ADDICTION
SSA SOCIETY FOR THE STUDY OF ADDICTION
RESEARCH REPORT
doi:10.1111/add.15148

Avoidance of tobacco health warnings? An eye-tracking approach

Carlos Sillero-Rejon[1,2,3], Ute Leonards[1], Marcus R. Munafò[1,2], Craig Hedge[4], Janet Hoek[5], Benjamin Toll[6], Harry Gove[1], Isabel Willis[1], Rose Barry[1], Abi Robinson[1] & Olivia M. Maynard[1,2]

School of Psychological Science, University of Bristol, Bristol, UK,[1] MRC Integrative Epidemiology Unit (IEU) at the University of Bristol, Bristol, UK,[2] The National Institute for Health Research Applied Research Collaboration West (NIHR AC West), University Hospitals Bristol NHS Foundation Trust, UK,[3] School of Psychology, University of Cardiff, Cardiff, UK,[4] Department of Public Health, University of Otago, Otago, New Zealand[5] and Department of Public Health Sciences, Medical University of South Carolina and Hollings Cancer Center, Charleston, SC, USA[6]

ABSTRACT

Aims Among three eye-tracking studies, we examined how cigarette pack features affected visual attention and self-reported avoidance of and reactance to warnings. **Design** Study 1: smoking status × warning immediacy (short-term versus long-term health consequences) × warning location (top versus bottom of pack). Study 2: smoking status × warning framing (gain-framed versus loss-framed) × warning format (text-only versus pictorial). Study 3: smoking status × warning severity (highly severe versus moderately severe consequences of smoking). **Setting** University of Bristol, UK, eye-tracking laboratory. **Participants** Study 1: non-smokers ($n = 25$), weekly smokers ($n = 25$) and daily smokers ($n = 25$). Study 2: non-smokers ($n = 37$), smokers contemplating quitting ($n = 37$) and smokers not contemplating quitting ($n = 43$). Study 3: non-smokers ($n = 27$), weekly smokers ($n = 26$) and daily smokers ($n = 26$). **Measurements** For all studies: visual attention, measured as the ratio of the number of fixations to the warning versus the branding, self-reported predicted avoidance of and reactance to warnings and for study 3, effect of warning on quitting motivation. **Findings** Study 1: greater self-reported avoidance [mean difference (MD) = 1.14; 95% confidence interval (CI) = 0.94, 1.35, $P < 0.001$, $\eta_p^2 = 0.64$] and visual attention (MD = 0.89, 95% CI = 0.09, 1.68, $P = 0.03$, $\eta_p^2 = 0.06$) to long-term warnings, but not for reactance (MD = 0.14, 95% CI = –0.04, 0.32, $P = 0.12$, $\eta_p^2 = 0.03$). Increased visual attention to warnings on the upper versus lower half of the pack (MD = 1.8; 95% CI = 0.33, 3.26, $P = 0.02$, $\eta_p^2 = 0.08$). Study 2: higher self-reported avoidance of (MD = 0.70; 95% CI = 0.59,0.80, $P < 0.001$, $\eta_p^2 = 0.61$) and reactance to (MD = 0.37; 95% CI = 0.27, 0.47, $P < 0.001$, $\eta_p^2 = 0.34$) loss-framed warnings but little evidence of a difference for visual attention (MD = 0.52; 95% CI = –0.54, 1.58, $P = 0.30$, $\eta_p^2 = 0.01$). Greater visual attention, avoidance and reactance to pictorial versus text-only warnings (all Ps < 0.001, $\eta_p^2 > 0.25$). Study 3: greater self-reported avoidance of (MD = 0.37; 95% CI = 0.25, 0.48, $P < 0.001$, $\eta_p^2 = 0.33$) and reactance to (MD = 0.14; 95% CI = 0.05, 0.23, $P = 0.003$, $\eta_p^2 = 0.11$) highly severe warnings but findings were inconclusive as to whether there was a difference in visual attention (MD = –0.55; 95% CI = –1.5, 0.41, $P = 0.24$, $\eta_p^2 = 0.02$). **Conclusions** Subjective and objective (eye-tracking) measures of avoidance of health warnings on cigarette packs produce different results, suggesting these measure different constructs. Visual avoidance of warnings indicates low-level disengagement with warnings, while self-reported predicted avoidance reflects higher-level engagement with warnings.

Keywords Attention, avoidance, eye-tracking, message framing, reactance, tobacco health warnings.

Correspondence to: Olivia Maynard, School of Psychological Science, University of Bristol, 12a Priory Road, Bristol, BS81TU UK.
E-mail: olivia.maynard@bristol.ac.uk
Submitted 2 September 2019; initial review completed 22 November 2019; final version accepted 29 May 2020

INTRODUCTION

Numerous studies show that tobacco health warnings, particularly pictorial warnings, increase negative affect, thereby changing smoking-related attitudes, intentions and behaviours [1,2]. However, some smokers may react defensively towards these [3] or fail to engage with their emotional content [4,5]. This research aims to understand how warnings content influences the responses elicited.

Visual attention to and self-reported predicted avoidance of warnings

Eye-tracking offers an objective measure of attention to warnings [6–9]. Our previous research found that daily smokers, but not occasional or non-smokers, voluntarily shift their attention from warnings and towards branding (i.e. avoid warnings) [10–12], although other research has found that daily smokers do attend to larger warnings on novel standardized packs [13]. The attention literature suggests that visual attention is a critical step in stimulus processing [14] and a prerequisite for higher-order cognitive processes, thus visual avoidance is probably a maladaptive response.

In contrast, longitudinal studies have found that self-reported predicted warning avoidance (often measured by asking participants if they would avoid looking at a warning—hereafter 'self-reported avoidance') appears to have an inverse relationship with quit attempts [15-17]. Self-reported avoidance may be a learned response to aversive stimuli, as supported by avoidance learning theory [18] and, recently, by a meta-analysis suggesting that pictorial warnings may be effective through eliciting aversive reactions and cognitive elaboration [2]. Together with Wegner's ironic process theory [19], these findings suggest that self-reported avoidance indicates higher-order cognitive processes related to warning engagement that aim (ineffectively) to remove the messages from mind.

Another self-reported measure used to assess health warnings is reactance, defined as 'the motivational state that is hypothesized to occur when a freedom is eliminated or threatened' [20]. Reactance (often measured as anger or irritability towards warnings) is negatively associated with quit intentions and perceived risk in some studies [21], but positively associated with adaptive behaviours in others [17].

Differences between avoidance and reactance, and mixed findings in relation to each, highlight the need to understand how these measures relate to one another; to our knowledge, our work is the first to address this question.

Warning design

Among three experiments, we measured visual attention to and self-reported avoidance of and reactance to warnings that vary in their location and immediacy (study 1), framing and format (study 2) and severity (study 3). We further investigated our previously observed differences in visual attention to warnings between non-smokers, weekly smokers and daily smokers.

Location

Although warnings have traditionally been placed on the lower portion of cigarette packs, many new warning policies world-wide require warnings on the upper-half of the pack. This change may increase attention to the warning, because people typically read from top to bottom.

Immediacy

Most warnings used in the United Kingdom and in the European Union focus on the long-term health consequences of smoking. Temporal discounting theories suggest that individuals discount future health outcomes more than proximal ones [22], and current smokers discount future outcomes more than never-smokers and ex-smokers [23]. Qualitative research has found that tobacco warnings featuring long-term risks of smoking lack relevance and salience among young people [24], while warnings depicting loss of social and physical attractiveness are aversive [25]. Consequently, emphasizing the short-term consequences of smoking (e.g. 'Smoking wastes your money'), may increase warning engagement among smokers.

Framing

Research on message framing is based on prospect theory, which suggests that individuals are risk-seeking when losses are salient but risk-averse when gains are salient [26]. The persuasiveness of gain-framed (positive benefits of quitting) and loss-framed (risks of continuing to smoke) messages are persuasive, depends upon whether the target health behaviour is a risk-averse prevention behaviour (e.g. applying sunscreen to prevent skin cancer) where gain-framed messages are more effective, or a risk-seeking detection behaviour (e.g. mammography, which could reveal breast cancer) where, instead, loss-framed messages are more effective [27,28]. Although smoking cessation is a preventative behaviour, there is disagreement over which message frame is most effective (e.g. [29–31]). This disagreement may be explained in part by individual differences among smokers, including their level of dependence [32,33], self-efficacy [34], perceptions of risk [35] and perceptions of quitting [36]. Intentions to quit seem important in influencing responses to warnings, with loss-framed warnings most effective among those intending to quit, while gain-framed warnings most effective for those with no quitting intentions [37].

Format

A recent meta-analysis found that pictorial warnings attract and hold attention, lead to stronger reactions and attitudes and increase intentions to quit compared to text-only warnings [2]. The impact of pictorial warnings may also be greater for certain types of warnings, such as the (typically more gruesome) loss-framed warnings compared with gain-framed warnings.

Severity

Previous research has found that compared to less severe warnings, highly severe warnings increase both self-reported and physiological emotional responses [38], are more believable and effective [1,39,40] and increase quit intentions [2,38,41]. A recent meta-analysis suggested that it is through increased negative affect and fear that highly severe warnings positively impact behaviour [42]. However, these warnings are more poorly recalled [2,41]. Understanding the role of message severity is important, given the widespread global reliance on severe warnings and the ongoing academic debate regarding their effects [43,44].

METHODS

The Supporting information, Table S1 shows all study characteristics. Each study protocol was pre-registered and this includes further details of procedures, statistical analysis plans and sample size calculations. Ethics approval was obtained from the University of Bristol Faculty of Science ethics board.

Design

For study 1, we examined two within-subject factors of warning immediacy (short- versus long-term) and warning location (upper versus lower). For study 2, we examined within-subject factors of warning framing (gain-versus loss-framed) and format (pictorial versus text-only) and for study 3, we examined one within-subject factor of warning severity (moderately severe versus highly severe). Moreover, for all studies, we had one between-subjects factor of smoking status (studies 1 and 3: non-smoker versus weekly smoker versus daily smoker; study 2: non-smoker versus non-contemplator versus contemplator).

Participants

All participants were aged 18 years or over. We assessed eligibility using on-line screening where participants were categorized as non-smokers (smoking fewer than 100 cigarettes in their life), weekly smokers (smoking at least one cigarette a week, but not every day) and daily smokers (smoking at least five cigarettes a day and within 1 hour of waking). Those who met one of these categories were invited to a testing session at which smoking status was confirmed using a breath carbon monoxide (CO) measurement (cut-offs described in pre-registered protocols). In study 2, we defined contemplators and non-contemplators using the Quitting Smoking Contemplation Ladder (QSCL) [45] at participant recruitment. As specified in our pre-registered protocol, we classified 'non-contemplators' as those scoring between 1 and 4 and 'contemplators' as scoring between 6 and 8. We did not recruit participants scoring 5 ('I often think about quitting, but have no plans to quit'), as they were neither contemplators nor non-contemplators.

Materials and measures

Cigarette pack stimuli

Cigarette packs featured branding from packs sold prior to standardized packaging legislation. All warning stimuli are in the relevant pre-registered protocols, and examples are in shown in Supporting information, Fig. S1.

For study 1, we obtained five unfamiliar warnings depicting the long-term health consequences of smoking from warnings used in EU countries. We obtained five unfamiliar warnings depicting the short-term consequences of smoking by searching on-line for warnings used world-wide and from previous warnings research. Each of the 10 warnings was combined with eight different popular UK tobacco brands, based on market share. Warnings were placed on both the upper- and lower-half of the pack to create 160 cigarette pack stimuli, from which 40 were chosen pseudo-randomly (see Supporting information, Table S1) for each participant separately. For all studies, warnings and branding each occupied 50% of the pack. The long- and short-term warnings were classified as such in pre-study piloting by asking participants to rate whether the warnings represented the long- or short-term health consequences of smoking (see protocol).

For studies 2 and 3, all warnings were placed on the lower-half of the pack to reflect practice in the United Kingdom and European Union [46] at the time of testing and current practice in many countries world-wide [47]. For study 2, loss-framed warnings were derived from warnings used in EU countries and unfamiliar gain-framed images were taken from stimuli developed by one of the authors (B.T.). Based on these, four stimulus types were created, each with 14 warnings: loss-framed pictorial (1); gain-framed pictorial (2); loss-framed text-only and (3) gain-framed text-only. Each of the 56 warnings was combined with the eight brands used in study 1 to create 448 cigarette pack stimuli from which 56 were selected pseudo-randomly (see Supporting information, Table S1) for each participant separately. We conducted pilot testing to ensure that the messages presented by the warning image and text were consistent, and that the warnings looked realistic.

For study 3, three moderately severe and three highly severe warnings depicting the physical effects of smoking were presented to participants. These came from a range of sources, including those used on cigarette packs world-wide and through on-line image searches. The warnings were tested in pre-study piloting (see protocol)

and participants rated the extent to which they were 'graphic' (i.e. 'showing gruesome and vivid physical effects of the smoking-related disease'). We used 10 branded pack images and combined these with the six warnings to create 60 stimuli, from which 12 were chosen pseudo-randomly (see Supporting information, Table S1) for each participant separately.

Visual attention

We measured the number of fixations to our two regions of interest (ROIs), the health warning and the branding, using an Eyelink II eye-tracker (SR Research Ltd, ON, Canada). The primary outcome measure was the bias in the number of fixations towards the warnings compared with the branding (calculated as a difference score).

Smoking behaviour and dependence

We administered the Fagerström Test for Nicotine Dependence (FTND) [48], the brief Questionnaire of Smoking Urges (QSU-Brief) [49] and the Quitting Smoking Contemplation Ladder (QSCL) [45].

Avoidance

We took a subset of three avoidance questions for smokers and two questions for non-smokers from the Population Assessment of Tobacco and Health (PATH) study [50]. The questions 'how likely is it that you would try to avoid thinking about the warning?', 'how likely is it that you would try to avoid looking at the warning on your cigarette packs?' and 'how likely is it that you would keep the pack out of sight to avoid looking at the warning?' (only for smokers) were answered on a five-point scale from 'not at all likely' (coded 1) to 'extremely likely' (coded 5).

Reactance

Four reactance statements were taken from the reactance to warnings scale [51]: 'this warning annoys me', 'this warning aggravates me', 'this warning irritates me' and 'the government shouldn't require warnings like this on packs'. Agreement with statements was scored on a five-point scale from 'strongly disagree' (coded 1) to 'strongly agree' (coded 5).

Motivation to quit

In study 3 we also assessed the impact of warnings on motivation to quit smoking. Smokers were asked 'to what extent would this warning motivate you to quit smoking?'. We asked non-smokers 'to what extent would this warning motivate smokers to quit smoking?' [52]. As these two questions asked participants to consider either their own or others' behaviour, they are not directly comparable. Agreement with these statements was scored on a five-point Likert scale from 'not at all' (coded 1) to 'a lot' (coded 5).

Procedure

We invited eligible participants to attend a single testing session lasting 30–45 minutes. After providing informed consent, participants completed the carbon monoxide (CO) test and the FTND, QSU-Brief and QSCL, followed by the eye-tracking task. Participants viewed cigarette package stimuli on screen in blocks (see Table 1 for further information) and were asked to remember them (a recall phase followed each block—data not analysed). Stimuli order was pseudo-randomized such that in each block the same number of each type of warning was shown. Stimuli were presented for 10000 ms and a gaze-contingent fixation cross was presented between trials randomly on the left or right side of the screen. Each trial only started once the participant had fixated the cross for 40 ms, after a mandatory fixation cross presentation time of 1000 ms. Participants then viewed each of the warnings in a randomized order, this time without eye-tracking, and answered the reactance and avoidance questions (and motivation questions in study 3). We then fully debriefed and reimbursed participants.

Statistical plan

For study 1, we conducted a 2 (location: upper, lower) × 2 (immediacy: short-term, long-term) × 3 (smoking status: non-smoker, weekly smoker and daily smoker) repeated-measures analysis of variance (ANOVA) of bias scores comparing attention to warnings versus branding. For study 2, we conducted a 2 (format: text versus pictorial) × 2 (framing: gain-framed versus loss-framed) × 3 (smoking status: non-smokers, non-contemplators versus contemplators) ANOVA of bias scores. For study 3, we conducted a 2 (severity: highly severe versus moderately severe) × 3 (smoking status: non-smoker, weekly smoker and daily smoker) ANOVA on bias scores. For all studies, interaction effects were explored correcting for multiple comparisons, using the Bonferroni method. Similar analyses were run for self-reported avoidance, reactance and motivation. Cronbach's alpha for both avoidance and reactance scores, respectively, was higher than 0.92 for all three studies and 0.88 for motivation in study 3.

Effect sizes were calculated as Cohen's *d* for *t*-tests and eta-squared for ANOVA. Correlation coefficients were calculated for eye-tracking and self-reported measures. We conducted a time–course analysis [10], which provides a qualitative comparison of visual attention to the warning and branding between stimulus types over the 10000 ms of stimulus presentation.

Table 1 Participant characteristics.

Study	*Smoking status*	*Age (years)*	*Female (%)*	*Number of cigarettes*	*CO level (p. p.m.)*	*QSCL*	*FTND*	*QSU*
Study 1: immediacy and location	Non-smokers (n = 25)	20.60 (2.00)	58	NA	0.44 (0.87)	NA	NA	NA
	Weekly smokers (n = 25)	20.56 (1.00)	52	10.84/week (5.96)	3.96 (0.79)	5.60 (1.98)	0.12 (0.33)	2.06 (0.84)
	Daily smokers (n = 25)	22.80 (4.06)	48	9.36/day (3.15)	18.04 (7.98)	4.64 (1.55)	3.36 (7.35)	3.07 (1.19)
Study 2: framing and format	Non-smokers (n = 37)	23.95 (4.47)	46	NA	0.78 (1.03)	NA	NA	NA
	Non-contemplators (n = 43)	22.47 (3.60)	44	9.77/day (3.22)	15.70 (7.08)	3.81 (0.76)	3.74 (1.98)	3.21 (1.17)
	Contemplators (n = 37)	22.51 (2.77)	51	8.81/day (3.11)	13.86 (5.45)	6.57 (0.73)	3.22 (1.53)	3.45 (1.15)
Study 3: severity	Non-smokers (n = 27)	24.33 (5.14)	52	NA	2.33 (0.78)	NA	NA	NA
	Weekly smokers (n = 26)	23.85 (3.34)	50	8.81/week (8.77)	4.15 (3.15)	5.19 (2.38)	0.12 (0.43)	2.18 (1.26)
	Daily smokers (n = 26)	24.81 (4.68)	50	10.19/day (4.50)	13.92 (8.06)	4.77 (1.53)	3.10 (1.74)	2.82 (1.00)

Displaying mean (M) and standard deviations (SD) for age, number of cigarettes per day, carbon monoxide (CO) level, Quitting Smoking Contemplation Ladder (QSCL), Fagerström Test for Nicotine Dependence (FTND) and Questionnaire of Smoking Urges (QSU). NA = not applicable; p.p.m. = parts per million. In study 2, six participants were re-assigned to the non-contemplator status due to initial miscoding of the QSCL.

For simplicity, we report only the results for the number of fixations, as we have performed previously [10–12]. Analyses of fixation duration provided similar results, and these are available on request. Statistical assumptions of ANOVA were met for all analyses.

We have avoided using the term 'significant' or 'non-significant', given the binary nature of the threshold that these terms rely upon [53]. Instead, we use terms such as 'weak' and 'strong evidence' to reflect the strength of the evidence, and we determine this using a range of factors including the effect size estimates, confidence intervals, exact *P*-values, the direction of the point estimate and whether that is consistent with our a priori predictions.

RESULTS

Participant characteristics are shown in Table 1 and test statistics for all analyses in Table 2. Figures 1–3 show box-plots of the visual attention data. Time–course analyses of visual attention are shown in Supporting information, Figs S2–S4 and the self-reported avoidance and reactance data in Supporting information, Figs S5–S7.

Effects of health warning design

Study 1: warning immediacy and location

Participants spent more time attending the warnings than the branding (means above zero in Fig. 1). This includes daily smokers, for whom we did not observe evidence of the warning leading to visual avoidance as we had observed previously [10]. The time–course analysis supports these interpretations and indicates that attention to warnings was sustained throughout stimulus presentation (Supporting information, Fig. S2). There was some evidence for a location × immediacy interaction such that attentional bias towards the warnings was greatest when long-term warnings were placed on the upper- versus lower-half of packs [mean difference (MD) = 1.8; 95% confidence interval (CI) = 0.33, 3.26; statistics in Table 2]. The time–course analysis also indicates that initial orientating of attention towards the warning was greater when the warning was placed on the upper-half of the pack, although after approximately 2000 ms, attention to warnings placed on the upper- and lower-half of the pack was approximately equivalent.

Although we found increased visual attention to long-term than short-term warnings [MD = 0.89, 95% CI = 0.09, 1.68], self-reported avoidance of long-term warnings was greater than for short-term warnings [MD = 1.14; 95% CI = 0.94, 1.35]. There was no clear evidence of a main effect of warning immediacy on reactance (MD = 0.14; 95% CI = –0.04, 0.32).

Study 2: warning framing and format

We did not observe evidence for a framing × format interaction and, as shown in Fig. 2, there was no evidence of more fixations to warnings than branding for loss-framed

Table 2 ANOVA statistics (main effects and interactions) for outcome measures visual attention, self-reported avoidance, reactance and motivation to quit smoking.

		Visual attention				*Avoidance*			*Reactance*			*Motivation*		
Study		*F*	*d.f.*[a]	*P*	η_p^2	*F*	*P*	η_p^2	*F*	*P*	η_p^2	*F*	*P*	η_p^2
Study 1: immediacy and location	Immediacy	4.94	1,72	0.03	0.06	127.87	< 0.001	0.64	2.40	0.12	0.03	NA		
	Location	6.03	1,72	0.02	0.08	NA		NA				NA		
	Smoking status	1.86	2,72	0.16	0.05	0.06	0.94	0.002	2.82	0.07	0.07	NA		
	Location × immediacy	3.04	1,72	0.09	0.04	NA		NA				NA		
	Smoking status × immediacy	0.62	2,72	0.54	0.02	1.18	0.31	0.03	0.37	0.69	0.01	NA		
	Smoking status × location	1.39	2,72	0.25	0. 04	NA		NA				NA		
Study 2: framing and format	Framing	1.06	1114	0.30	0.01	178.50	< 0.001	0.61	58.00	< 0.001	0.34	NA		
	Format	52.98	1114	< 0.001	0.32	77.63	< 0.001	0.40	37.77	< 0.001	0.25	NA		
	Smoking status	1.8	2114	0.25	0.02	5.69	0.04	0.09	12.51	< 0.001	0.18	NA		
	Framing × format	2.57	1114	0.11	0.02	206.30	< 0.001	0.64	48.75	< 0.001	0.30	NA		
	Smoking status × framing	0.40	2114	0.67	0.01	4.88	0.01	0.08	8.23	< 0.001	0.13	NA		
	Smoking status × format	0.45	2114	0.64	0.01	0.08	0.92	0.002	0.43	0.65	0.01	NA		
Study 3: Severity	Severity	1.39	1,76	0.24	0.02	36.56	< 0.001	0.33	9.38	0.003	0.11	11.86	0.001	0.14
	Smoking status	0.50	2,76	0.61	0.01	21.41	< 0.001	0.36	1.61	0.21	0.04	8.78	< 0.001	0.19
	Smoking status × severity	2.02	2,76	0.14	0.05	0.17	0.84	0.004	1.24	0.29	0.03	1.27	0.29	0.03

[a]Degrees of freedom (d.f.) for visual attention are the same for other outcome measures. ANOVA = analysis of variance; NA = not applicable.

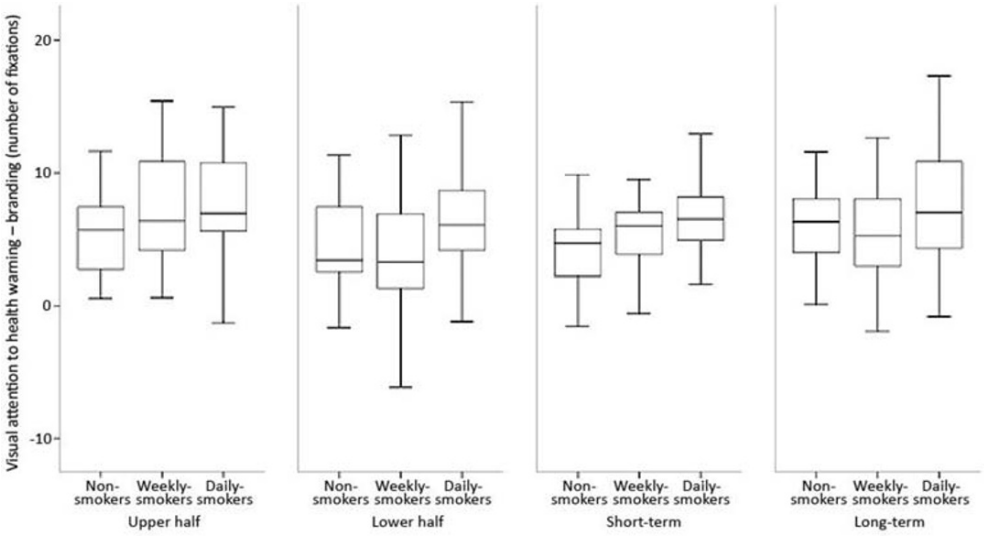

Figure 1 Box-plots of visual attention to warnings, measured as the number of fixations toward the warning minus the number of fixations toward the brand for study 1: warning immediacy and location

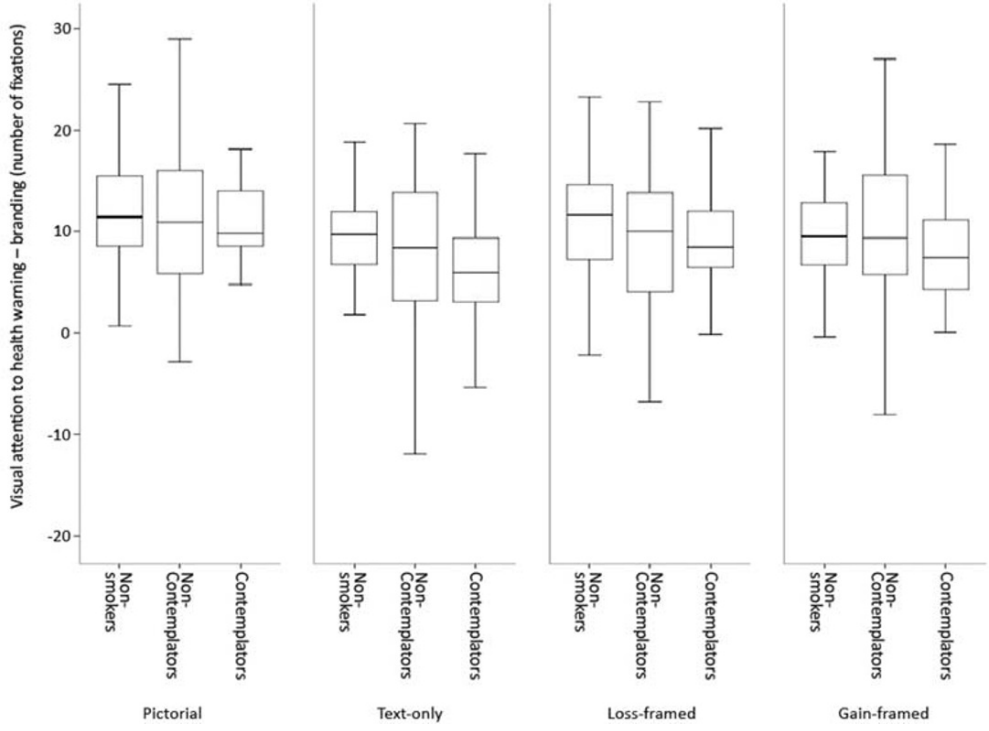

Figure 2 Box-plots of visual attention to warnings, measured as the number of fixations toward the warning minus the number of fixations toward the brand for study 2: warning format and framing

compared with gain-framed warnings (MD = 0.52; 95% CI = –0.54, 1.58: see Table 2 for all test statistics). This was supported by the time–course analysis which showed sustained attention to both gain- and loss-framed warnings across the stimulus presentation duration (Supporting information, Fig. S3). However, there was strong statistical evidence for greater visual attention towards pictorial versus text-only warnings (MD = 4.22; 95% CI = 3.08, 5.36). The time–course analysis indicated that, although both pictorial and text-only warnings elicited high rates of initial visual attention, this was more sustained for the pictorial warnings.

However, self-reported avoidance of and reactance to loss-framed warnings was greater than for gain-framed

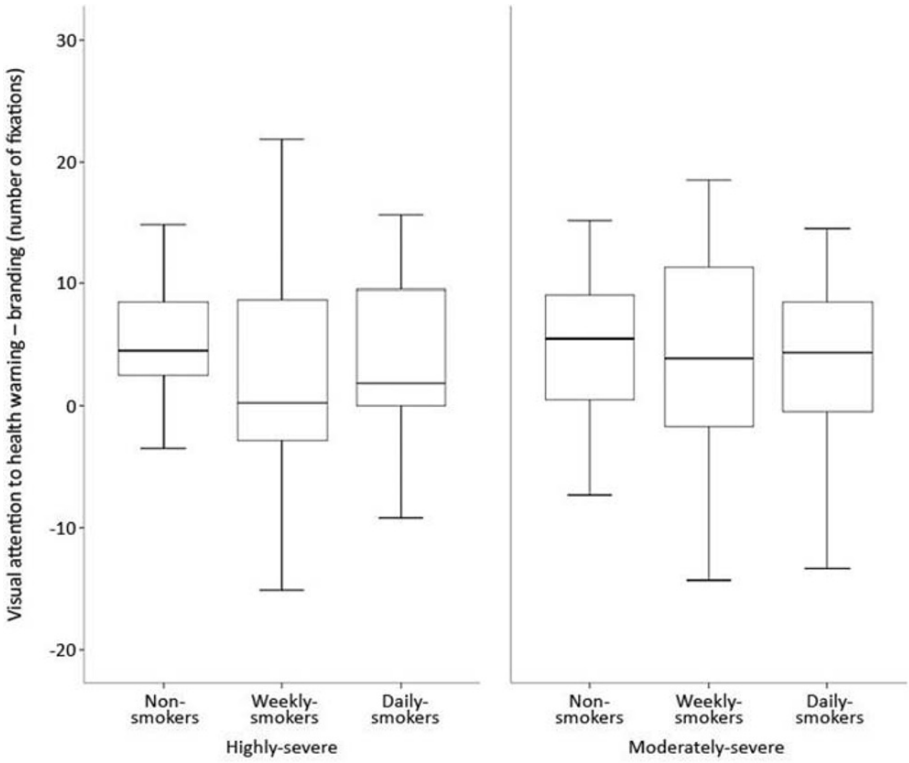

Figure 3 Box-plots of visual attention to warnings, measured as the number of fixations toward the warning minus the number of fixations toward the brand for study 3: warning severity

warnings (avoidance: MD = 0.70; 95% CI = 0.59, 0.80; reactance: MD = 0.37; 95% CI = 0.27, 0.47; Supporting information, Fig. S6) and for pictorial warnings versus text-only warnings (avoidance: MD = 0.34; 95% CI = 0.27, 0.42; reactance: MD = 0.18; 95% CI = 0.12, 0.23).

For avoidance, there was strong evidence for the framing × format interaction, such that self-reported avoidance was highest for pictorial loss-framed warnings (mean = 3.13, SD = 0.91) while pictorial gain-framed warnings obtained the lowest self-reported avoidance (mean = 2.02, SD = 0.87). For reactance, there was strong evidence for the framing × format interaction in the same direction as avoidance.

Study 3: warning severity

We found no evidence of a difference in visual attention between highly severe and moderately severe warnings (MD = –0.55; 95% CI = –1.5, 0.41; Fig. 3). Avoidance of and reactance to highly severe warnings was greater than to moderately severe warnings (avoidance: MD = 0.37; 95% CI = 0.25, 0.48; reactance: MD = 0.14; 95% CI = 0.05, 0.23; Supporting information, Fig. S6). Highly severe warnings also increased motivation to quit more than moderately severe warnings (MD = 0.25; 95% CI = 0.11, 0.39).

Differences by smoking status

Study 1: warning immediacy and location

For visual attention, there was no evidence for a main effect of smoking status or the smoking status × immediacy interaction. However, there was some evidence for the smoking status × location interaction and inspection of the box-plot (Fig. 1) indicates that daily smokers attended the warnings more than weekly smokers or non-smokers when the warnings appeared on the lower-half of the pack. There was no evidence of a difference in self-reported avoidance between the smoking groups and no smoking status × immediacy interaction. For reactance, there was little evidence that weekly smokers showed greater reactance than non-smokers (MD = 0.42; 95% CI = –0.02, 0.86) and no evidence for a smoking status × immediacy interaction.

Study 2: warning framing and format

For visual attention, there was no evidence for a main effect of smoking status nor for any interactions between smoking status and either message framing or format. This finding is further supported by the time–course analyses, which show a similar pattern for all three groups.

For self-reported avoidance, there was evidence for a difference between the smoking groups, and *post-hoc t*-tests

indicated that contemplators reported more avoidance of warnings than non-smokers (MD = 0.61; 95% CI = 0.17, 1.04; $t_{(114)}$ = 17.79; P = 0.003), although there was no clear difference between contemplators and non-contemplators (MD = 0.34; 95% CI = –0.08, 0.76; $t_{(114)}$ = 2.26; P = 0.15) or between non-contemplators and non-smokers (MD = 0.26; 95% CI = –0.16, 0.68; $t_{(114)}$ = 1.07; P = 0.40). There was evidence for a smoking status × warning framing interaction, such that although self-reported avoidance was higher for loss-framed versus gain-framed warnings regardless of smoking status, this difference was smallest for non-smokers (mean = 0.52, SD = 0.61), intermediate for non-contemplators (mean = 0.65, SD = 0.42) and greatest among contemplators (mean = 0.92, SD = 0.66) who showed high levels of loss-framed avoidance.

The pattern for reactance was similar. A main effect of smoking status indicated that non-smokers showed less reactance toward warnings than non-contemplators (MD = 0.51; 95% CI = 0.16, 0.87; $t_{(114)}$ = 22.56; P = 0.002) and contemplators (MD = 0.74; 95% CI = 0.37, 1.1; $t_{(114)}$ = 302.62, P < 0.001). There was also strong evidence for a smoking status × framing interaction, in the same direction as for avoidance, with the increased reactance to loss-framed warnings being smallest for the non-smokers (mean = 0.14, SD = 0.29), intermediate for non-contemplators (mean = 0.34, SD = 0.49) and greatest among the contemplators (mean = 0.63, SD = 0.71).

Study 3: warning severity

For visual attention, there was no evidence of a main effect of smoking status or of a smoking status × severity interaction.

For self-reported avoidance, we found strong evidence for a main effect of smoking status, and *post-hoc t*-tests revealed that weekly smokers reported more avoidance than non-smokers (MD = 1.59; 95% CI = 0.99, 2.19; $t_{(76)}$ = 6153.44; P < 0.001) and daily smokers (MD = 0.59; 95% CI = –0.01, 1.20; $t_{(76)}$ = 3.96; P = 0.06). There was no evidence of a severity × smoking status interaction. For reactance, there was also no evidence of a main effect of smoking status or the severity × smoking status interaction (see Supporting information, Fig. S7).

For motivation to quit, we again found strong evidence for a main effect of smoking status. *Post-hoc t*-tests indicated that non-smokers assumed that the warnings would motivate quitting among smokers to a greater degree than did weekly smokers (MD = 0.79; 95% CI = 0.15, 1.43; $t_{(76)}$ = 9.88; P = 0.01) or daily smokers (MD = 1.05; 95% CI = 0.41, 1.69; $t_{(76)}$ = 48.68, P < 0.001). However, this finding should be treated with caution, given that non-smokers were considering the extent to which the warning would motivate smokers to quit, while smokers were reporting their own motivation. There was no evidence of an interaction between warning severity and smoking status.

Correlation between measures

In study 1, there was no evidence that either avoidance (r = 0.19, P = 0.11) or reactance (r = 0.10, P = 0.37) was correlated with the number of fixations. There was also no evidence for a correlation between avoidance and reactance (r = 0.16, P = 0.16).

In study 2, there was no evidence that either self-reported avoidance (r = −0.07, P = 0.40) or reactance (r = −0.11, P = 0.27) was correlated with the number of fixations. Unlike study 1, self-reported avoidance and reactance were moderately correlated (r = 0.46, P < 0.001).

In study 3, as in studies 1 and 2, there was no evidence that either self-reported avoidance (r = −0.08, P = 0.45), reactance (r = −0.09, P = 0.40) or motivation to quit smoking (r = 0.19, P = 0.09) was correlated with visual attention. However, there was evidence of a moderate correlation between self-reported avoidance and reactance (r = 0.55, P < 0.001).

DISCUSSION

Our results have important implications for warning design, and supports previous research which found that responses differed by warning content [1,54]. Visual attention was greater for long- versus short-term warnings (study 1) but did not differ by warning framing (study 2) or severity (study 3). We observed greater levels of self-reported avoidance for long-term, loss-framed and highly severe warnings, greater levels of self-reported reactance for loss-framed and highly severe health warnings and greater motivation to quit for highly severe warnings. Overall, our findings support use of 'fear appeals' (i.e. warnings that arouse negative affect). Although conducted before standardized packaging was introduced in the United Kingdom, our studies show increased visual attention to warnings on the upper-half of packs (study 1) and pictorial warnings (study 2), both key features of standardized packaging. Our findings may support attempts to introduce these warning formats in countries yet to require them.

Importantly, visual attention to warnings was not correlated with self-reported avoidance and while participants visually attended the long-term warnings (study 1) and pictorial warnings (study 2) more than their counterparts, self-reports indicated increased avoidance of these formats. These ostensibly paradoxical findings merit closer analysis. We propose that visual avoidance reflects an immediate voluntary disengagement from an unpleasant or uninteresting stimulus [10–12]. Its counterpart, visual attention, is an adaptive critical first step in stimulus processing. In

line with avoidance learning theories [18], self-reported avoidance occurs when individuals attempt to alleviate negative emotions caused by warnings and therefore indicates threat communication—an important attribute of effective warnings [2,15,42,55–57], explaining its relation to increased quit attempts [15–17].

The relationship between avoidance and reactance is important, given ongoing debates over the effectiveness of threatening health warnings [41,43,44]. In studies 2 and 3 we found self-reported avoidance and reactance were positively correlated, supporting previous research [17]. We tentatively suggest that warnings can simultaneously result in both adaptive (e.g. negative affect and self-reported avoidance) and defensive responses (e.g. reactance), as previously suggested [15]. Longitudinal research should focus upon disentangling the different effects of avoidance and reactance on quitting. Nonetheless, we suggest that warnings increasing self-reported avoidance (and visual attention), but minimizing reactance, could promote overall effectiveness.

Adding efficacy messages (through Quitline information [58] and Canadian-style in-pack inserts [59,60]), as suggested by message communication models (e.g. [61]), may help to achieve balance between avoidance and reactance. While there is no evidence from our data that omitting these attributes from fear appeals would backfire, as predicted by the 'strong efficacy hypothesis' [62], fear appeals were clearly effective on their own (see study 2). However, we cannot exclude the possibility that adding these attributes might enhance the effects of fear appeals as proposed by the 'weak efficacy hypothesis' [62]. Moreover, study 2 found lower reactance and avoidance to gain- versus loss-framed messages; and, although not really investigated here, it is possible that gain-framed warnings work via another mechanism, such as increasing quitting efficacy.

We also observed differences in visual attention and self-reported responses to warnings between smoking groups. Regarding initial visual attention, our findings are consistent with our previous research [11,12]: compared to smokers, non-smokers visually attended warnings for longer in two of the three studies (see time–course analyses). Study 2 showed that individuals contemplating quitting displayed the largest increase in both self-reported avoidance of and reactance to loss- versus gain-framed warnings. Our findings suggest that these warnings are eliciting the greatest fear response among those for whom quitting is most salient. However, the direction of causality is unknown: quit intentions may have been increased by previous warning exposure, or individuals with increased quit intentions may be processing the warnings differently. We did not find increased attention to branding over warnings or large differences in visual attention to warnings according to smoking status, as we have found previously [10].

Our studies have some limitations. First, while we focused upon visual attention and self-reported measures, we did not measure the impact on quit intentions or actual behaviour. Secondly, although two-dimensional stimuli are commonly used in research of this kind [2], responses may vary from those elicited following exposure to actual cigarette packs. Further, participants viewed the warnings in a single exposure, and future research should use field-experimental designs with repeated exposure (e.g. [63]) to explore effects on visual attention. As a result, we cannot draw strong conclusions about which warning characteristics are most critical. While we attempted to match long- and short-term warnings in study 1, these warnings differed in wording, imagery and immediacy. In addition, study 2 used different pictorials and text for the gain- and loss-framed warnings. Although this approach is more realistic, it is more difficult to disentangle the elements of each warning's relative contributions. Finally, our participants were predominantly young adults, and the warnings may be less salient for a group known to self-exempt from the risks shown [24].

In summary, we suggest that visual avoidance, as measured by unconscious eye-movement behaviour, and self-reported avoidance measure different constructs: the first is a maladaptive reaction towards a warning threat while the second represents a higher-order learnt construct, assessing threat communication. To our knowledge, this is the first study to examine the relationship between initial sensory attention toward health warnings and self-reported avoidance. Understanding these differences will be critical in developing and testing effective tobacco health warnings.

Declaration of interests

B.T. testifies as an expert witness on behalf of plaintiffs who have filed litigation against the tobacco industry. All other authors declare no competing interests.

Acknowledgements

This work was supported by funding awarded to O.M.M. by Cancer Research UK (C51287/A19332), the ESRC (ES/R003424/1) and the Medical Research Council Integrative Epidemiology Unit at the University of Bristol, which is supported by the Medical Research Council and the University of Bristol (MC_UU_12013/6). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

A preprint of this article before peer review by Addiction can be found at https://psyarxiv.com/p5z9u/; https://doi.org/10.31234/osf.io/p5z9u).

Author contributions

Carlos Sillero-Rejon: Conceptualization; data curation; formal analysis; investigation; project administration; visualization. **Ute Leonards:** Conceptualization. **Marcus Munafo:** Conceptualization. **Craig Hedge:** Conceptualization; formal analysis; visualization. **Janet Hoek:** Conceptualization. **Benjamin Toll:** Conceptualization; conceptualization. **Harry Gove:** Conceptualization; data curation; formal analysis; investigation; project administration. **Isabel Willis:** Conceptualization; formal analysis; investigation. **Rose Barry:** Conceptualization; investigation; project administration. **Abi Robinson:** Conceptualization; investigation; project administration. **Olivia Maynard:** Conceptualization; data curation; formal analysis; funding acquisition; methodology; project administration; resources; software; supervision; visualization.

References

1. Hammond D. Health warning messages on tobacco products: a review. *Tob Control* 2011; **20**: 327–37.
2. Noar S. M., Hall M. G., Francis D. B., Ribisl K. M., Pepper J. K., Brewer N. T. Pictorial cigarette pack warnings: a meta-analysis of experimental studies. *Tob Control* 2016; **25**: 341–54.
3. Erceg-Hurn D. M., Steed L. G. Does exposure to cigarette health warnings elicit psychological reactance in smokers? *J Appl Soc Psychol* 2011; **41**: 219–37.
4. Glock S., Kneer J. Are deterrent pictures effective? The impact of warning labels on cognitive dissonance in smokers. *Appl Psychol Health Well-Being* 2009; **1**: 356–73.
5. Stothart G., Maynard O., Lavis R., Munafò M. Neural correlates of cigarette health warning avoidance among smokers. *Drug Alcohol Depend* 2016; **161**: 155–62.
6. Kaufman A., Klein E. G., Koblitz A., Price S. A vision for eye-tracking research in tobacco regulatory science. *Tob Regul Sci* 2018; **4**: 3–7.
7. Maynard O. M., McClernon F. J., Oliver J. A., Munafò M. R. Using neuroscience to inform tobacco control policy. *Nicotine Tob Res* 2019; **21**: 739–46.
8. Meernik C., Jarman K., Wright S. T., Klein E. G., Goldstein A. O., Ranney L. Eye tracking outcomes in tobacco control regulation and communication: a systematic review. *Tob Regul Sci* 2016; **2**: 377–403.
9. Thrasher J. F., Brewer N. T., Niederdeppe J., Peters E., Strasser A. A., Grana R. *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* 2019; 21: 855–62.
10. Maynard O. M., Attwood A., O'Brien L., Brooks S., Hedge C., Leonards U., *et al.* Avoidance of cigarette pack health warnings among regular cigarette smokers. *Drug Alcohol Depend* 2014; **136**: 170–4.
11. Maynard O. M., Munafò M. R., Leonards U. Visual attention to health warnings on plain tobacco packaging in adolescent smokers and non-smokers. *Addiction* 2013; **108**: 413–9.
12. Munafò M. R., Roberts N., Bauld L., Leonards U. Plain packaging increases visual attention to health warnings on cigarette packs in non-smokers and weekly smokers but not daily smokers. *Addiction* 2011; **106**: 1505–10.
13. Retzler C., Shiraj N., Retzler J. Eye movement data reveal increased attention to combined health warnings on cigarette packs. *Drug Alcohol Depend* 2019; **194**: 336–40.
14. Posner M. I. Orienting of attention. *Q J Exp Psychol* 1980; **32**(1), 3–25.
15. Brewer N. T., Parada H. Jr., Hall M. G., Boynton M. H., Noar S. M., Ribisl K. M. Understanding why pictorial cigarette pack warnings increase quit attempts. *Ann Behav Med* 2019; **53**: 232–43.
16. Borland R., Yong H.-H., Wilson N., Fong G. T., Hammond D., Cummings K. M., *et al.* How reactions to cigarette packet health warnings influence quitting: findings from the ITC four-country survey. *Addiction* 2009; **104**: 669–75.
17. Cho Y. J., Thrasher J. F., Swayampakala K., Yong H.-H., McKeever R., Hammond D. *et al.* Does reactance against cigarette warning labels matter? Warning label responses and downstream smoking cessation amongst adult smokers in Australia, Canada, Mexico and the United States. *PLOS ONE* 2016; **11**; e0159245.
18. Krypotos A.-M., Effting M., Kindt M., Beckers T. Avoidance learning: a review of theoretical models and recent developments. *Front Behav Neurosci* 2015; **9**: 189.
19. Wegner D. M. Ironic processes of mental control. *Psychol Rev* 1994; **101**: 34–52.
20. Brehm S. S., Brehm J. W. *Psychological Reactance: A Theory of Freedom and Control*. Cambridge, MA: Academic Press; 2013, p. 447.
21. Hall M. G., Sheeran P., Noar S. M., Boynton M. H., Ribisl K. M., Parada H. Jr., *et al.* Negative affect, message reactance and perceived risk: how do pictorial cigarette pack warnings change quit intentions? *Tob Control* 2018; **27**: e136–e142.
22. Chapman G. B. Temporal discounting and utility for health and money. *J Exp Psychol Learn Mem Cogn* 1996; **22**: 771–91.
23. Bickel W. K., Odum A. L., Madden G. J. Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology* 1999; **146**: 447–54.
24. Hoek J., Hoek-Sims A., Gendall P. A qualitative exploration of young adult smokers' responses to novel tobacco warnings. *BMC Public Health* 2013; **13**: 609.
25. Gendall P., Eckert C., Hoek J., Louviere J. Estimating the effects of novel on-pack warnings on young adult smokers and susceptible non-smokers. *Tob Control* 2018; **27**: 519–25.
26. Tversky A., Kahneman D. The framing of decisions and the psychology of choice. *Science* 1981; **211**: 453–8.
27. Gallagher K. M., Updegraff J. A. Health message framing effects on attitudes, intentions, and behavior: a meta-analytic review. *Ann Behav Med* 2012; **43**: 101–16.
28. O'Keefe D. J., Jensen J. D. The relative persuasiveness of gain-framed loss-framed messages for encouraging disease prevention behaviors: a meta-analytic review. *J Health Commun* 2007; **12**: 623–44.
29. Floyd D. L., Prentice-Dunn S., Rogers R. W. A meta-analysis of research on protection motivation theory. *J Appl Soc Psychol* 2000; **30**: 407–29.
30. Latimer A. E., Krishnan-Sarin S., Cavallo D. A., Duhig A., Salovey P., O'Malley S. A. Targeted smoking cessation messages for adolescents. *J Adolesc Health* 2012; **50**: 47–53.
31. Toll B. A., Martino S., Latimer A., Salovey P., O'Malley S., Carlin-Menter S., *et al.* Randomized trial: Quitline specialist training in gain-framed versus standard-care messages for smoking cessation. *J Natl Cancer Inst* 2010; **102**: 96–106.

32. Fucito L. M., Latimer A. E., Salovey P., Toll B. A. Nicotine dependence as a moderator of message framing effects on smoking cessation outcomes. *Ann Behav Med* 2010; **39**: 311–7.
33. Szklo A. S., Coutinho E. S. F. The influence of smokers' degree of dependence on the effectiveness of message framing for capturing smokers for a Quitline. *Addict Behav* 2010; **35**: 620–4.
34. van't Riet J., Ruiter R. A., Werrij M. Q., De Vries H. The influence of self-efficacy on the effects of framed health messages. *Eur J Soc Psychol* 2008; **38**: 800–9.
35. Toll B. A., Salovey P., O'Malley S. S., Mazure C. M., Latimer A., McKee S. A. Message framing for smoking cessation: the interaction of risk perceptions and gender. *Nicotine Tob Res* 2008; **10**: 195–200.
36. Latimer-Cheung A. E., Fucito L. M., Carlin-Menter S., Rodriguez J., Raymond L., Salovey P., *et al*. How do perceptions about cessation outcomes moderate the effectiveness of a gain-framed smoking cessation telephone counseling intervention? *J Health Commun* 2012; **17**: 1081–98.
37. Moorman M., van den Putte B. The influence of message framing, intention to quit smoking, and nicotine dependence on the persuasiveness of smoking cessation messages. *Addict Behav* 2008; **33**: 1267–75.
38. Droulers O., Gallopel-Morvan K., Lacoste-Badie S., Lajante M. The influence of threatening visual warnings on tobacco packaging: measuring the impact of threat level, image size, and type of pack through psychophysiological and self-report methods. *PLOS ONE* 2017; 12: e0184415.
39. Maynard O. M., Gove H., Skinner A. L., Munafò M. R. Severity and susceptibility: measuring the perceived effectiveness and believability of tobacco health warnings. *BMC Public Health* 2018; **18**: 468.
40. Benjamin W., Merrill R. M., Lindsay G. B. Cigarette pack warning labels in Russia: how graphic should they be? *Eur J Public Health* 2011; **21**: 366–72.
41. Kees J., Burton S., Andrews J. C., Kozup J. Understanding how graphic pictorial warnings work on cigarette packaging. *J Public Policy Mark* 2010; **29**: 265–76.
42. Noar SM, Rohde JA, Barker JO, Hall MG, Brewer NT. Pictorial cigarette pack warnings increase some risk appraisals but not risk beliefs: a meta-analysis. *Hum Commun Res*. 2020; **46**: 250–72 [cited 2020 Dec 2];(hqz016).
43. Kok G., Peters G.-J. Y., Kessels L. T., Ten Hoor G. A., Ruiter R. A. Ignoring theory and misinterpreting evidence: the false belief in fear appeals. *Health Psychol Rev* 2018; **12**: 111–25.
44. Peters G.-J. Y., Ruiter R. A., Ten Hoor G. A., Kessels L. T., Kok G. Towards consensus on fear appeals: a rejoinder to the commentaries on Kok, Peters, Kessels, ten Hoor, and Ruiter (2018). *Health Psychol Rev* 2018; **12**: 151–6.
45. Biener L., Abrams D. B. The contemplation ladder: validation of a measure of readiness to consider smoking cessation. *Health Psychol* 1991; **10**: 360–5.
46. European Commission. Tobacco Products Directive. Directive 2014/40/EU of the European Parliament and of the Council [internet]. 2014. Available at: https://ec.europa.eu/health/sites/health/files/tobacco/docs/dir_201440_en.pdf. (accessed 15 June 2020).
47. Cohen J. E., Brown J., Washington C., Welding K., Ferguson J., Smith K. C. Do cigarette health warning labels comply with requirements: a 14-country study. *Prev Med* 2016; **93**: 128–34.
48. Heatherton T. F., Kozlowski L. T., Frecker R. C., Fagerström K.-O. The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire. *Br J Addict* 1991; **86**: 1119–27.
49. Cox L. S., Tiffany S. T., Christen A. G. Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine Tob Res* 2001; **3**: 7–16.
50. Hyland A., Ambrose B. K., Conway K. P., Borek N., Lambert E., Carusi C., *et al*. Design and methods of the Population Assessment of Tobacco and Health (PATH) study. *Tob Control* 2017; **26**: 371–8.
51. Hall M. G., Sheeran P., Noar S. M., Ribisl K. M., Bach L. E., Brewer N. T. Reactance to health warnings scale: development and validation. *Ann Behav Med* 2016; **50**: 736–50.
52. Fathelrahman A. I., Omar M., Awang R., Cummings K. M., Borland R., Samin A. S. B. M. Impact of the new Malaysian cigarette pack warnings on smokers' awareness of health risks and interest in quitting smoking. *Int J Environ Res Public Health* 2010; **7**: 4089–99.
53. Sterne J. A., Smith G. D. Sifting the evidence—what's wrong with significance tests? *Phys Ther* 2001; **81**: 1464–9.
54. Anshari D., Yong H.-H., Borland R., Hammond D., Swayampakala K., Thrasher J. Which type of tobacco product warning imagery is more effective and sustainable over time? A longitudinal assessment of smokers in Canada. *Australia and Mexico. BMJ Open* 2018; **8**: e021983.
55. Yong H.-H., Borland R., Hammond D., Thrasher J. F., Cummings K. M., Fong G. T. Smokers' reactions to the new larger health warning labels on plain cigarette packs in Australia: findings from the ITC Australia project. *Tob Control* 2016; **25**: 181–7.
56. Thrasher J. F., Swayampakala K., Borland R., Nagelhout G., Yong H.-H., Hammond D., *et al*. Influences of self-efficacy, response efficacy, and reactance on responses to cigarette health warnings: a longitudinal study of adult smokers in Australia and Canada. *Health Commun* 2016; **31**: 1517–26.
57. Osman A., Thrasher J. F., Yong H.-H., Arillo-Santillán E., Hammond D. Disparagement of health warning labels on cigarette packages and cessation attempts: results from four countries. *Health Educ Res* 2017; **32**: 524–36.
58. Hoek J., Gendall P., Eckert C., Rolls K., Louviere J. A comparison of on-pack Quitline information formats. *Tob Control* 2016; **25**: 211–7.
59. Thrasher J. F., Osman A., Abad-Vivero E. N., Hammond D., Bansal-Travers M., Cummings K. M., *et al*. The use of cigarette package inserts to supplement pictorial health warnings: an evaluation of the Canadian policy. *Nicotine Tob Res* 2015; **17**: 870–5.
60. Thrasher J. F., Swayampakala K., Cummings K. M., Hammond D., Anshari D., Krugman D. M., *et al*. Cigarette package inserts can promote efficacy beliefs and sustained smoking cessation attempts: a longitudinal assessment of an innovative policy in Canada. *Prev Med* 2016; **88**: 59–65.
61. Witte K. Putting the fear back into fear appeals: the extended parallel process model. *Commun Monogr* 1992; **59**: 329–49.
62. Tannenbaum M. B., Hepler J., Zimmerman R. S., Saul L., Jacobs S., Wilson K., *et al*. Appealing to fear: a meta-analysis of fear appeal effectiveness and theories. *Psychol Bull* 2015; **141**: 1178–204.
63. Dijkstra A., Bos C. The effects of repeated exposure to graphic fear appeals on cigarette packages: a field experiment. *Psychol Addict Behav* 2015; **29**: 82–90.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 Study characteristics
Fig S1 Stimuli examples
Fig S2 Time-course analyses for Study 1 (warning immediacy and location), across the 10000 ms stimulus presentation period to show the percentage of trials in which participants were fixating the branding (grey lines) as opposed to health warnings (black lines) for different packs types and between smoking groups.
Fig S3 Time-course analyses for Study 2 (warning framing and format), across the 10000 ms stimulus presentation period to show the percentage of trials in which participants were fixating the branding (grey lines) as opposed to health warnings (black lines) for different packs types and between smoking groups.
Fig S4 Time-course analyses for Study 3 (warning severity), across the 10000 ms stimulus presentation period to show the percentage of trials in which participants were fixating the branding (grey lines) as opposed to health warnings (black lines) for different packs types and between smoking groups.
Fig S5 Means and standard errors for self-reported measures of avoidance and reactance for Study 1 – warning immediacy and location
Fig S6 Means and standard errors for self-reported measures of avoidance and reactance for Study 2 – warning framing and format
Fig S7 Means and standard errors for self-reported measures of avoidance, reactance and motivation to quit for Study 3 – warning severity.

