Front-of-pack images can boost the perceived health benefits of dietary products

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Images on dietary supplement packaging can help identify the products' supposed function. However, research shows that these images can also lead people to infer additional health benefits of consuming the products. The present research investigated the extent to which front-of-pack imagery affects people's perceptions of the health risks and benefits of fictional products. In three randomized experiments, participants saw fictitious dietary supplement packages. Some of the packages included a health-related image (e.g. a heart), whereas others did not. Participants were asked to infer the products' intended purpose and then to rate the perceived risks and benefits of consuming the product. In Experiment 1 ($N = 546$), the inclusion of a health-related image increased the perceived benefits of consuming the product, with minimal effect on the perceived risks. This finding was replicated in Experiment 2 ($N = 164$), but was contingent on whether each product's assumed health function was confirmed or disconfirmed. In Experiment 3 ($N = 306$), which used a pre-registered design and analysis plan, the inclusion of a health-related image increased the perceived benefits and decreased the perceived risks of consuming the product. Again, these effects were contingent on whether the assumed health functions were confirmed or disconfirmed. These findings indicate that health-related imagery could lead consumers to infer additional health properties from non-diagnostic information featured on a product's packaging, perhaps as a consequence of increased processing fluency. This research underscores the importance of regulating the use of imagery in health marketing, to protect consumers from the effects of potentially misleading claims.

Key words: imagery; health claims; benefits; risks; processing fluency

Front-of-pack images can boost the perceived health benefits of dietary products

1. Introduction

Visual imagery can offer an effective way for marketers to inform consumers and to capture their interest. However, images can also sometimes convey subtle or even unintended meanings (Gil-Pérez, Rebollar, Lidón, Martín, van Trijp, & Piqueras-Fiszman, 2019a). In 2010, for example, regulators forced the Dannon Company to alter their product packaging and advertisements, which had claimed—without scientific evidence—that eating their probiotic yogurts would reduce digestive transit time (Federal Trade Commission, 2010). Not only did Dannon ultimately abandon these written health claims from their packaging, but gone too was a downwards-pointing yellow arrow that had previously been superimposed over an image of a svelte woman's waist. This arrow, it was claimed, constituted a more subtle kind of health claim. As one commentator put it, "The arrow is code for 'This will go right through you'" (cited in Sandler, 2008; see also Singer, 2011).

Dannon's yellow arrow aptly illustrates how easily health-related imagery can be used in product marketing to imply—in valid or misleading ways—supposed health benefits. In this paper we ask whether adding a simple health-related image to a dietary supplement's packaging could unduly boost its apparent health benefits and reduce its apparent risks.

1.1. Inferring health functions

Many countries legally regulate the appropriate use of health claims on the packaging of food and dietary supplements, including probiotic yogurts, to ensure that consumers are well-informed and not misled (European Commission, 2006; Food and Drugs Act 1985, n.d.; Food and Drug Administration, 2019). From a sizeable research literature in health and consumer psychology, we know a lot about the effects of written health claims on people's appraisals of products. For example, when a short written claim—such as "Calcium may reduce the risk of osteoporosis"—is added to a product's packaging, prospective consumers typically judge the product more favourably (Kozup, Creyer, & Butron, 2003), giving higher ratings of its perceived healthiness (Wills, Bonsmann, Kolka, & Grunert, 2012) and of their intent to purchase it (Roe, Levy, & Derby, 1999). Recent work into promoting healthier food choices showed that a written health claim increased older adults' self-reported likelihood of consuming beans (Farrell, Doma, Leith-Bailey, Soucier, & Duncan, 2019), and that participants perceived drinks carrying a written health claim as healthier than those without the claim, irrespective of the products' actual healthiness (Franco-Arellano, Vanderlee, Ahmed, Oh, & L'Abbé, 2020). However, whereas written claims communicate information about health functions explicitly, some countries' laws acknowledge that images can convey similar kinds of information, and therefore demand that the use of such imagery is also regulated (e.g., European Commission, 2006). In contrast with the sizeable literature on written health claims, relatively few studies have explored the comparable effects of health imagery on people's appraisals of products.

In one study, researchers found that adding a 'natural' or 'medical' graphic to a product's package led participants to infer that it was healthier (Saba et al., 2009). Similarly, Carrillo, Fiszman, Lähteenmäki, and Varela (2014) used a word association task to demonstrate that even ambiguous health-related images—including an image of a person running, some olives, or a heart and stethoscope—can increase the overall appeal and trustworthiness of the product. In another study, participants categorized a product's attributes (e.g. this product *is spicy*) more rapidly when the name of the product was accompanied by a relevant image (e.g. 'Tabasco sauce' accompanied by a fire graphic; Gil-Pérez, Rebollar, Lidón, Piqueras-Fiszman, & van Trijp, 2019b). Other research shows that health-related images can lead people to believe they saw health claims, which in fact they only inferred (Klepacz, Nash, Egan, Hodgkins, & Raats, 2016). In three experiments, Klepacz et al.'s participants saw pictures of fictional product packages—some of which contained a health-related image such as a heart-shaped graphic—and also read written facts about each product. Afterwards participants were tested on their memory for the details about the various products. When products' packages had featured health-related images, participants often falsely recalled having read positive health claims about them—such as that the product was beneficial to heart health. Participants made these memory errors even when explicitly warned to disregard the health-related images; a finding that suggests participants formed their inferences implicitly and automatically, rather than with conscious awareness.

However, Klepacz et al.'s (2016) data cannot tell us whether the participants actually believed their inferences were true. For example, they might believe that a product is marketed to benefit heart functioning, but not necessarily believe that it would truly have this benefit. From a legislative and health psychology perspective, this is an important issue to address, especially as frameworks such as the Theory of Planned Behaviour predict that people's behavioral intentions—such as their intent to purchase or consume a product—are governed not by their inferences per se but by their beliefs in those inferences (Ajzen, 1991). Moreover, in all of the studies described above, the health images were the only relevant cue that signalled information to participants about the products' health properties. It therefore makes sense that participants inferred health functions when seeing these health function images. We know less about whether images affect people's inferences about a product only when they have no other information to inform their understanding, or instead, whether images would guide people's inferences even when they are given written information about the product's health properties.

There are at least two reasons to predict that health-related images would indeed shape people's appraisals of products' benefits and risks, even when they receive other, more relevant written information. The first reason is that imagery may simply make the product package more aesthetically appealing, leading people to think more positively in general about the qualities of the product. There are many examples in the psychological literature wherein people afford globally positive attributions to an object or individual, on the basis of observing a single positive yet non-diagnostic characteristic. For example, these so-called 'halo effects' lead us to assume that more-attractive defendants are less likely to be guilty of criminal acts (Mazzella & Feingold, 1994), and lead to essays being marked more favorably when attributed to an attractive author (Landy & Sigall, 1974). These kinds of overgeneralizations arise, too, when we judge health products. For instance, people assume that a product carrying an 'organic' claim will contain fewer calories than an equivalent product without the claim (Schuldt & Schwarz, 2010); that products marketed by socially responsible corporations are healthier (Peloza, Ye, & Montford, 2015); and that products whose names contain a nutritive term (e.g. protein bar) will contain higher levels of other, unrelated nutrients, such as fiber and iron (Fernan, Schuldt, & Niederdeppe, 2018). We might therefore expect that people would judge a dietary supplement as more appealing when its packaging uses imagery, and in turn, that people would anticipate such products to have other positive features, such as being beneficial and posing a low-risk to health.

A second, related reason to make this same prediction comes from the literature on processing fluency, which demonstrates that when we process information in ways that subjectively feel 'quick and easy', we are more likely to experience a (sometimes mistaken) sense of comprehending the information well, and to consequently make positive appraisals of the information's target (Schwarz, 1998). For example, Dohle and Montoya (2017) demonstrated that people were willing to administer higher doses of imaginary drugs that had easy-to-pronounce, fluent names, than of drugs with difficult-to-pronounce, dysfluent names. In a related study, people perceived food additives with hard-to-pronounce names as significantly more harmful than additives with fluent names (Song & Schwarz, 2009).

Crucially, we know that images—just like easily-processed text— afford feelings of processing fluency that can shape people's judgments of information. For instance, Cardwell, Lindsay, Förster, and Garry (2017) showed participants statements about complex natural or mechanical processes—such as how a rainbow forms—some of which were preceded by a related yet uninformative photo, such as an image of a rainbow. Participants then rated the extent to which they felt they understood how each process worked. In six experiments, viewing uninformative images led participants to believe they had a greater understanding of these complex processes. Similarly, a simple nonprobative photograph (i.e., one that provides no relevant evidence) can make people more likely to believe that a claim is true (Newman, Garry, Bernstein, Kantner, & Lindsay, 2012; Newman et al., 2015), and when added to a wine bottle, can even make the wine seem better tasting (Cardwell, Newman, Garry, Mantonakis, & Beckett, 2017). In a similar vein, we would predict that the addition of a health-related image to a product's package could provide a sense of perceptual and conceptual fluency that affects people's judgments of its health properties.

In short, the aesthetic and processing fluency accounts both lead us to predict that adding a health-related image to a dietary supplement's packaging would increase people's positive evaluations of the product, such that they would judge its health benefits to be more likely, and the risks less likely. Here we tested this prediction in three experiments. Participants saw images of fictitious dietary supplement packages, some of which contained a health-related image. For each product, participants were then explicitly told the product's 'real' health function, and were informed about two health benefits and two health risks of consuming the product. They then made judgements about the likelihood that someone with the specific target health concern would benefit from, and be at risk from, consuming the product.

2. Experiment 1

2.1. Method

The studies reported in this paper received approval from the University of Surrey (Experiments 1 & 2) and Aston University (Experiment 3) Ethics Committees.

2.1.1. Participants and design

Via an online panel provider, Toluna, we recruited 546 permanent residents of Italy (*n* = 153), Romania (*n* = 212), and the UK (*n* = 181), using stratified sampling to obtain a representation of males and females across a breadth of age-groups within each nationality (overall, 258 females and 288 males, mean age = 43.30, *SD* = 15.35, range = 18-75). All participants completed the study in full and received points from the panel provider that could be accrued and exchanged for cash or vouchers. People were excluded from participating if they indicated at the start of the study that they worked professionally in the ‘nutrition/dietetics’ or ‘food or drink retail/manufacturing’ industries, and/or had a comprehensive understanding of Dutch or German. The latter criterion was used due to the characteristics of our stimulus images, described in the Materials section below. Participants who did not meet these criteria were automatically excluded from the dataset by the panel provider, and it is not therefore possible to know how many responses were excluded. All of the study instructions and questions were presented to participants in their respective national language (i.e. Italian, Romanian, or English). The study used a within-subjects design, with function image (present vs. absent) as the sole independent variable.

2.1.2. Materials

Supplement packaging. We created packaging labels for six fictional dietary supplements, similar to those used by Klepacz et al. (2016), each representing one of six health function categories (weight management, cold and flu, memory, joints and muscles, bowel function, heart health). To this end, we collected digital images of the front-of-pack labels of several genuine dietary supplements that were not available for sale in the three sampled countries. We then used Adobe Photoshop to isolate various visual elements of these products' packaging designs, and combined these various components together to create the fictional supplement labels, each of which incorporated a visually appealing design, a fictional brand name, the name of the active ingredient (e.g., Camellia Sinensis), the quantity of this ingredient contained in the supplement (e.g., 300mg), some other peripheral text (e.g., the number of capsules in the packet), and one written health claim from the EU's '*Register of nutrition and health claims made on food*' (European Commission, 2013). All peripheral text and written health claims appeared on the package labels in Dutch; these labels therefore simulated dietary supplements that might hypothetically be available for sale on the Dutch market. Our choice to present the stimuli in Dutch served two functions. First, this approach meant that the same stimuli could be used in all three of the sampled countries, rather than presenting different product labels according to participant nationality. Second, by ensuring that all participants saw products in a non-native language, we aimed to simulate a scenario in which a consumer might attempt to scour difficult-to-understand text for information about a product. That is to say, rather than using plain packages with or without health imagery (as in some prior studies), we wanted to include textual elements that were minimally informative, but that would nevertheless make the health image itself seem rather less focal and more incidental.

For each of the six fictional supplements, we then created a secondary version onto which a health-related image, representing the intended function of the product, was digitally added (hereafter, we refer to these as 'function images'). For example, for the supplement representing 'weight management', we chose an image of a tape measure wrapped around a silhouetted female torso (see Figure 1 and supplementary materials). We obtained the function images for all six products from the packaging of genuine dietary supplements that were unavailable for sale in the three sampled countries. In short, we created two versions of each supplement package, one with a function image (hereafter, the image-present packages), and one without a function image (the image-absent packages).

Benefit and risk claims. For each of the six fictional dietary supplements, we consulted scientific literature and formal regulatory guidance to gather information about the potential health benefits and risks of consuming the active plant ingredient that it purportedly contained. Based on this consultation, we developed a stimulus set of four claims – two benefit claims and two risk claims – to accompany each product. For example, for the ingredient *Camellia Sinensis* (Green Tea), which represented the weight management function, the benefit claims were 'Contributes to fat oxidation' and 'Helps to reduce the appetite'; the risk claims were 'Cases of liver damage have been reported' and 'May cause sleep disturbances' (European Food Safety Authority, 2010; European Medicines Agency, 2013).

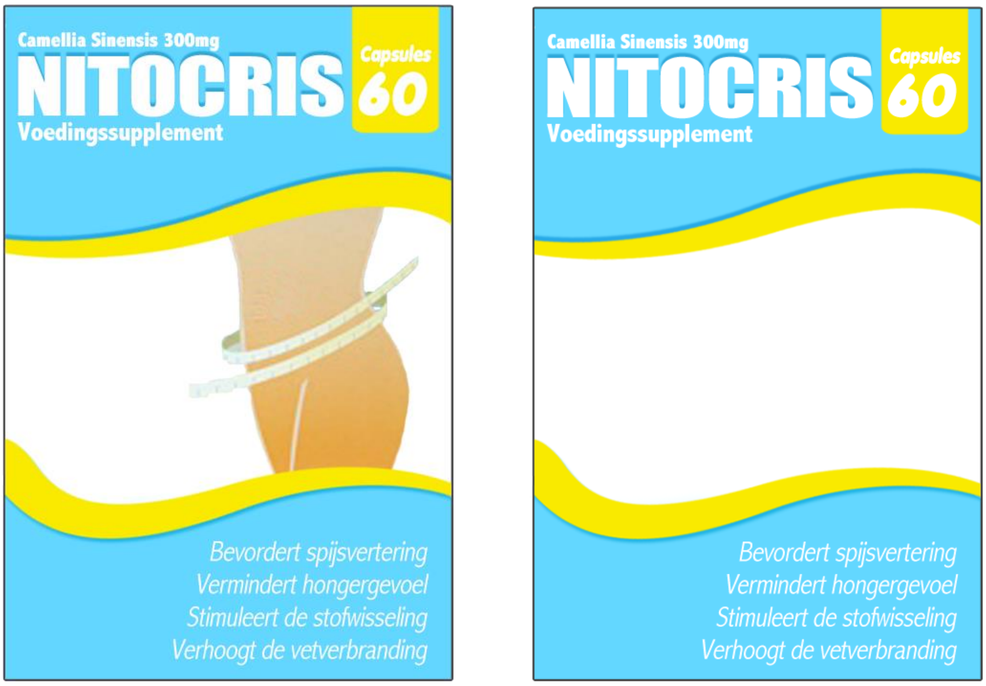


Figure 1. *Example of the fictional dietary supplement labels, with image-present (left) and image-absent (right).*

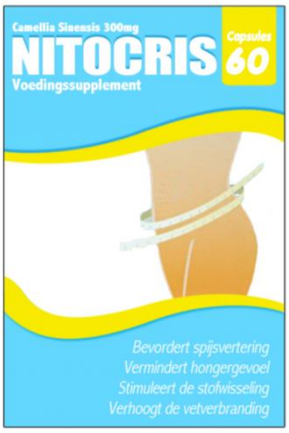
2.1.3. Procedure

Participants completed the study online, and were simply told they would be evaluating some fictional health products. After giving consent, participants first reported their age, gender, and occupation, and specified whether they had a comprehensive understanding of Dutch and/or German. Those who were eligible to take part based on these responses then received written instructions in their own language; non-eligible participants were thanked and exited the study.

To begin, a random exemplar of our fictional dietary supplement labels appeared on the screen accompanied by the question “Based on the packaging shown above, what do you think this product might be used for?” Participants were instructed to rate, on 8-point Likert scales, the likelihood that each of eight statements about the product was true. Each of these statements began “This product…”, and ended: “aids in the maintenance of a healthy heart”; “supports weight loss”; “helps improve memory”; “aids in the maintenance of healthy joints and muscles”; “improves bowel function”; “aids sleep and promotes restfulness”; “relieves the symptoms associated with colds and flu”; and “relieves the symptoms of low mood and anxiety”. The eight statements were presented in random order. For each of the six products, one of these statements was ‘correct’ insofar that it described the product’s actual supposed function. We refer to this hereafter as the *critical* statement (i.e., the statement about which we were interested in manipulating participants’ belief), and we refer to the seven incorrect statements collectively as the *noncritical* statements.

After rating all eight statements, a new screen appeared, again displaying the same product label. Underneath the label a text-box appeared prominently, which explicitly stated the specific health concern that the product supposedly remedied (using the same wording as the critical statement). Alongside the product label, a table appeared with the heading “Benefits” in the left column, and “Risks” in the right column (see Figure 2). Under these headings, the two benefit and two risk statements for that particular product were presented. Participants were instructed to read this information carefully, before responding to three further questions on 10-point Likert scales. Specifically, participants were asked to rate the degree to which [1] somebody with the specified health concern might benefit from taking this product (1 = definitely will not benefit; 10 = definitely will benefit), [2] somebody with the specified health concern might be at risk from taking the product (1 = definitely at risk; 10 = definitely not at risk), and [3] the benefits of taking the product outweigh the risks (1 = the risks outweigh the benefits; 10 = the benefits outweigh the risks). These three questions were always presented in the same order. Note that for all three questions, the scale anchors were framed such that a higher rating was more positive; therefore, higher ratings on the risk measure actually signified appraisals of lesser risk. We return to consider the possible implications of this design decision in Experiment 3.

Here is some more information about the product you just saw.



Benefits	Risks
➤ Contributes to fat oxidation. ➤ Helps to reduce the appetite.	➤ Cases of liver damage have been reported. ➤ May cause sleep disturbances.

This product supports weight loss.

Figure 2. *Example of how fictional dietary supplement labels were re-displayed along with benefit and risk information.*

Once participants had made these three ratings, a new product label appeared, and the procedure was repeated until the participant had appraised all six products. Each participant saw three image-present labels and three image-absent labels; the assignment of labels to image conditions was randomly counterbalanced across participants.

2.2. Results

2.2.1. Manipulation check

When function images were included on products' packaging, participants rated the critical statements as more likely (M = 6.64, SD = 1.52) than they did when the images were absent (M = 4.10, SD = 1.76), $t(545) = 28.10$, $p < .001$, $d_z = 1.20$. In contrast, people rated the noncritical statements as less likely when the images were present (M = 2.35, SD = 1.51) than when they were absent (M = 3.19, SD = 1.46), $t(545) = 19.47$, $p < .001$, $d_z = 0.83$. These results confirm that the function images led participants to form systematic expectations about the products' intended functions.

It is notable that people gave higher ratings to the critical statements than to noncritical statements even in the image-absent condition, $t(545) = 12.09$, $p < .001$, $d_z = 0.52$. This tells us that even excepting the health images, the packages did still contain clues to product function that guided participants' expectations – perhaps because some participants could infer the meaning of certain words from the Dutch text, or perhaps because the packaging designs seemed especially apt for the correct health functions.

2.2.2. Perceptions of benefit and risk

Of foremost interest were participants' ratings of the extent to which a person—experiencing the same health concern that the particular dietary supplement was designed to remedy—might benefit from and be at risk from consuming that supplement. Paired *t*-tests showed that the addition of a function image had a small but statistically significant effect on participants' ratings of the benefits of taking the supplement, ($M_{Present}$ = 6.55, *SD* = 2.15; M_{Absent} = 6.17, *SD* – 2.16; $t(545) = 6.33$, $p < .001$, $d = 0.27$), and also on the extent to which the benefits outweighed the risks ($M_{Present}$ = 5.81, *SD* = 2.23; M_{Absent} = 5.60, *SD* = 2.18; $t(545) = 3.21$, $p < .01$, $d = 0.14$). However, the presence of the function image did not significantly influence participants' ratings of the risks of consuming the product, ($M_{Present}$ = 5.18, *SD* = 2.14; M_{Absent} = 5.06, *SD* = 2.10; $t(545) = 1.89$, $p = .06$, $d = 0.08$).[1]

To summarize, adding function images to dietary supplement labels informed people's beliefs that the product was intended for a specific function. When then told that the supplement did indeed serve that specific function, the function image made people appraise its potential benefits as more likely, and as outweighing its risks to a greater extent.

3. Experiment 2

Above we described two theoretical accounts of why health-related images might lead people to make more positive appraisals of a product's health benefits and (in principle, although this was not the case in Experiment 1) their risks. In Experiment 2 we attempted to tease apart these two different interpretations of the data from Experiment 1. To do this, we manipulated the written information that people received about each product after they

[1] We repeated these analyses with the participant's country added as a between-subjects variable. There were no significant Image x Country interactions for any dependent variable, and so we do not discuss effects of country further.

guessed its intended function. Specifically, people sometimes received the same information as in Experiment 1, which generally matched their expectations about the product's function. But other times people received non-matching information: they instead learned that the product was intended for a different health function, and they likewise received benefit and risk information that related to a different health function. In this design, the match or mismatch between the written information and people's expectations should be especially salient in the image-present conditions, because the function images should lead people to have stronger prior expectations of what the products' functions would be.

We reasoned that if health images increase a product's aesthetic appeal, then they should do so regardless of what participants are told about the product. Therefore, if aesthetic appeal accounts for why function images increase people's positive appraisals of products, then we should expect to observe these effects irrespective of whether we confirm or disconfirm people's expectations about the products' functions.

In contrast, we know that images normally only create processing fluency when they are relevant. For example, when asked whether the liquid in a thermometer is magnesium, people are more likely to incorrectly answer 'yes' if they are shown a nonprobative photo of a thermometer: the photo increases processing fluency that in turn evokes a positive feeling of 'truthiness'. Yet the same does not occur if people are shown a photo of a lizard—still non-probative, but also irrelevant—while they answer the same question (Newman et al., 2015). Findings like these show that processing fluency is usually contingent on there being a congruence or coherence between different elements of an experience (Newman et al., 2014; Song & Schwarz, 2009). Similarly, whereas an image on its own may evoke various interpretations (Smith, Barratt, & Selsøe Sørensen, 2015), recent research shows that an image can make people's judgments of a product less effortful, but only when the image is conceptually related to the judgment. For instance, when judging whether 'tabasco sauce' is spicy, participants made quicker judgments if a picture of fire appeared next to the name of the product. But when judging whether ‘ice cream’ is spicy, the addition of a picture of fire slowed down participants’ judgments (Gil-Pérez et al., 2019b).

Based on these kinds of findings, we reasoned that if health images create fluency, then this fluency should be undermined when people discover that their intuitions about a product’s function are incorrect. Therefore, if processing fluency accounts for why function images boost people’s positive appraisals of products, then we should expect to observe this effect only when people’s expectations are confirmed, and not when they are disconfirmed.

3.1. Method

3.1.1. Participants and design

A total of 170 students from a British further education college took part voluntarily. The sample size was determined solely by the number of students available to participate within a fixed time-period. We excluded six participants from analyses because they indicated at the end of the study that they understood Dutch or German sufficiently to understand the product labels they had seen. All analyses are based on the data from the remaining 164 participants (123 females and 41 males, mean age = 16.88, *SD* = 0.39, range = 16-19). The study used a 2 x 2 within-subjects design, with function image (present vs. absent) and expectation (confirmed vs. disconfirmed) as the independent variables.

3.1.2. Materials and procedure

Participants completed this study within a computer laboratory containing 5 to 15 people who worked independently without discussion. They followed the same procedure as in Experiment 1, but this time only saw four of the six fictional dietary supplements used in that experiment; specifically, we used the heart health, joints and muscles, memory, and weight management supplements, but did not use the bowel function or the cold and flu supplements.

The main change in Experiment 2 was to the written information that participants saw after studying each product label. Participants in Experiment 1 were always told explicitly what the product's health function was, and they read about two benefits and two risks of consuming the product. In the expectation-confirmed conditions of Experiment 2, participants saw the exact same information as in Experiment 1. In the expectation-disconfirmed conditions, participants instead saw the information that actually related either to the (unused) bowel function supplement or to the cold and flu supplement. For example, in the image-present, expectation-disconfirmed condition, participants might see a supplement label bearing an image of a heart, but then learn that the product is a remedy for bowel problems, and would see benefits and risks that were relevant to bowel function. The allocation of products to image and expectation conditions was randomly counterbalanced across participants; each participant saw one product in each of the four conditions.

3.2. Results

3.2.1. Manipulation check

When function images appeared on dietary supplements' packaging, participants rated the critical statements as more likely (M = 6.91, SD = 0.99) than when the function images were absent (M = 4.27, SD = 1.46), $t(163) = 21.50$, $p < .001$, $d_z = 1.68$. In contrast, people rated the noncritical statements as less likely when the images were present (M = 2.53, SD = 0.84) than when they were absent (M = 3.63, SD = 0.91), $t(163) = 14.96$, $p < .001$, $d_z = 1.17$. These results again confirm that the function images led participants to form systematic expectations about the products' functions.

Notably, people gave higher ratings to critical statements than to noncritical statements even in the image-absent condition, $t(163) = 5.88$, $p < .001$, $d_z = 0.46$, showing that the image-absent packages still contained some clues to product function.

3.2.2. Perceptions of benefit and risk

A 2 (Image: present vs. absent) x 2 (Expectation: confirmed vs. disconfirmed) ANOVA on participants' ratings of each product's benefits revealed no significant main effect of image, $F(1, 163) = 1.28$, $p = .26$, $\eta^2_p < .01$ (see top row of Table 1). The main effect of expectation was significant, with the benefits considered greater in the disconfirmed condition than in the confirmed condition, $F(1, 163) = 76.25$, $p < .01$, $\eta^2_p = .32$; however, this main effect is unimportant because different benefits and risks were described in the confirmed and disconfirmed conditions (i.e., this information was not counterbalanced). For this reason, the severity/importance of the written benefit and risk information shown was not matched across the confirmed and disconfirmed conditions, and a main effect of expectation can therefore be attributed to the materials alone. Most importantly, the predicted two-way interaction was statistically significant, $F(1, 163) = 4.37$, $p = .04$, $\eta^2_p = .03$. Post-hoc *t*-tests showed that when participants' expectations were confirmed, the function image increased the perceived benefits of the product, relative to when the image was absent, $t(163) = 2.19$, $p = .03$, $d = 0.17$. In contrast, when participants' expectations were disconfirmed, function images had no significant effect on their ratings of benefits, $t(163) = -0.55$, $p = .58$, $d = -0.04$.

Looking to participants' risk judgments, a second 2 x 2 ANOVA revealed a significant (but unimportant) main effect of expectation, $F(1, 163) = 31.47$, $p < .001$, $\eta^2_p = .16$, but this time neither the main effect of image, $F(1, 163) = 0.01$, $p = .94$, $\eta^2_p < .001$, nor the two-way interaction, $F(1, 163) = 2.01$, $p = .16$, $\eta^2_p = .01$, were statistically significant (middle row of Table 1). These results parallel the findings from Experiment 1, where function images influenced perceived benefits but not of risks.

Table 1. *Mean (SDs) ratings of dietary supplements' benefits, risks, and the risk/benefit tradeoff in Experiment 2*

Judgment	**Expectation**			
	Confirmed		**Disconfirmed**	
	Image absent	**Image present**	**Image absent**	**Image present**
Benefits	5.74 (2.18)	6.17 (2.07)	7.28 (1.80)	7.18 (1.87)
Risks	4.19 (2.28)	4.41 (2.12)	5.33 (2.09)	5.09 (2.32)
Risk/benefit trade-off	4.73 (2.51)	4.70 (2.43)	6.65 (2.33)	6.49 (2.23)

Note: Higher ratings represent more positive appraisals, namely greater benefits, lesser risks, and a greater advantage of the benefits relative to the risks.

Finally, a 2 x 2 ANOVA on participants' judgments of the risk/benefit trade-off gave a significant (but unimportant) main effect of expectation, $F(1, 163) = 85.45$, $p < .001$, $\eta^2_p = .34$, but no significant main effect of image, $F(1, 163) = 0.26$, $p = .61$, $\eta^2_p < .01$, nor a two-way interaction, $F(1, 163) = 0.20$, $p = .66$, $\eta^2_p < .01$ (bottom row of Table 1). The absence of a two-way interaction differs from the findings of Experiment 1, where the effect of function images extended to risk/benefit trade-off judgments as well as to judgments of benefits alone.

4. Experiment 3

Both Experiments 1 and 2 generally show that health images on products' packaging increased people's perceptions of those products' health benefits, but not their risks. Importantly, our analysis of Experiment 2 also lends support to the processing fluency-based account, in that people's appraisals of a product's health benefits were only enhanced when their initial expectations about the products prove to be correct. Our findings do not fit well, though, with the aesthetic account, which would predict an effect of health images regardless of whether or not people's expectations were confirmed.

The purpose of Experiment 3 was therefore to replicate these findings using a pre-registered study plan and a larger sample size. By specifying our study plan, analytic plan, and target sample in advance of conducting the study, we aimed to determine the reliability of our findings, and control the researcher degrees of freedom that can contribute to Type I errors and inflated estimates of effect sizes.

4.1. Method

The procedure and analysis plan for this study were pre-registered prior to data collection through AsPredicted.org, and can be found at https://aspredicted.org/k7b2j.pdf.

4.1.1. Participants and design

The effects of images in Experiments 1 and 2 were small, and a power analysis indicated that at least 265 participants would be required in order to detect a small effect (d = 0.2) in a two-tailed t-test with 90% power and alpha = .05. We therefore aimed to exceed this sample size by collecting valid data from 300 participants. Ultimately, we recruited a total of 324 participants via an online panel provider, Qualtrics. All participants completed the study in full and were subsequently awarded points that could be accrued and exchanged for money and/or vouchers. Per our pre-registered plan, we excluded people from participating if they reported having a comprehensive understanding of the Dutch or German language, if they gave identical responses to every item, or if they failed the attention check described below. In keeping with Experiment 1, we also excluded people from participating if they indicated that they worked professionally as a nutritionist or dietician - we neglected to pre-register this particular exclusion criterion, but any such participants were automatically exited from the survey before they provided any data. This left a final sample of 306 participants (222 females and 84 males; mean age = 42.93, SD = 14.73, range = 18-77) from the UK (n = 152) and USA (n = 154) respectively, slightly above our pre-registered target of 300. The study used a 2x2 within-subjects design, with function image (present vs. absent) and expectation (confirmed vs. disconfirmed) as the independent variables.

4.1.2. Procedure

Participants completed the study online, and were told they would evaluate some fictional dietary supplement packages. Participants followed the same procedure as Experiment 2, with two notable exceptions. Recall that participants in Experiments 1 and 2 rated the perceived risks of consuming the fictitious products on a positively-framed scale, whereby a lower rating indicated a higher risk. In both experiments we found no significant effect of images on risk perceptions. However, we wanted to ensure that this outcome was not an artefact of some participants being confused by the ordering of the risk response scale, which could arguably have seemed counterintuitive. To this end, in Experiment 3 each participant was randomly assigned to see the risk scales either in the same format as in the previous experiments, (1 = definitely at risk; 10 = definitely not at risk), or in the reversed form where a high score indicated a greater risk (i.e., 1 = definitely not at risk; 10 = definitely at risk). As an attention check, after participants had rated all four fictitious health supplements, they were shown a screen depicting two previously seen stimuli and two entirely new fictional product packages constructed in the same way. To pass the attention check, participants were asked to correctly select the two product packages that they recalled from the experiment.

4.2. Results

4.2.1. Manipulation check

When the supplements' packaging included a function image, participants rated the critical statements as more likely (M = 6.54, SD = 1.60) than they did when the function image was absent (M = 3.71, SD = 1.71), $t(305) = 24.77$, $p < .001$, $d_z = 1.42$. In contrast, people rated the noncritical statements as less likely when the images were present (M = 2.33, SD = 1.09) than when they were absent (M = 3.20, SD = 1.20), $t(305) = 14.22$, $p < .001$, d_z = .81. These results again confirm that the health images caused participants to form systematic expectations about the products' intended functions.

As before, people gave higher ratings to the critical statements than to the noncritical statements even in the image-absent condition, $t(305)$, = 6.04, $p < .001$, $d_z = 0.35$, suggesting that the image-absent packages still conveyed some clues to the products' intended functions.

4.2.2. Perceptions of benefits

The top row of data in Table 2 illustrates participants' ratings of the products' perceived benefits. A 2 (Image: present vs. absent) x 2 (Expectation: confirmed vs. disconfirmed) repeated-measures ANOVA of these ratings revealed no significant main effects of image, $F(1, 305) = 0.13$, $p = .72$, $\eta^2_p < .001$, or expectation, $F(1, 305) = 1.96$, p = .16, $\eta^2_p = .01$. Crucially though, the two-way interaction was statistically significant, $F(1, 305) = 28.97$, $p < .001$, $\eta^2_p = .09$. Post-hoc *t*-tests showed that when participants' expectations of the products' functions were confirmed, a function image increased the perceived benefits of consuming the product, relative to when the image was absent, $t(305) = 4.26$, $p < .001$, d_z = 0.24. Conversely, when participants' expectations were disconfirmed (i.e. a function image was added that was incongruent with the supplementary information they received), the function image *decreased* the perceived benefits of taking the product, $t(305) = -3.49$, p = .001, $d_z = 0.20$.

Table 2. *Mean (SDs) ratings of supplement benefits, risks and the risk/benefit trade-off in Experiment 3*

Judgement	**Expectation**			
	Confirmed		**Disconfirmed**	
	Image absent	**Image present**	**Image absent**	**Image present**
Benefits	5.46 (2.48)	6.05 (2.54)	6.15 (2.51)	5.64 (2.52)
Risks*	4.64 (2.25)	5.06 (2.33)	5.41 (2.47)	5.08 (2.33)
Risk/Benefit trade-off	4.66 (2.46)	5.05 (2.56)	5.45 (2.50)	5.20 (2.51)

Note: Higher ratings represent more positive appraisals, namely greater benefits, lesser risks, and a greater advantage of the benefits relative to the risks.

4.2.3. Perceptions of risks

Next, we examined whether the inclusion of a function image affected participants' perceptions of the risks of consuming the products. Before conducting this analysis, we reverse-scored all of the responses from those participants who saw the risk scale in its new, negatively-framed format. This transformation meant that for all participants, higher scores in the analysis would indicate a lesser perceived risk (for ease of comparison with the previous experiments). A 2 (Image: present vs. absent) x 2 (Expectation: confirmed vs. disconfirmed) x 2 (Risk scale order: positive vs. negative) mixed-factor ANOVA of the risk ratings revealed no statistically significant interactions of scale order with any other independent variable(s). There was a significant main effect of scale order, $F(1, 304) = 9.14$, $p < .01$, $\eta^2_p = .03$, with participants indicating greater risks when the question had been framed in its original, positive format ($M = 4.76$, $SD = 1.58$), than when the response scale was reversed ($M = 5.33$, $SD = 1.70$). Because this main effect was independent of any of our effects of interest, though, we did not consider it further, and therefore we conducted the main, pre-registered analysis with the scale order factor removed, for parity with our other main analyses.

A 2 (Image: present vs. absent) x 2 (Expectation: confirmed vs. disconfirmed) repeated-measures ANOVA of the risk ratings revealed no significant main effect of image, $F(1, 305) = -0.16$, $p = .69$, $\eta^2_p = .001$ (see middle row of Table 2). The main effect of expectation was significant, with risks rated more severe in the confirmed condition compared to the disconfirmed condition, $F(1, 305) = -14.36$, $p < .001$, $\eta^2_p = .05$; however, as in Experiment 2, this main effect is unimportant because participants viewed different health benefits and risks in the confirmed and disconfirmed conditions. Of greatest importance, the two-way interaction was significant, $F(1, 305) = -12.30$, $p = .001$, $\eta^2_p = .04$. Post-hoc *t*-tests showed that when participants' expectations about the product were confirmed, the function image decreased the perceived risks associated with consuming the product, relative to when the image was absent, $t(305) = 2.95$, $p < .01$, $d_z = 0.17$. On the other hand, when participants' expectations about the product were disconfirmed, the function image had no significant effect on the perceived risks, $t(305) = 1.93$, $p = .054$, $d_z = -0.11$.

4.2.4. Risk-benefit trade-off

Finally, a 2 (Image: present vs. absent) x 2 (Expectation: confirmed vs. disconfirmed) repeated-measures ANOVA of participants' ratings of the risk-benefit trade-off revealed no significant effect of image, $F(1, 305) = .46$, $p = .50$, $\eta^2_p = .001$. As before, the main effect of expectation was significant, with the benefits seemingly outweighing the risks to a greater extent in the disconfirmed condition than in the confirmed condition, $F(1, 305) = 21.03$, $p = < .001$, $\eta^2_p = .065$. This finding, again, is unimportant. The predicted two-way interaction, though, was significant, $F(1, 305) = 7.47$, $p < .01$, $\eta^2_p = .02$. Post-hoc *t*-tests showed that when participants' expectations about the product were confirmed, the addition of a function image increased the perceived extent to which the benefits outweighed the risks, relative to when the image was absent, $t(305) = 2.85$, $p = .005$, $d_z = 0.16$. Conversely, when participants' expectations about the product were disconfirmed, the addition of a function image had no significant effect on this perceived trade-off, $t(305) = -1.46$, $p = .15$, $d_z = -0.08$.

5. Discussion

Taken together, the results of these three experiments indicate that front-of-pack imagery can shape how people appraise the health properties of dietary supplements. Specifically, in all three experiments we found that the addition of a function image to a product's packaging increased participants' perceptions of the likelihood that somebody experiencing the target health concern would benefit from consuming the product. Similarly, we found evidence that function images led participants to inflate the extent to which the products' benefits outweighed the risks. There was, however, only weak and inconsistent evidence that function images affected judgments of risk per se.

Of course, the images used in these experiments contained no information that should logically influence people's interpretations and appraisals of the benefit- and risk-related information about the products. The findings from Experiments 2 and 3, though, permit an initial test of the cognitive mechanism that underpins these effects. In particular, our key finding is that the effects of function images depended on whether or not people's expectations about the product's function (informed by the function image, when present) were confirmed. When people's expectations were confirmed, we found the effects described above. But when people's expectations were subsequently disconfirmed, the function images either had no effect or a reversed effect. These findings do not fit with the proposal that the effects arise because packages with function images are more visually appealing. If this mechanism could explain our findings, then people's perceptions of the benefits and risks should have been affected similarly, irrespective of whether the information people subsequently received was consistent or inconsistent with their expectations. Instead, then, our findings are more consistent with a fluency-based explanation (Schwarz, 1998). According to this account, the addition of a function image gives participants a subjectively easy, fluent feeling of comprehending the product, which in turn leads them to make generally positive appraisals about the product's other characteristics. However, this fluency is interrupted when participants receive disconfirming information, which impedes or reverses their sense of processing fluency, and thus their appraisals of the product itself.

These findings expand on a thus-far small body of empirical research, which demonstrates that in the absence of other meaningful information, function images can enhance the perceived healthiness of a product and lead people to infer other, more specific health-boosting effects of consuming the product (Klepacz et al., 2016; Saba et al., 2009). Similarly, these findings contribute to the visual semiotics literature by demonstrating that contextual information can determine how people use an image to inform their inferences of an otherwise ambiguous image (Gil-Pérez et al., 2019a, b). Extending those prior findings, the present research demonstrates that this kind of marketing imagery can subtly influence people's appraisals even when people have access to other more explicit, written information (i.e., in the present studies, people were explicitly told about the products' benefits and risks) to inform those appraisals. These findings therefore have potential ramifications for the ways in which regulators govern the use of product imagery. In particular, whereas much regulatory focus has been placed on protecting consumers from misleading pictorial claims, this research shows that even pictures that are not overtly misleading can shape the way consumers appraise crucial—and heavily regulated—written health information. It is difficult to prescribe exactly how policy-makers should respond to this finding: certainly, it would seem untenable to suggest that manufacturers should abandon the use of images on packaging altogether. However, policy recommendations might be best informed by further research that explores the extent to which additional health-related information on product packaging—such as traffic light labels, or written health claims—could mitigate the effects we have documented. This point seems of particular importance for companies that distribute their products to a global market, given that a single graphic can often assume different meanings across different cultural contexts (Carrillo et al., 2014).

A strength of the present research is that we reproduced the results of Experiments 1 and 2—which did not involve *a priori* sample justifications—using a pre-registered study plan in Experiment 3, thus increasing our confidence in the robustness of the observed effect. Furthermore, the replicability of the findings across four countries (Italy, Romania, UK, and USA) lends support to their generalizability. Nevertheless, the data from the present research are based on simplistic measures of people's appraisals of benefits and risks that are not validated. Whereas this approach was important as a first step in exploring these research questions, future research using more comprehensive and empirically validated measures would support our ability to draw confident inferences about whether the addition of a function image to a product's packaging would influence consumers' behaviour. Previous research has demonstrated that fluency-based effects can have behavioral consequences (e.g., Dohle & Montoya, 2017); it would therefore be pertinent to investigate the effect of function images on consumers' behaviour using more realistic and consequential tasks and dependent measures. In addition, it would be important to better understand individual differences in the extent to which people are unduly influenced by product imagery – we might for instance expect that individuals with more advanced literacy or language comprehension skills would place less emphasis on using pictorial cues for gleaning their understanding (e.g., Austin, Matlack, Dunn, Kesler & Brown, 1995). Further examination of such individual differences could be an important part of efforts to address societal health inequalities.

Images on product packaging can provide useful information for consumers when navigating an ever-crowded marketplace. Similarly, images may afford consumers the opportunity to better understand the causal relationships between a nutritive and its intended health outcome (Banks, Egan, Hodgkins, Peacock, & Raats, 2018). But considered together, the present findings show that such images can also lead people to make more optimistic assumptions about the magnitude of these products' health benefits. Our data provide initial evidence that this effect occurs because images can provide a rapid, intuitive sense of comprehension, which leads people to make more positive evaluations. In this respect, regardless of how much Dannon's probiotics truly increase digestive transit, the svelte woman image and yellow arrow on their packaging might have given consumers an altogether different feeling of quick and fluent processing.

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