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Evaluating the influence of message framing and graphic imagery on perceptions of food product health warnings

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ABSTRACT

Food product health warnings may be a valuable intervention strategy for helping reduce obesity rates and the negative health outcomes associated with consuming an unhealthy diet. Research into the efficacy of food product health warnings has shown promising effects on consumers' beliefs and behaviour, but existing research has typically featured a single or limited number of simple, text-only warnings. Two studies are presented that tested the influence of text-only and text-and-graphic, positively and negatively framed health warnings on perceived efficacy, negative affect and motivation to change behaviour. Using a between-subjects design, Study 1 found that negatively framed health warnings and text-and-graphic health warnings produced more negative emotional responses than positively framed and text-only health warnings. Study 2 then featured the highest rated message topics from Study 1. Using a within-subjects design, Study 2 found that participants rated text-and-graphic health warnings as more effective than text-only warnings, and negatively framed warnings as more effective than positively framed warnings, though all warning groups scored above the scale mid-point on perceived efficacy. Negatively framed warnings produced stronger negative emotional responses, while positively framed warnings produced stronger feelings of motivation to change behaviour. Results indicate that food product health warnings were perceived as capable of effectively promoting behavioural change. While negatively framed warnings were seen as most effective, positively framed warnings may also be effective, possibly through a different persuasive pathway.

1. Introduction

In spite of increased attention, the worldwide prevalence of overweight and obesity and associated health consequences remains a global epidemic (Williams, Mesidor, Winters, Dubbert, & Wyatt, 2015). One regulatory approach that has been suggested to combat rising obesity rates is the use of product and point-of-sale health warnings. These have been proposed as a means of educating consumers about the health risks associated with excess body weight and unhealthy eating practices and of promoting reduced consumption of energy dense, nutrient poor food and beverages. For example, legislative bills introduced in New York (N.Y. State Assembly Bill 2320-B, 2015), California (Senate Bill-1000, 2014; Senate Bill-203, 2015), Vermont (Vermont House Bill H0089, 2015), Washington (State of Washington House Bill 2789, 2016), and Hawaii (State of Hawaii Senate Bill 1270, 2015) would require health warnings to be displayed on the packaging of sugar sweetened beverages (SSBs), and front-of-pack warnings on food products featuring excess sugar, salt, or saturated fat have been required in Chile since 2012 (Corvalán, Reyes, Garmendia, & Uauy, 2013). Interest in this legislation follows the international success of similar tobacco control warning messages which are now featured on tobacco products in over 100 nations (Canadian Cancer Society, 2016). While research into the efficacy of tobacco control health warnings is extensive (Noar, Francis, et al., 2016; Noar, Hall, et al., 2016), only a small number of studies have investigated the influence of food product health warnings on consumer beliefs and behaviour (e.g., Bollard, Maubach, Walker, & Mhurchu, 2016; Roberto, Wong, Musicus, & Hammond, 2016; VanEpps & Roberto, 2016), and the extent to which findings from tobacco control research can be applied to the domain of obesity prevention remains unclear (West, 2007).

Initial studies into the efficacy of food product health warnings for influencing beliefs about unhealthy food products and promoting healthy dietary behaviour have produced promising results. When exposed to health warning messages, people displayed reduced

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preferences for SSBs, and reduced intentions to purchase these beverages for themselves (Bollard et al., 2016) or their children (Roberto et al., 2016). Teenagers who viewed health warnings were also less likely to select a SSB when given the option to select a beverage (VanEpps & Roberto, 2016). In the same study, participants who viewed health warnings were less likely to believe that SSBs were healthy or would help them lead a healthy life, and estimated that SSBs contained more added sugar than participants who had not viewed health warnings. Similarly, health warnings have been shown to reduce parents' preferences for fruit or sports drinks, correcting the perception that these constitute healthy alternatives to soft drinks (Moran & Roberto, 2018). There is also evidence that food product health warnings are more successful at influencing both purchase intentions and behaviour relative to front of pack calorie labels (Roberto et al., 2016) or traffic light systems that colour code nutrient contents (Arrúa et al., 2017). Furthermore, health warnings have been found to improve dietary self-control in a laboratory setting, and to reduce brain signals evoked by appetitive food cues (Rosenblatt, Bode et al., 2018; Rosenblatt, Summerell, et al., 2018), while a recent field study conducted in a hospital cafeteria demonstrated that health warnings can effectively drive healthier drink purchases in real world dietary choice environments (Donnelly, Zatz, Svirsky, & John, 2018). Lastly, simulations indicate that the introduction of health warnings in three American cities could result in a 2.65% reduction in obesity prevalence over a 7-year period, on average (Lee et al., 2018). Collectively, these results indicate that food product health warnings may provide a valuable contribution to existing obesity prevention efforts. However, the majority of these studies feature one or few simple text based health warning messages (notably excepting Donnelly et al., 2018; Rosenblatt, Bode et al., 2018), and as such, a number of questions remain open concerning how the characteristics of food product health warnings influence their efficacy.

As with the food product health warnings that have been proposed or introduced to date, early tobacco health warnings featured simple text-only messages. Over time, these warnings were strengthened to include confronting messages about various harmful health consequences of tobacco products, augmented by images vividly depicting these health effects or other motivational imagery designed to evoke an emotional response (Hiilamo, Crosbie, & Glantz, 2013). The term 'graphic health warning' is used throughout this article to refer to this type of health warnings specifically and not other image based health communications (e.g. traffic light systems). Research comparing graphic tobacco control health warnings to their text-only counterparts has found that graphic warnings outperform text warnings on most outcomes measured. For example, graphic health warnings were more likely to be perceived as effective (O'Hegarty et al., 2006), and to be attended to, discussed, and recalled (Hammond, 2011). Graphic warnings were also more effective in influencing likely precursors to smoking cessation such as beliefs and attitudes concerning the risks associated with smoking

(Hammond, Fong, McDonald, Cameron, & Brown, 2003), produced greater self-efficacy regarding behaviour change and intentions to quit or not start smoking (Fathelrahman et al., 2013) and generated stronger emotional responses (Newman-Norlund et al., 2014; Wang, Lowen, Romer, Giorno, & Langleben, 2015). Furthermore, findings from laboratory, observational and randomised controlled trial studies support the conclusion that graphic health warnings are more effective in producing actual behaviour change when compared to text-only warnings (Brewer et al., 2016; Noar, Francis, et al., 2016; Noar, Hall, et al., 2016). Similar to graphic health warnings on tobacco products, graphic warnings for unhealthy food and beverage products, depicting the harmful health consequences of an unhealthy diet (e.g. tooth decay, excess body fat and diseases of inner organs), also appear to produce improved results over text-only warnings (Rosenblatt, Bode et al., 2018). However, further empirical evidence is needed to help determine the efficacy of different health warning formats for influencing consumers' beliefs, emotions and behaviour.

Another aspect of health warning design that has seen some attention in the context of tobacco control but remains underexplored with regards to food product health warnings is the influence of message framing on efficacy. In the context of health communication, negative (or loss-framed) message framing refers to presenting messages that attempt to persuade by focusing on the negative health consequences associated with engaging in a behaviour, whereas positive (or gain-framed) message framing focuses on the health benefits associated with abstaining from the behaviour (Rothman & Salovey, 1997). While it is commonly argued on theoretical grounds that positive message framing should be more effective than negative framing for messaging targeting preventive behaviours such as dieting (Salovey & Williams-Piehota, 2004), experimental findings on this topic have been mixed.

A *meta*-analysis by Gallagher and Updegraff (2012) found support for the use of positive message framing when targeting illness prevention behaviours such as physical activity and smoking cessation. However, a study investigating the influence of message framing on dietary behaviour found no difference in attitudes or behavioural intentions between message framing conditions (van Assema, Martens, Ruiter, & Brug, 2002). While some studies have found support for positive message framing when targeting smoking cessation (Schneider et al., 2001) or continued abstinence after successfully quitting (Toll et al., 2007), both of these studies featured relatively complex messages that included visual and audio materials. Studies that investigated message framing effects on tobacco health warnings specifically have predominantly found greater efficacy when negative frames are used (Bansal-Travers, Hammond, Smith, & Cummings, 2011; Goodall & Appiah, 2008; Nan, Zhao, Yang, & Iles, 2014). These findings are further supported by a recent study where negatively framed food product health warnings more effectively promoted dietary self-control than positively framed warnings (Rosenblatt, Bode et al., 2018). One possible explanation for this discrepancy is that effective negatively framed messages are easier to convey on the limited space afforded by health warnings, while positively framed messages may be more effective when using a format that allows for further elaboration. Further study into message framing effects for food product health warnings is necessary to better understand this relationship.

As food product health warnings are yet to be implemented in any country besides Chilé (where only simple text-based warnings have been introduced), it is difficult to investigate the influence of health warning design characteristics on population behaviour. Nonetheless, existing formative research studying the influence of health communication messages on perceived efficacy and other message evaluation measures has demonstrated a substantial positive relationship between these measures and actual efficacy (Dillard, Weber, & Vail, 2007). In addition to perceived efficacy measures, other behavioural antecedents and predictors of efficacy such as attitudes, beliefs and emotional responses may be informative about the influence of health warning design on efficacy. Tobacco control health messages that generate strong fear responses have been shown to produce higher rates of seeking help and advice (Ayers, Althouse, & Emery, 2015; Durkin, Wakefield, & Spittal, 2011) and provoke more quit attempts (Durkin, Biener, & Wakefield, 2009; Farrelly et al., 2012). As negative message framing and the addition of graphic imagery both contribute to a health warning's ability to produce fear responses, this may aid in explaining the apparent superiority of these types of health warnings.

However, a recent study into the relationship between emotional responses and health warning efficacy demonstrates that besides fear, other negative (guilt, sadness) and positive (hope) emotions may also contribute to health warning efficacy in some cases (Durkin, Bayly, Brennan, Biener, & Wakefield, 2018). It therefore bears noting that positively framed warnings are likely better able to produce positive emotions such as hope. As hope is a motivational force associated with improved self-efficacy (belief in one's ability to act) and perseverance (Nabi & Myrick, 2018; Nabi, 2015), which are known to be predictive of behaviour change (Bundura, 1977), positively framed warnings may

Table 1
Factor loadings and communalities based on a principal components analysis with oblimin rotation for 22 health warning evaluation items.

Health warning evaluation item	Perceived Efficacy	Negative Emotional Responses	Behaviour Change Motivation	Communality
This health warning is effective.	0.79			0.75
This health warning would prompt me to purchase a healthier snack.	0.71			0.67
This health warning will prompt people to purchase healthier snack foods.	0.86			0.7
This health warning makes me feel concerned about my weight/eating habits.	0.67			0.7
This health warning makes me feel confident in my ability to reach or stay a healthy weight/eat a healthy diet.	0.67			0.69
This health warning is easy to understand.	0.64			0.35
This health warning is worth remembering.	0.79			0.62
This health warning grabs my attention.	0.69			0.58
This health warning is believable.	0.7			0.42
This health warning makes a strong argument for being a healthy weight/eating a healthy diet.		0.41		0.49
This health warning makes me feel disgusted.		0.78		0.6
This health warning makes me feel anxious.		0.85		0.73
This health warning makes me feel ashamed.		0.8		0.64
This health warning makes me feel fearful.		0.78		0.67
This health warning makes me feel guilty.		0.77		0.61
This health warning makes me feel sad.		0.82		0.67
This health warning makes me feel confused.		0.6		0.41
This health warning makes me feel uncomfortable.		0.85		0.72
This health warning makes me feel motivated to take action to achieve or stay a healthy weight/eat a healthy diet.			0.52	0.46
This health warning makes me feel inspired.			0.84	0.75
This health warning makes me feel hopeful.			0.85	0.71
This health warning makes me feel encouraged.			0.86	0.79

Note. Factor loadings < 0.4 are suppressed.

yet be effective for promoting healthy eating. Positively framed messages that produce greater hope responses and improved self-efficacy could also be associated with other benefits such as reduced risk of stigmatising overweight and obese individuals (Puhl, Peterson, & Luedicke, 2012) and may receive less resistance from industry, indicating the importance of developing our understanding of this relationship.

Across two online survey studies, the present paper examined the influence of food product health warning design characteristics (text-only vs. text-and-graphic health warnings, positively framed vs. negatively framed health warning messages) on health warning evaluation items measuring perceived efficacy, emotional responses and ability to produce behaviour change motivation. The first study presented here tested these relationships on a large sample of health warning messages using a between-subjects design. This study also allowed for the validation of the messages topics in the health warnings presented. The second study featured the health warning messages that were perceived as most effective across all four health warning formats, ensuring that all health warnings featured were of a similarly high perceived efficacy. The second study then employed a within-participant design, allowing for a more direct comparison of the different health warning formats while controlling for individual level variance and balancing order effects. It was hypothesised that, consistent with findings in the tobacco control health warning literature and the limited evidence for food choices, graphic health warnings would be perceived as more effective than text-only warnings. It was further hypothesised that negatively framed health warnings would be perceived as more effective and produce stronger negative emotional responses than positively framed health warnings. Lastly, it was hypothesised that positively framed health warnings would evoke stronger feelings of motivation and hope about being able to change one's behaviour than negatively framed health warnings.

2. Study 1

The aims of this study were to investigate how health warning design characteristics (message framing, text and graphic formats) influence health warning perceptions, and to select health warning message topics that were perceived to be most effective across all health warning groups for inclusion in Study 2.

3. Method

3.1. Participants

Participants were recruited via advertisements posted on social media platforms, via paper advertisements around The University of Melbourne, and via email to recipients of the Decision Neuroscience Laboratory participant mailing list who had previously consented to be contacted for future studies. Following a detailed description of the requirements of the study, all participants provided consent before taking part. The University of Melbourne Human Research Ethics Committee (No. 1443258) approved all study procedures. Participants were not reimbursed but could enter the draw to win an iPad.

Out of 381 participants who initially accessed the online explanatory statement and consent form, 126 went on to complete the survey, which took approximately 60 min. The low consent rate was most likely due to the long duration of the study. Of those who completed the survey, 26 participants were excluded for poor data quality (entering the same value for all or most responses, failure to complete demographic information) resulting in a final sample of 100 participants (mean age = 27.59, SD = 10.82) of which 74 were female (mean age = 27.91, SD = 10.69) and 26 were male (mean age = 26.57, SD = 11.43).

3.2. Health warning stimuli

Health warning stimuli were created based on current medical and epidemiological evidence and were consistent with the National Health and Medical Research Council Dietary Guidelines for Australians (2013). Some of the health warning message topics focused on the relationship between diet and health, while others focused on the link between excess body weight and health. From these areas, 18 topics were identified that were deemed suitable for inclusion as health

Table 3
Average perceived efficacy rating across health warning all four health warning formats for each health warning topic.

Health warning topics	Mean perceived efficacy score
Heart disease	**3.74**
Stroke	**3.69**
Arthritis	**3.68**
Cancer	**3.66**
Diet affects health	**3.62**
Type 2 diabetes	**3.61**
Infertility	**3.6**
Shorter life	**3.6**
Tooth decay	**3.59**
High blood pressure	**3.58**
Mental health	3.57
Osteoporosis	3.56
Sleep quality	3.54
Diet affects body weight	3.52
Difficulty breathing	3.41

Note: 15 topics are listed, as the negatively framed groups featured multiple cancer focused message topics, and only the most effective was selected and averaged. Health warning topics featured in Study 2 are listed in **bold**.

warning message topics (see Table 3).

For each of the 18 health warning topics, appropriate health warning variants were created to encompass the four health warning formats of interest: text-only/positively-framed warnings (henceforth “text-positive warnings”), text-only/negatively-framed warnings (“text-negative warnings”), text-and-graphic/positively-framed warnings (“graphic-positive warnings”), and text-and-graphic/negatively-framed warnings (“graphic-negative warnings”). Positively and negatively framed variants of each warning featured the same message content, phrased in opposite directions (e.g., for the message topic “tooth decay”, the negatively framed message read “Eating sugary foods increases your risk of tooth decay”, while the positively framed message read “Avoiding sugary foods reduces your risk of tooth decay”). The graphic-negative health warnings variants were accompanied by imagery of the negative health outcome in question (e.g., an image of dental caries), whereas positive variants featured positive imagery that aimed to capture the healthy equivalent of this condition (e.g., healthy teeth). See Fig. 1 for examples of the respective health warning formats tested. Each of the health warning variant groups therefore contained 18 health warning stimuli, with the exception of the graphic-positive group. Due to difficulty finding appropriate imagery for graphic-positive variants of messages discussing the relationship between diet and different forms of cancer, the variants for these messages in this group instead featured a single health warning that focused on cancer and diet generally, rather than a specific form of cancer, and this group therefore contained only 15 distinct health warnings. As a result, 69 different health warnings were featured in the present study.

3.3. Experimental paradigm

A between-subjects design was employed, with each participant viewing all health warnings of one format only. This was necessary to prevent the survey from being prohibitively long. Allocation of participants to health warning conditions was randomized, resulting in a final sample of 22 participants in the text-negative condition, 21 text-positive participants, 33 graphic negative participants and 24 graphic positive participants. A chi-squared goodness of fit test indicated that the randomization was successful and no significant deviation from the expected values was observed ($\chi^2(3) = 3.6$, $p = .31$). Within each condition, the order of health warning topic presentation was randomized for each participant. Each health warning was evaluated on 24 items by presenting statements that were rated using a 5-point scale ranging from “Strongly Disagree” to “Strongly Agree”. The health warning evaluation items were adapted from past research assessing the efficacy of health communication messages and advertising material aimed at influencing health and dietary behaviours (Dixon, Scully, Cotter, Maloney, & Wakefield, 2015; Emery, Romer, Sheerin, Jamieson, & Peters, 2014; Mays et al., 2015). The health warning evaluation items were selected to measure the extent to which participants thought each warning would effectively promote healthier dietary choices and related constructs such as message acceptance, behaviour change self-efficacy and positive and negative emotional responses (see Table 1 for list of items). The presentation order for each item was randomized.

In addition to the health warning evaluation items, participants completed the Dutch Eating Behavior Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986). All survey data were collected using Qualtrics online survey delivery tool (Qualtrics, 2018) and analyzed using Release, 2014b (MathWorks, 2014) and R (Core Team, 2016).

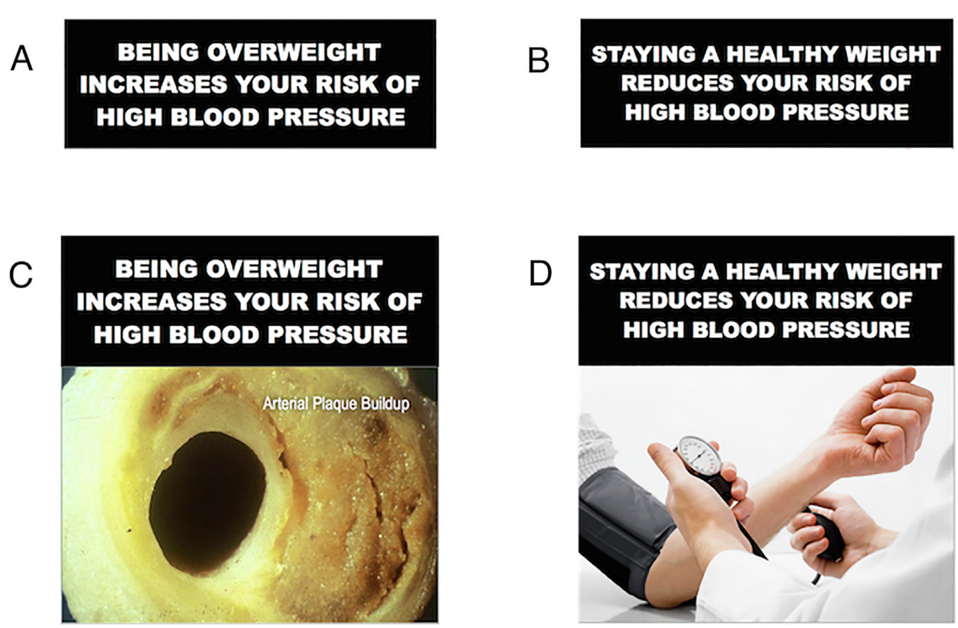

Fig. 1. Health warning format example images: (A) text-only, negatively framed; (B) text-only, positively framed; (C) text-and-graphic, negatively framed; and (D) text-and-graphic, positively framed.

3.4. Procedure

First, participants were instructed that for each question, they should imagine the featured health warnings being displayed on snack food items that are high in caloric content and low in nutritional content or at the point-of-sale in stores that sell these food items, as they would be used as part of an obesity prevention messaging campaign. Participants were then randomly allocated to one of the four health warning format groups, and completed the health warning evaluation section of the study. Participants were next asked to answer a short questionnaire that recorded information about their dietary habits and demographic characteristics, followed by the DEBQ (van Strien et al., 1986). Lastly, participants were asked to provide a contact e-mail address, should they be interested in entering the prize draw.

3.5. Statistical analysis

Initially, differences in age, sex, BMI, food consumption variables, and subscales of the DEBQ between members of the health warning groups were tested, to determine whether randomization to conditions was successfully achieved. Between-subjects analyses of variance (ANOVA) for continuous variables, Kruskal-Wallis tests for ordinal data, and chi-squared tests for proportions were conducted to test for differences in individual and demographic factors between groups. A *p*-value of < 0.05 in these tests was used as grounds to include the corresponding variable as a covariate in subsequent analyses.

Principal components analysis was conducted to identify and compute composite scores summarizing the underlying covariation structure of the 24 health warning evaluation items. The factorability of the health warning evaluation items was examined using several well-recognized criteria (see Results) and principal components analysis was deemed appropriate for all 24 items. Inspection of initial eigenvalues and scree plot results were used to identify parsimonious factor solutions. These were then examined using an oblique (oblimin) rotation, due to expected correlation between the underlying factors. Once the most interpretable factor solution was identified, items that did not contribute to a simple factor loading structure and failed to meet the criteria of having a primary factor loading of 0.4 or higher, and no cross-loading of 0.4 or higher, were removed. Descriptive factor names were determined following inspection of the items that made up each factor, and internal consistencies for each scale were examined using Cronbach's alpha. Lastly, composite scores were created for each of the factors based on the mean of the items that had their primary loadings on each factor.

Next, linear mixed-effects models were computed to test for differences between each of the health warning format conditions on each of the health warning evaluation scales that were identified using principal components analysis. These models were beneficial here, as they allow for two sources of random variation to be controlled simultaneously. In this case, participants and stimuli were both specified as random intercepts in all models, in order to control for participant- and stimulus-level dependencies while maximising the statistical power afforded by the sample by analyzing all data collected rather than participant-level averages. Satterthwaite degrees of freedom approximation was used to calculate *p*-values. Bonferroni corrected post-hoc tests were conducted following significant framing by text/graphic condition interaction results. Mixed effect model analyses was conducted using the lme4 package in R (Bates, Mächler, Bolker, & Walker, 2015).

4. Results

4.1. Demographic characteristics

No significant differences in age ($F(3,93) = 1.05$, $p = .37$), sex ($\chi^2(3) = 1.82, p = .61$), BMI ($F(3, 85) = 1.2, p = .32$), nor frequency of consuming vegetables ($\chi^2(3) = 2.64$, $p = .45$), fruit ($\chi^2(3) = 2.65$, $p = .45$), soft drink ($\chi^2(3) = 4.25$, $p = .24$), or confectionary ($\chi^2(3) = 1.18, p = .76$), were detected between participants in the four health warning groups. The four groups also displayed no differences on the restrained eating ($F(3,93) = 0.21$, $p = .89$), emotional eating ($F(3,90) = 1.9$, $p = .14$), or external eating ($F(3,94) = 0.75$, $p = .52$) subscales of the DEBQ. Thus these variables were not included as covariates in subsequent analyses.

4.2. Principal components analysis

Initially, the factorability of the health warning evaluation items was examined. Firstly, 23 of the 24 items showed a correlation of at least 0.3 with at least one other item, suggesting reasonably good factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.94, indicating excellent factorability (Kaiser, 1974), and Bartlett's test of sphericity was significant ($\chi^2(276) = 27983.1$, $p < .001$). Lastly, the measures of sampling adequacy for each item (i.e. the diagonals of the anti-image correlation matrix) were all above 0.85, far above the recommended minimum of 0.5, and communalities were also high (see Table 1), supporting the inclusion of each item in the analysis. Given these indicators, principal components analysis was conducted on all 24 items.

The initial eigenvalues and the scree plot indicated that a three or four factor solution was most appropriate for the data. Three and four factor solutions were both tested, using an oblimin rotation of the factor loading matrix. The three factor solution was preferred due to an insufficient number of primary loadings and difficulty interpreting the fourth factor. Two items ("This health warning was relevant to me" and "This health warning taught me something new") did not display primary loadings at the minimum level of 0.4 on any of the factors and were therefore eliminated from the final model. A principal components analysis of the remaining 22 items was conducted using an oblimin rotation, with the three factors explaining 59.5% of the total variance.

An inspection of the items making up each factor revealed that the first factor contained items assessing the extent to which each health warning was perceived as effective in prompting healthier dietary choices or increasing the desire to maintain a healthy body weight, the second factor captured negative emotional responses evoked by health warnings such as the extent to which they evoked fear or disgust, and the third factor captured the extent to which a health warning made participants feel motivated or hopeful about their ability to eat a healthy diet or lose weight. These factors were named "Perceived Efficacy", "Negative Emotional Responses" and "Behaviour Change Motivation", respectively. The factor loading matrix for this final three factor solution is presented in Table 1.

Internal consistencies for each scale were examined using Cronbach's alpha. The reliabilities for all scales were high (Perceived Efficacy, 9 items, $\alpha = 0.92$; Negative Emotional Responses, 9 items, $\alpha = 0.92$; Behaviour Change Motivation, 4 items, $\alpha = 0.89$). No substantial increases in alpha for any of the scales could have been achieved by eliminating more items. Composite scores were created for each of the three factors, based on the mean of the items that had their primary loadings on each factor.

4.3. Health warning perceptions

Three linear mixed effects models were constructed to test how the different health warning conditions influenced participants' perceptions of health warning efficacy, negative emotional responses and motivation to change behaviour. Each model featured one of the health warning evaluation scale measures as the dependent variable, and included the main effects of framing (positive, negative) and graphic condition (text-only, text-and-graphic) and the two-way interaction of these two factors as independent variables. Participants and stimuli were modelled as random effects. Omnibus significance values are

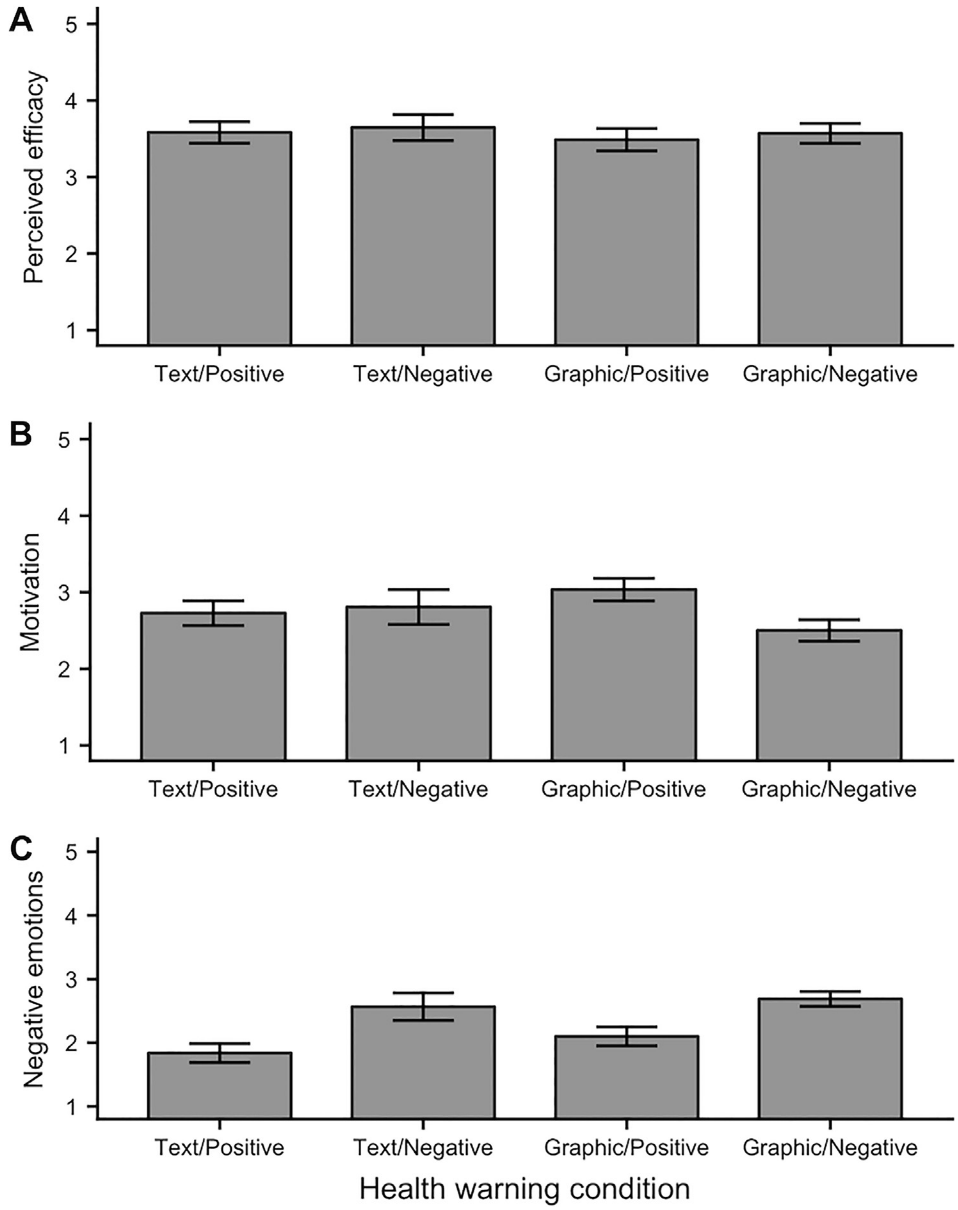

Fig. 2. Mean health warning evaluation scale scores by health warning group for participants in Study 1. (A) Mean perceived efficacy scores; (B) mean behaviour change motivation scores; and (C) Mean negative emotional reactions scores. Error bars denote standard error.

presented using Wald chi-square tests. Log-likelihood ratio tests were also conducted using a backward selection approach and produced the same results. Bonferroni corrected post-hoc tests were conducted following significant interaction effects. See Fig. 2 for rating scale scores for each health warning condition.

Perceived efficacy. The main effects of framing ($\chi^2(1) = 0.38$, $p = .54$), text/graphic condition ($\chi^2(1) = 0.49$, $p = .48$), and the framing-by-text/graphic condition interaction effect ($\chi^2(1) = 0.006$, $p = .94$) on perceived efficacy were all not significant.

Behaviour change motivation. The main effects of framing ($\chi^2(1) = 3.05$, $p = .08$) and text/graphic condition ($\chi^2(1) = 0.03$, $p = .88$) on behaviour change motivation did not reach significance. However, a significant frame-by-text/graphic condition interaction was observed ($\chi^2(1) = 4.12$, $p = .042$). Positively framed health warnings produced significantly higher behaviour change motivation ratings than negatively framed health warnings when health warnings featured graphic images ($\chi^2(1) = 7.04$, $p = .016$), while no difference was observed when text-only warnings were used ($\chi^2(1) = 0.13$, $p = 1$).

Negative emotional responses. The main effect of framing on negative emotional responses was significant ($\chi^2(1) = 25.41$, $p < .001$), indicating that negatively framed health warnings (M = 2.64, SE = 0.03) produced significantly stronger negative emotional responses than positively framed health warnings (M = 1.97, SE = 0.03). No other significant main or interaction effects were identified.

4.4. *Health warning stimulus selection*

To identify the best performing health warning topics, perceived efficacy ratings were averaged across health warning stimuli of all four design characteristics (text-negative, text-positive, graphic-negative, graphic-positive) for each message topic. The 10 health warning topics with the highest average perceived efficacy across all formats (see Table 3) were retained for inclusion in Study 2. As Study 2 employed a within-subjects design, it would have been too burdensome for participants to rate health warnings on all 18 topics across all four format conditions. See supplemental information for full set of selected health warning stimuli.

5. Study 2

The purpose of Study 2 was to investigate how health warning messages with different design characteristics (message framing, text and graphic formats) would be perceived when presented in combination rather than isolation. For this, the health warning message topics perceived as most effective in Study 1 were tested again, but instead of presenting different groups of participants with warnings of a single format, all participants were presented with a mixture of warnings reflecting the different health warning formats (within-subjects design). This second step was important to eliminate frame of reference effects, as participants in Study 1 saw only health warnings of one format (e.g. text-negative warnings), participant responses were possibly biased by exposure to stimuli of this group, leading to a reduced breadth of health warning evaluation scale responses across groups. The goal of Study 2 was to establish the degree to which health warning messages would be perceived as effective by the *same* people when comparing warnings across design characteristics.

6. Method

6.1. Participants

An independent sample of participants was recruited via the same methods used in Study 1. All participants read a detailed description of the study requirements and provided consent before taking part. 126 participants initially accessed the survey link, and 43 participants (mean age = 24.85, SD = 8.69) completed the survey with satisfactory data quality. Participants were removed for failing to complete all ratings questions, for not providing sufficient demographic data, or for providing the same response to all or most ratings questions. The final sample consisted of 25 women (mean age = 25.36, SD = 9.49) and 18 men (mean age = 23.25, SD = 5.63). Given that this study utilised a within-subjects design, and mixed-effects modelling was applied, this sample size was sufficient for the planned statistical analyses.

6.2. Health warning stimuli

In order to ensure that the health warning stimuli featured in this study were all of a similarly high level of perceived efficacy, a subset of 40 of the health warnings (4 formats × 10 message topics) featured in Study 1 were presented (as described in Section 4.4). All four variants (text-negative, text-positive, graphic-negative and graphic positive) of the chosen message topics were presented.

6.3. Experimental paradigm

A within-subjects design was employed, such that each participant saw health warnings of all formats. In order to reduce the time commitment required, health warning message topics were assigned to one of two experimental blocks using balanced random allocation. Each of the experimental blocks featured all 4 health warning variants of 5 of the health warning message topics, ensuring that each participant saw 5 health warnings from each health warning design characteristic group and thus rated 20 health warnings total. At the beginning of the survey, participants were randomly allocated to one of these blocks, and the order of health warning presentation was randomised for each participant.

Participants rated each health warning on the same health warning evaluation questionnaire items used in Study 1. Scale composite scores were calculated using the average responses to scale items identified using principal components in Study 1. Participants also completed demographic and dietary behaviour surveys and the DEBQ (van Strien et al., 1986).

6.4. Procedure

Participants provided informed consent and read task instructions before being randomly allocated to one of the two experimental blocks and completing the health warning evaluation questionnaire. Participants then provided demographic information, completed dietary behaviour questionnaires and were given the option to enter the draw to win a prize as incentive for taking part in the study.

6.5. Statistical analysis

Differences in age, sex, BMI, food consumption variables, and subscales of the DEBQ between members of each of the experimental blocks were tested to ensure that both blocks featured comparable sample characteristics and could therefore be combined in subsequent analyses.

Principal components analysis of this data, to be interpreted with caution given the smaller sample size, produced the same factors found in Study 1, providing evidence in support of this factor structure (data not shown). To test for differences between health warning format groups, linear mixed-effects models were computed for each of the health warning evaluation scales. As fixed effects, these models featured the main effects of framing (positive, negative) and text/graphic condition (text-only, text-and-graphic) and the two-way interaction of these two factors, while participants and stimuli were both specified as random intercepts in all models. This allowed for the analysis of all data collected without participant-level data aggregation, and the increased statistical power associated with this approach. Satterthwaite degrees of freedom approximation was used to calculate *p*-values. Post-hoc tests were conducted using Bonferroni's correction following a significant interaction effect. Mixed effect model analyses was conducted using the lme4 package in R (Bates et al., 2015).

7. Results

7.1. Demographic characteristics

The participants in each of the experimental blocks did not significantly differ in age ($F(1,32) = 1.04$, $p = .32$), sex ($\chi^2(1) = 1.33$, $p = .25$), BMI ($F(1, 30) = 0.32$, $p = .58$), nor frequency of consuming vegetables ($\chi^2(1) = 0.046$, $p = .83$), fruit ($\chi^2(1) = 0.37$, $p = .54$), soft drink ($\chi^2(1) = 0.36$, $p = .55$), or confectionary ($\chi^2(1) = 0.49$, $p = .49$). Participants in the two blocks also displayed no differences on the restrained eating ($F(1,32) = 1.82$, $p = .19$), emotional eating ($F(1,32) = 0.03$, $p = .86$), or external eating ($F(1,32) = 0.03$, $p = .87$) subscales of the DEBQ. These results indicated that both experimental blocks were composed of comparable samples, and their rating results could be pooled for further analyses.

7.2. Health warning perceptions

Linear mixed effects models were used to test the influence of health warning format on perceptions of health warning efficacy, negative emotional responses, and on behaviour change motivation. As with Study 1, one model was constructed for each of the health warning evaluation scale measures, with the main effects of framing (positive, negative) and graphic condition (text-only, text-and-graphic) and the two-way interaction of these factors entered as independent variables, however this time a within-participants design was used. Once again, participants and stimuli were modelled as random effects. Wald chi-squared tests were used to establish significance for fixed effects and post-hoc tests using Bonferroni's correction were conducted following a significant interaction result. See Fig. 3 for mean scale scores for each health warning condition.

Perceived efficacy. When tested using a within-participants design, the main effects of framing ($\chi^2(1) = 55.53$, $p < .001$) and text/graphic

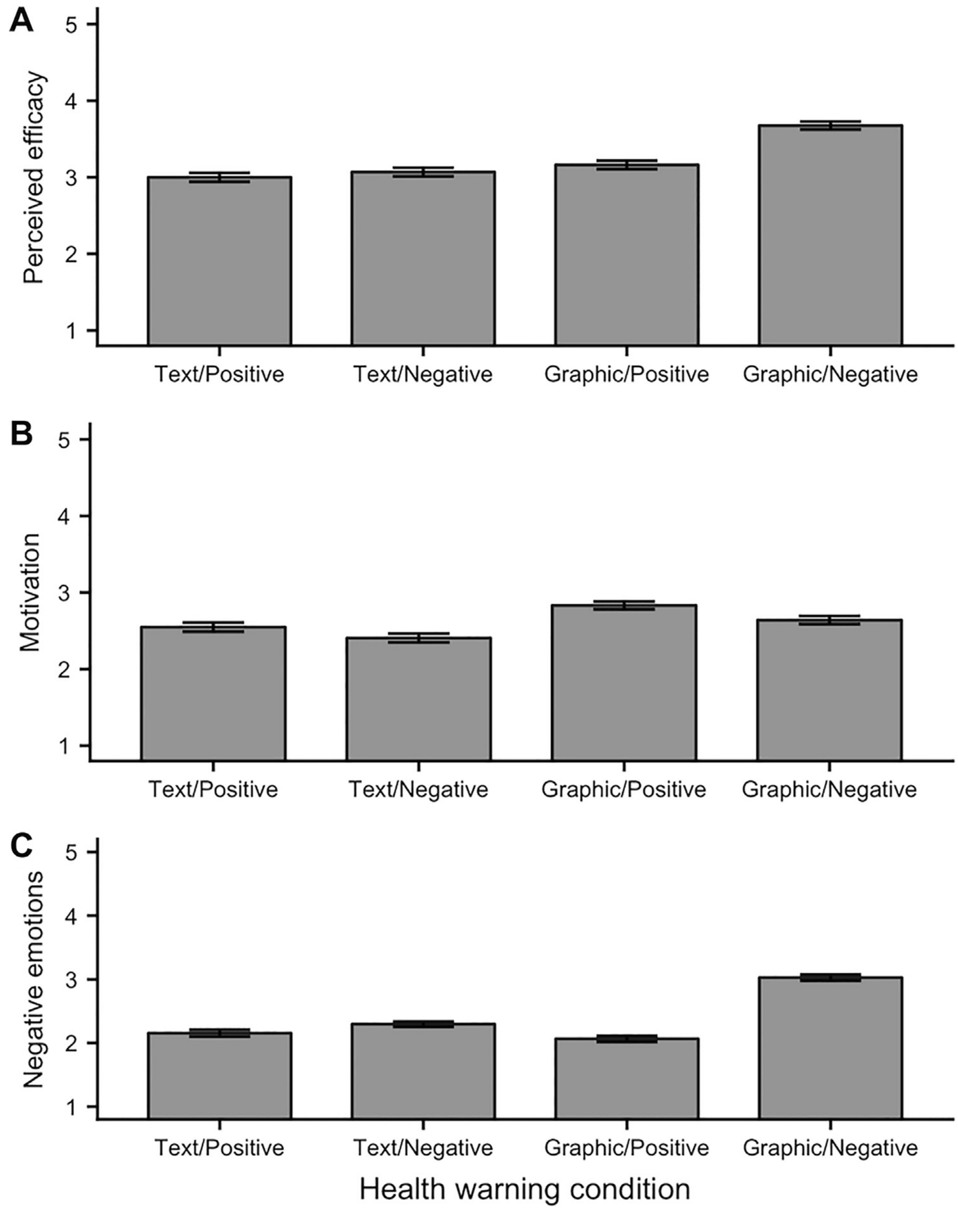

Fig. 3. Mean health warning evaluation scale scores by health warning group for participants in Study 2. (A) Mean perceived efficacy scores; (B) mean behaviour change motivation scores; and (C) Mean negative emotional reactions scores. Error bars denote standard error.

condition ($\chi^2(1) = 96.44$, $p < .001$) on perceived efficacy were both significant, indicating that negatively framed health warnings (M = 3.37, SE = 0.04) were perceived as more effective than positively framed warnings (M = 3.08, SE = 0.04) and that graphic health warnings (M = 3.42, SE = 0.04) were perceived as more effective than text-only warnings (M = 3.03, SE = 0.04). Furthermore, the effect of the frame-by-text/graphic condition interaction on perceived efficacy was also significant ($\chi^2(1) = 32.17$, $p < .001$). Health warnings featuring graphic images were perceived as more effective than text-only health warnings, and this effect was stronger when messages were negatively framed ($\chi^2(1) = 120.01$, $p < .001$) than when they were positively framed ($\chi^2(1) = 8.6$, $p = .007$). Similarly, negatively framed health warnings were perceived as more effective when health warnings featured graphic images ($\chi^2(1) = 86.12$, $p < .001$), but not when text-only warnings were used ($\chi^2(1) = 1.58$, $p = .42$).

Behaviour change motivation. The main effects of framing condition ($\chi^2(1) = 10.6$, $p = .0011$) and text/graphic condition ($\chi^2(1) = 25.45$, $p < .001$) on behaviour change motivation were both significant, indicating that graphic health warnings (M = 2.74, SE = 0.04) produced greater feelings of motivation towards eating a healthy diet or losing weight than text-only warnings (M = 2.48, SE = 0.04) and that positively framed health warnings (M = 2.69, SE = 0.04) produced greater behaviour change motivation than negatively framed warnings (M = 2.52, SE = 0.04). The interaction between framing and text/graphic condition did not reach significance ($\chi^2(1) = 0.22$, $p = .64$).

Negative emotional responses. The main effects of framing ($\chi^2(1) = 199.48$, $p < .001$) and text/graphic condition ($\chi^2(1) = 67.33$, $p < .001$), and the two-way interaction of these factors ($\chi^2(1) = 110.09$, $p < .001$) on negative emotional responses were all significant. The main effects indicated that negatively framed health warnings (M = 2.66, SE = 0.04) produced more negative emotional responses than positively framed warnings (M = 2.11, SE = 0.03), and that graphic warnings (M = 2.55, SE = 0.04) produced more negative emotional responses than text-only warnings (M = 2.23, SE = 0.03). Post-hoc contrasts using Bonferroni's correction revealed that negative message framing was associated with increased negative emotional responses, and this effect was stronger in the text-and-graphic condition ($\chi^2(1) = 302.98$, $p < .001$) than in the text-only condition

($\chi^2(1) = 6.59$, $p = .02$). Graphic health warnings produced significantly stronger negative emotional responses than text-only warnings when negative framing was employed ($\chi^2(1) = 174.81$, $p < .001$) but this relationship did not reach significance when health warnings were positively framed ($\chi^2(1) = 2.62$, $p = .21$); see Fig. 3.

8. Discussion

The purpose of the current research was to investigate the effectiveness of graphic versus text-only food product health warnings. We also sought to expand current literature by assessing the influence of message framing (positive vs. negative) on food product health warning efficacy. In addition to measuring perceived efficacy, related constructs identified through principal components analysis targeting negative emotional responses and the degree to which health warnings promoted feelings of motivation and hope towards changing one's behaviour were also examined.

While the first study, in which only one health warning format was presented to each participant, found no significant differences in perceived efficacy between positively- and negatively-framed text-only and text-and-graphic health warnings, significant perceived efficacy differences between these conditions were identified in Study 2, where all participants were shown health warnings of all formats. As hypothesised, the observed pattern of results indicates that the addition of images and the use of negative message framing contribute to higher perceived efficacy ratings than those for text-only and positively framed health warnings. Across both studies, negatively framed health warnings produced greater negative emotional reactions than positively framed warnings, and these effects were strongest in the graphic health warning conditions. Lastly, in both studies, we found evidence that positive message framing and the use of graphic health warnings produced stronger feelings of hope and motivation to change behaviour than when negative message framing and text-only health warnings were presented.

While the results of Study 1 predominantly did not conflict with those produced in Study 2, having trended in the same direction in most cases, the findings were not as clear as in the second study. This apparent discrepancy may have been driven by a few different factors. Firstly, while both studies featured a range of health warning topics that focused on the health outcomes associated with different dietary practices or with being overweight, the full set of health warning topics featured in Study 1 had not been externally validated. By including only the health warning topics in Study 2 that had consistently been rated as most effective in Study 1, it was possible to remove underperforming message topics, which possibly reduced noise in our measures, making the effect of the design characteristics on perceived efficacy more detectable.

A second potential explanation for the discrepancy in results is that, as Study 2 used a within-participant design, the results were less prone to frame of reference effects (Bing, Whanger, Davison, & VanHook, 2004; Lievens, De Corte, & Schollaert, 2008). When participants were exposed to health warnings of a single group only (e.g., graphic negative health warnings), as in Study 1, their responses were more likely to capture the relative efficacy of health warning message *topics* (e.g. tooth decay, heart disease, etc.) within that group alone. By presenting example health warnings of each health warning format, as in Study 2, participants were more likely to provide responses that accurately captured the relative perceived efficacy of health warnings from these different groups across all featured topics.

The results of this study are consistent with existing literature demonstrating that graphic health warnings commonly outperform text-only warnings in terms of perceived and actual efficacy

(Borland et al., 2009; Cameron, Pepper, & Brewer, 2015; Schneider, Gadinger, & Fischer, 2012). As the majority of research on the relative efficacy of graphic and text-only health warnings has investigated this question in the context of smoking related beliefs and behaviour (Noar, Francis, et al., 2016; Noar, Hall, et al., 2016), this finding supports the notion that this existing evidence may be applicable to our understanding of how to design effective diet-related health warnings. It is worth noting that perceived efficacy ratings for all health warnings groups were above the midpoint of the scale on average, indicating positive (but reduced) perceptions of efficacy for text-only health warnings in addition to graphic warnings. Furthermore, these results closely mirror the pattern of findings in our recent laboratory-based experiment that investigated the impact of these health warning message formats on actual dietary decisions (Rosenblatt, Bode et al., 2018).

Theoretical and empirical work examining the influence of message framing on perceived, and actual, health message efficacy has produced mixed results. While a number of authors have argued for the use of positive message frames for preventive behaviours such as eating healthily (Rothman, Bartels, Wlaschin, & Salovey, 2006; Salovey & Williams-Piehota, 2004), and the evidence in support of either message framing approach appears to be highly variable across different behaviours or individual characteristics (Mays et al., 2015; Van 'T Riet, Ruiter, Werrij, Candel, & De Vries, 2010; Wansink & Pope, 2014), health warning research has commonly found support for negative message frames (Nan et al., 2014; Zhao, Nan, Yang, & Alexandra Iles, 2014). Findings from the present study, along with our recent behavioural experiment (Rosenblatt, Bode et al., 2018) corroborate existing work in tobacco control showing improved perceptions of health warning efficacy when negative message frames are used, and extend this evidence to the domain of food product health warnings. This effect is most pronounced for the negatively framed graphic warning group, which significantly out-performed all other groups in this study. This may be due to their ability to produce stronger risk perceptions (Mays et al., 2015) and their ability to evoke strong emotional responses.

In addition to receiving the highest perceived efficacy ratings, graphic negative health warnings produced the strongest negative emotional reactions. As would be expected, the text-based negatively framed health warnings also produced more negative emotional reactions than either of the positively framed warning groups. These findings complement existing research demonstrating that negative emotions, and fear in particular, are more easily evoked using a negative message frame (Shen & Dillard, 2016), and that these emotions can in turn successfully produce behaviour change (Tannenbaum et al., 2015). Although positive health warnings, both graphic and text-only, were least effective at producing negative emotional reactions, positively framed graphic health warnings were associated with the second highest perceived efficacy ratings (following graphic negative warnings).

While they produced minimal negative emotional reactions, graphic positive health warnings scored the highest on their ability to produce feelings of self-efficacy and positive emotions associated with behaviour change motivation. These results indicate that positive message framing and the positive emotional responses associated with it may be an effective approach for health warning design, and that this effect may operate independently of the increased efficacy that has commonly been observed through the use of fear appeals (Block & Keller, 1995). This is consistent with a study by Van 'T Riet et al. (2010) that found that positive and negative message frames were both effective but achieved this efficacy through different pathways. In their study, positive frames were associated with positive affect, which led to increased message acceptance, which in turn produced increased intentions to change behaviour and thus had a *persuading* influence, whereas negative frames produced increased negative affect which influenced behaviour change intentions directly, and instead exerted a *motivating* influence. Although these specific pathways were not examined in the present study, this notion may explain our finding that both positive and negative frames were both seen as effective to at least some degree in this study.

Although this study presented a wide range of message topics relative to most existing research into the efficacy food product health warnings (e.g., Bollard et al., 2016; Roberto et al., 2016; VanEpps & Roberto, 2016), the topics featured here focused exclusively on the health outcomes associated with unhealthy eating practices and excess body weight. A number of other topics or themes (e.g., cost of certain products, social norms, impact of certain products on mood, motivating messages, educational messages) have been shown to be effective in the domain of tobacco control (Brennan, Gibson, Kybert-Momjian, Liu, & Hornik, 2017) and remain untested in this domain. This may be particularly relevant in the context of our finding that negative message frames out-performed positive frames, particularly in the graphic condition. It is likely that for messages targeting health outcomes, negative imagery (typically featuring depictions of disease and bodily organs) is simply more evocative and attention grabbing than any relevant positive imagery (typically featuring depictions of healthy bodily organs or individuals), and this accounts for the observed difference in perceived efficacy to some extent. It is possible that positive imagery and message framing could be more effective when different (perhaps more compatible) message topics are used. Future research extending these findings to other message topics might help to better elucidate the nature of this relationship, and may indicate a place for positive message frames instead of, or in addition to, negative messages focusing on health outcomes. In addition to investigating other message topics, future work should also seek to study these effects in larger and more varied samples, to ensure that these results are broadly generalisable beyond the predominantly student-based sample featured here.

9. Conclusions

The present study investigated how perceptions of food product health warnings differed when presented using a positive or negative message frame, and when presented with or without imagery. We found evidence for the likely superiority of negatively framed graphic warnings, corroborating the approach most commonly used in existing tobacco control health warnings and extending the evidence for this approach to the domain of food product warnings. Nonetheless, positively framed health warnings did generate more behaviour change motivation than negatively framed health warnings. Future research might study how to maximise desired outcomes for positively framed health warnings, and attempt to understand how a combination of negative and positive warnings might fare against positive-only or negative-only message framing. These results support the notion that health warnings deserve further attention as a potentially valuable and cost effective tool in the fight against rising global obesity rates.

10. Availability of data and materials

Data and materials are available from the corresponding author on request.

11. Ethics approval and consent to participate

The University of Melbourne Human Research Ethics Committee approved all study procedures (reference number 1443258), and all participants provided informed consent.

Author contributions

D.H.R., M.W., H.D., and S.B. designed the study. D.H.R. conducted initial data analysis and wrote original manuscript. All authors contributed to planning analyses, interpreting the findings and writing the manuscript. All authors gave final approval for the submitted manuscript.

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Declaration of interests

M.W. and H.D. currently work for organisations involved in public health research and advocacy. The other authors declared no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2019.05.003.

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