ The tobacco industry defeated the original FDA-proposed PWLs in court by arguing that adding graphic images to extant textual warnings violated free speech and elicit emotional responses rather than convey factual information.⁴ Our data demonstrate that when consecutively exposed to all 9 of the FDA-proposed PWLs, 95 daily nontreatment seeking smokers generally were drawn to the image of the PWL faster than the text, spent more time initially viewing the text than the image, and spent more overall time attending to the image than the text. These findings provide evidence against industry concerns that the proposed PWLs were too graphic and would elicit negative emotional responses, as smokers objectively spent more time engaging with the images rather than text. Given that allocation of attention has been associated with ability to recall information in cigarette PWL research^{18,22} and other domains,²³ findings support that PWLs have value in conveying risk information to smokers.

We further contend that provoking emotional responses and conveying factual information are not mutually exclusive.²⁴ Although patterns of engagement with individual PWLs were somewhat complex, depending on attention measure and AOI, findings generally indicated that smokers had greater engagement with the image of the PWLs depicting a dead body, diseased lungs, diseased mouth, and tracheotomy, and greater engagement with the textual warning for PWLs depicting a man wearing an "I quit" shirt, crying woman, man wearing oxygen mask, and cartoon baby. Whereas we cannot conclude that these differences in viewing are causally related to PWL features, it is striking that the PWLs depicting disease and death demonstrated greater attention to the image AOI. Our results suggest that smokers did not find these depictions off-putting, at least to the extent that the more relatively gruesome images gained their attention faster and sustained attention longer than less graphic images.

Regarding effects of PWL attributes on engagement, congruent PWLs generally demonstrated greater attention to image, and incongruent PWLs elicited greater attention to text. Findings related to greater dwell time on text for incongruent PWLs and shorter latency to image for congruent PWLs replicate our previous work.^{14,15} However, we also found that congruent (vs incongruent) PWLs had longer dwell time for image, and longer latency duration for both image and text. Because message congruency in PWLs has been associated with subsequent recall of PWL content,^{14,15} these findings further support the importance of congruency as a construct in evaluating PWL effectiveness. Cigarette packs have contained factual information in the form of textual warnings of the Surgeon General since the 1980s. Their use over the past 30 years suggests that factual information on cigarette packs is indeed acceptable by the tobacco industry and public health community. Congruent PWLs provide an alternative means to convey further support and illustrate the same factual information as the textual warnings, but in a different medium. Because individuals with low socioeconomic status and education suffer a disproportionate burden of cigarette smoking, reading and literacy issues should be considered when trying to effectively communicate cigarette risk to these individuals. With a long history of non-contested, factual text warnings on cigarette packages, consideration of congruently formatted PWLs that support these factual claims should be considered. Future work should examine how congruency in PWLs better informs those most vulnerable to the harms of smoking.

PWLs displaying text across the warning label demonstrated greater attention to image, compared to those displaying left text, which had greater attention to text. These findings are perhaps unsurprising, as smokers attended faster and longer with content that they encountered first (ie, left to right). Future PWLs should consider examining the impact of placing crucial content to the left portion of warning labels where smokers are more likely to view it. Alternatively, should the FDA not pursue PWLs as a tobacco control strategy and continue to use textual warnings as a primary means for conveying health-risk information to consumers, findings suggest that text placement is an important format consideration for general warning label design.

Finally, PWLs that participants ranked most effective at making them want to quit smoking generally demonstrated greater attention to image, and those that participants ranked least effective had greater attention to text. Self-reported effectiveness ratings are used often as a subjective, self-report measure to evaluate smokers' responses to PWLs, but their relationship with behavior change has been unclear. Our data link these rankings with an objective measure of engagement, as PWLs associated with increased attention were more likely to be PWLs that smokers themselves ranked as most effective in helping them to quit. Given that increased engagement is associated with recall,^{18,22} future studies should evaluate relationships of self-reported effectiveness rankings with recall and behavior change (ie, smoking behaviors, changes in risk perceptions) to determine how this construct relates to more complex processes and behavior.

Our findings should be interpreted with consideration of several limitations. First, smokers viewed 4 of the 9 PWLs 5 days earlier (albeit only once per PWL), which may have decreased subsequent attention to these PWLs. We examined potential interaction effects of initial exposure with the 9 PWLs (results not reported) and found that initial exposure did

not affect subsequent viewing of all 9 PWLs. Second, although using a non-randomized design limits our ability to interpret findings, each PWL exposure was separated by a 15-s washout period. Furthermore, we did not observe any obvious time trends (eg, dwell time decreasing across the 9 PWLs) and it is unlikely that participants experienced task fatigue as the entire task lasted only 5 minutes. Third, displaying cross-hairs between PWLs in the center of the computer screen (which then became the image portion of the PWL) may have biased participants toward having a shorter latency to AOI image. Future studies could provide alternative PWL settings, such as placing the PWL on a cigarette or tobacco product package. Finally, we did not assess recall following PWL exposure, and thus, cannot conclude that increased attention to an AOI necessarily indicates processing of the PWL message. Despite these limitations, findings remain informative for the design and evaluation of future PWLs through demonstrating that PWL formats and self-reported effectiveness drive differences in objective measures of visual engagement while controlling for individual differences.

IMPLICATIONS FOR TOBACCO REGULATION

In an exploratory, within-subject study of 95 daily non-treatment-seeking smokers, visual engagement with the content of the FDA's proposed PWLs, measured objectively using eye-tracking method, varied among individual PWLs and by PWL message congruency, text location, and self-reported effectiveness rankings. We observed that smokers generally had greater attention to image for PWLs that contained congruent image and textual information, displayed textual warnings across the label, and were ranked by participants as most effective in encouraging cessation. In contrast, we observed greater attention to textual information among PWLs that contained incongruent content, displayed textual warnings on the left side of the label, and were ranked by participants as least effective in helping them to quit. Thus, we conclude that eye-tracking methods can be used objectively to assess viewing patterns, which have been associated with the ability to recall information in cigarette PWL research^{18,22} and other domains.²⁴ Moreover, eye-tracking methods can be used to determine how best to format PWLs to increase engagement with their content, and ultimately, maximize their effectiveness.

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References

1. US Congress. Family Smoking Prevention and Tobacco Control Federal Reform Act.; 2009 Available at: <https://www.fda.gov/tobaccoproducts/labeling/rulesregulations-guidance/ucm237092.htm>. Accessed July 22, 2018.
2. World Health Organization (WHO). WHO Framework Convention on Tobacco Control. Geneva, Switzerland: WHO; 2005 Available at: http://www.who.int/fctc/text_download/en/. Accessed July 22, 2018.

3. Canadian Cancer Society. Cigarette Package Health Warnings: International Status Report. 5th ed. 2016 Available at: <http://www.tobaccolabels.ca/wp/wp-content/uploads/2016/11/Cigarette-Package-Health-Warnings-International-Status-Report-English-CCS-Oct-2016.pdf>. Accessed February 26, 2018.th
4. R.J. Reynolds Tobacco Co. et al v Food & Drug Administration et al. 696 F.3d 1205(D.C. Cir. 2012). Available at: [https://www.cadc.uscourts.gov/internet/opinions.nsf/4C0311C78EB11C5785257A64004EBFB5/\\$file/11-5332-1391191.pdf](https://www.cadc.uscourts.gov/internet/opinions.nsf/4C0311C78EB11C5785257A64004EBFB5/$file/11-5332-1391191.pdf). Accessed July 22, 2018.
5. Thrasher JF, Brewer NT, Niederdeppe J, et al. Advancing tobacco product warning labels research methods and theory: a summary of a grantee meeting held by the US National Cancer Institute. *Nicotine Tob Res.* 2018 2 10. doi: 10.1093/ntr/nty017. [Epub ahead of print]
6. Hammond D Health warning messages on tobacco products: a review. *Tob Control.* 2011;20(5): 327–337. [PubMed: 21606180]
7. Monárrez-Espino J, Liu B, Greiner F, et al. Systematic review of the effect of pictorial warnings on cigarette packages in smoking behavior. *Am J Public Health.* 2014;104(10):e11–e30.
8. Noar SM, Hall MG, Francis DB, et al. Pictorial cigarette pack warnings: a meta-analysis of experimental studies. *Tob Control.* 2016;25(3):341–354. [PubMed: 25948713]
9. Noar SM, Francis DB, Bridges C, et al. The impact of strengthening cigarette pack warnings: systematic review of longitudinal observational studies. *Soc Sci Med.* 2016;164:118–129. [PubMed: 27423739]
10. Brewer NT, Hall MG, Noar SM, et al. Effect of pictorial cigarette pack warnings on changes in smoking behavior: a randomized clinical trial. *JAMA Intern Med.* 2016;176(7):905–912. [PubMed: 27273839]
11. Meernik C, Jarman K, Wright ST, et al. Eye tracking outcomes in tobacco control regulation and communication: a systematic review. *Tob RegulSci.* 2016;2(4):377–403.
12. Bol N, Boerman SC, Romano Bergstrom JC, Kruike-meier S. An overview of how eye tracking is used in communication research In Antona M, Stephanidis C, eds. *Universal Access in Human-Computer Interaction. Methods, Techniques, and Best Practices.* Vol 9737 New York, NY: Springer International Publishing; 2016:421–429.
13. Higgins E, Leinenger M, Rayner K. Eye movements when viewing advertisements. *Front Psychol.* 2014;5:1–15. [PubMed: 24474945]
14. Lochbuehler K, Mercincavage M, Tang KZ, et al. Effect of message congruency on attention and recall in pictorial health warning labels. *Tob Control.* 2018;27:266–271.
15. Lochbuehler K, Wileyto EP, Mercincavage M, et al. Temporal effects of message congruency on attention to and recall of pictorial health warning labels on cigarette packages. *Nic Tob Res.* 2018 6 16. doi: 10.1093/ntr/nty124. [Epub ahead of print]
16. Klein EG, Shoben AB, Krygowski S, et al. Does size impact attention and recall of graphic health warnings? *Tob Regul Sci.* 2015;1(2):175–185. [PubMed: 26550583]
17. Huang L-L, Thrasher JF, Reid JL, Hammond D. Predictive and external validity of a pre-market study to determine the most effective pictorial health warning label content for cigarette packages. *Nicotine Tob Res.* 2016;18(5):1376–1381. [PubMed: 26377516]
18. Strasser AA, Orom H, Tang KZ, et al. Graphic-enhanced information improves perceived risks of cigar smoking. *Addict Behav.* 2011;36(8):865–869. [PubMed: 21481542]
19. Girden E ANOVA: Repeated Measures Newbury Park, CA: Sage; 1992.
20. Heatherton TF, Kozlowski LT, Frecker RC, Fagerström KO. The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire. *Br J Addict.* 1991;86(9):1119–1127. [PubMed: 1932883]
21. Biener L, Abrams D. The contemplation ladder: validation of a measure of readiness to consider smoking cessation. *Health Psychol.* 1991;10(5):360–365. [PubMed: 1935872]
22. Lochbuehler K, Tang KZ, Souprontchouk V, et al. Using eye-tracking to examine how embedding risk corrective statements improves cigarette risk beliefs: implications for tobacco regulatory policy. *Drug Alcohol Depend.* 2016;164:97–105. [PubMed: 27160034]
23. Lochbuehler K, Wileyto EP, Tang KZ, et al. Do current and former cigarette smokers have an attentional bias for e-cigarette cues? *J Psychopharmacol (Oxf).* 2018;32(3):316–323.

24. Peters E, Evans AT, Hemmerich N, Berman M. Emotion in the law and the lab: the case of graphic cigarette warnings. *Tob Regul Sci.* 2016;2(4):404–413. [PubMed: 29057296]

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Figure 1.
The 9 Cigarette PWLs Proposed by the FDA

Table 1

Participant Rankings of Effectiveness

Warning Label	% Endorsed as Top 3 Most Effective	% Endorsed as Top 3 Least Effective
Dead Body	18.6	6.0
Diseased Lungs	18.6	5.0
Cartoon Baby	4.2	19.4
Man Wearing “I Quit” Shirt	3.9	25.4
Tracheotomy	19.7	1.1
Diseased Mouth	16.5	3.9
Woman Crying	6.0	19.4
Man with Oxygen Mask	3.9	10.9
Toddler and Smoke	8.8	9.2

Note.

Bolded percentages indicate the top 3 PWLs most commonly endorsed as most and least effective at making participants want to quit smoking.

Table 2

Latency, Latency Duration, and Dwell Time for AOI Image and AOI Text for All 9 PWLs, Presented as M (SD)

Warning Label	Latency		Latency Duration		Dwell Time	
	AOI Image	AOI Text	AOI Image	AOI Text	AOI Image	AOI Text
Dead Body	.22 (.91)	1.29 (2.39)	1.12 (1.46)	.47 (.59)	13.52 (3.90)	3.03 (2.55)
Diseased Lungs	.07 (.32)	1.15 (1.80)	1.03 (1.73)	.58 (.75)	12.98 (3.99)	3.83 (2.80)
Cartoon Baby	.22 (.93)	.93 (1.43)	.56 (.61)	1.93 (1.85)	11.21 (3.77)	4.92 (3.22)
Man Wearing “I Quit” Shirt	.02 (.06)	.75 (.82)	.68 (.66)	.90 (.92)	9.80 (3.25)	7.84 (3.29)
Tracheotomy	.17 (.73)	.73 (1.08)	.49 (.46)	.73 (.87)	12.83 (3.74)	3.66 (2.59)
Diseased Mouth	.36 (1.75)	1.18 (1.86)	1.15 (1.78)	.37 (.69)	13.45 (4.19)	3.45 (3.00)
Woman Crying	.99 (1.61)	.20 (1.44)	.49 (1.34)	.85 (1.15)	8.27 (3.42)	8.65 (3.60)
Man with Oxygen Mask	.26 (1.04)	.60 (.75)	.52 (.64)	1.21 (1.43)	10.40 (4.05)	6.53 (3.56)
Toddler and Smoke	.21 (.74)	.58 (.62)	.54 (.54)	1.21 (1.12)	11.08 (3.74)	5.65 (2.94)

Table 3

Results of Paired t-tests of Latency, Latency Duration, and Dwell Time for AOI Image and AOI Text by PWL Attributes and Self-reported Effectiveness Rankings, Presented as M (SE)

Outcome	PWL Attributes And Self-Reported Ranked Effectiveness							
	Message Congruency			Text Placement		Ranked Effectiveness		
	Congruent	Incongruent	p	Text Across	Text Left	3 Most Effective	3 Least Effective	p
Latency								
AOI Image	.13 (.04)	.46 (.09)	**	.23 (.07)	.34 (.07)	.32 (.09)	.31 (.06)	
AOI Text	1.03 (.11)	.71 (.08)	**	1.15 (.13)	.53 (.05)	*** .96 (.12)	.69 (.08)	*
Latency Duration								
AOI Image	.85 (.09)	.66 (.06)	*	.96 (.10)	.54 (.04)	*** .86 (.06)	.62 (.06)	**
AOI Text	.96 (.06)	.80 (.06)	*	.59 (.04)	1.18 (.08)	*** .74 (.06)	1.15 (.09)	***
Dwell Time								
AOI Image	11.87 (.28)	11.20 (.29)	***	12.78 (.32)	10.43 (.27)	*** 12.47 (.36)	10.52 (.27)	***
AOI Text	4.93 (.20)	5.57 (.25)	***	3.81 (.23)	6.51 (.22)	*** 4.26 (.26)	6.41 (.23)	***

Note.

* indicates p-value < .05,

** = p < .01,

*** = p < .001