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Abstract

Visual ecology is the study of how different species perceive their visual surroundings. We introduce the concept to consumer research and show that the micro-ecology of product packaging has a predictable visual ecology. Analyzing images of 158 consumer products, we show that brand-related packaging elements are visually conspicuous in terms of visual salience, surface size, and distance to center, while elements related to credence characteristics like sustainability and nutrition are visually inconspicuous. We show that the visual ecology of product packaging is a strong driver of consumer attention independently of consumer goals. Our findings suggest that the reason consumers regularly ignore sustainability and nutrition information is not lack of motivation, but because their visual environment acts as a barrier to attending this information. We conclude with a prediction for consumer attention given a policy intervention to increase the conspicuity of sustainability and nutrition information.

Keywords: consumer attention, eye movements, bottom-up control, top-down control, visual ecology

The visual ecology of product packaging and its effects on consumer attention

The human visual system has developed over eons to respond to particular features in our visual environment. A forager, for instance, takes advantage of this ability to detect ripe fruit in a crowded foliage because the fruit has a different color than the foliage (Hiramatsu et al., 2008). Our visual system is tuned to detect the color difference between red fruit and green foliage and directs our eyes to objects that stand out from the crowd. Other species respond to other features in their environment—from bees that see ultraviolet to dogs that see black and white (Land & Nilsson, 2012). The type and structure of the visual features animals respond to is termed their visual ecology (Cronin, Johnsen, Marshall, & Warrant, 2014). Each species has abilities according to their needs. Like the forager, consumers can take advantage of their visual abilities to detect differently colored objects in their environment, from car lights to traffic signs or promotion signs in the supermarket (Wedel & Pieters, 2008). What is different about consumers is that they navigate a visual environment designed by others to attract or distract their attention. The visual ecology of consumers is, in other words, a product of culture. This begs the question then, of what features in the visual environment consumers respond to and what is the structure and distribution of these features?

In this article, we address these questions in the context of product packaging. We begin by introducing known characteristics of the human visual system and discuss features in the environment that are likely to attract consumer attention. In the first of two studies, we examine the structure of these features in the context of product packaging. We find that within each product, packaging elements have highly predictable visual features. Packaging elements that are closely related to the brand are generally more visually conspicuous, while elements related to credence characteristics as sustainability and nutrition, which are not necessarily part of the brand positioning but have been added because such information is regarded as socially desirable, are less conspicuous in terms of color, size, and position. We show that these differences influence consumer attention to specific packaging elements. In the second study, we address some limiting conditions of the first study and show that the visual ecology of consumers exerts a strong influence on attention independently of consumer goals. We conclude with predictions of how a change in the conspicuity of packaging elements, due to brand repositioning or due to a policy intervention, might influence consumer attention.

Features that attract attention

A great deal is known about the human visual system and what features in the visual ecology we respond to. These ecological features are commonly referred to as bottom-up factors, and previous research has identified several such factors that influence attention. The most researched and canonical bottom-up factor is visual salience (salience for short). The concept captures the color differences discussed above, but also extends to other features such as the orientation and contrast of objects relative to their surroundings. Salience can be loosely defined as the conspicuity of a visual object relative to its surroundings. Several models of salience have been proposed based on different aspects of visual conspicuity such as contrast, color, edge orientation, or motion (Borji & Itti, 2013; Itti & Koch, 2001). Salience models take any visual scene as input layer and output a topographical salience map of the most conspicuous locations in the scene, i.e., those locations that are brighter, have sharper edges, or different colors than their surroundings. The salience map predicts the order and likelihood of each location in the map being looked at, with the most salient areas being the most likely to be looked at. Several studies have shown that salience maps can predict attention in tasks such as scene viewing (Foulsham & Underwood, 2008; Parkhurst, Law, & Niebur, 2002), visual search (Rutishauser & Koch, 2007), decision-making (Orquin & Lagerkvist, 2015; Towal, Mormann, & Koch, 2013), and consumer behavior (Lohse, 1997; Milosavljevic, Navalpakkam, Koch, & Rangel, 2012; Navalpakkam, Kumar, Li, & Sivakumar, 2012).

A second bottom-up factor is the relative surface size of objects, which has been shown to exert a robust effect on consumer attention (for a review see Peschel & Orquin, 2013). This effect is probably due to the object being more likely to attract attention by chance, but also to psychophysical properties of the visual system (Dehaene, 2003) since increasingly larger objects exhibit a diminishing marginal effect on attention (Lohse, 1997). Surface size effects have been shown in different consumer situations, for instance, are products with more shelf facings (Chandon, Hutchinson, Bradlow, & Young, 2009; Gidlöf, Anikin, Lingonblad, & Wallin, 2017), larger ads (Lohse, 1997), and larger elements within ads (Pieters, Warlop, & Wedel, 2002; Pieters & Wedel, 2004) more likely to be looked at.

A third bottom-up factor is object position. Position effects have been shown both in one and two dimensions. When information is structured in a one-dimensional arrays such as rows or columns, consumers typically read columns of information from top to bottom (Chen, 2010; Sütterlin, Brunner, & Opwis, 2008) and rows of information from left to right (Navalpakkam et al., 2012). This, of course, only holds in societies where the reading direction is from left to right. The position of an object not only influences when it is looked at, but also the likelihood of it being looked at. Many consumers ignore a large part of the available information and consequently, objects at the top or to the left are more likely to be seen. In two-dimensional arrays, consumers typically look at the middle of the array, while the corners often go unnoticed (Atalay, Bodur, & Rasolofoarison, 2012; Clarke & Tatler, 2014; Meißner, Musalem, & Huber, 2016). There is some evidence suggesting that positioning effects in two dimensional arrays depend on the object type, i.e. visual or textual (Otterbring, Shams, Wästlund, & Gustafsson, 2013). Positioning effects are well known in retailing where products in the middle of a shelf are chosen more frequently, presumably because they are seen more often than the products in the corners of the shelf (Chandon et al., 2009; Gidlöf et al., 2017). However, in the context of retailing, position effects may be a mix of both bottom up and top down factors since consumers believe that the more popular products are located in the middle of the shelf (Valenzuela & Raghubir, 2009, 2015) even though this is not the case (Valenzuela, Raghubir, & Mitakakis, 2013). Whether consumers hold similar beliefs about positioning of labels on product packaging remains to be shown.

Besides these bottom-up factors, other less researched factors have been identified. Research shows that the amount of visual complexity or clutter affects the likelihood of consumers looking at an object (Pieters, Wedel, & Batra, 2010; Reutskaja, Nagel, Camerer, & Rangel, 2011). The predictability of object locations has also been shown to affect consumer attention (Orquin, Chrobot, & Grunert, 2017). In this article, we focus on salience, size, and position since these bottom-up factors are well understood and can be operationalized in an unambiguous way.

Top-down control

So far, we have discussed bottom-up factors as if these were the only factors influencing attention. However, this is not the case. Unlike other species, humans have an excellent capacity for attending to objects that are relevant to their goals and ignore objects that are irrelevant, irrespective of bottom-up factors. Humans can ignore irrelevant objects either based on known locations of the irrelevant object (Orquin et al., 2017) or based on peripheral vision (Wästlund, Shams, & Otterbring, 2018). Such goal-driven attention is commonly referred to as top-down control (Corbetta & Shulman, 2002). Previous research has identified a wide range of top-down factors that influence attention such as goals, task instructions, preferences, decision style, cognitive load, involvement, task complexity and mood (for reviews see Orquin & Mueller Loose, 2013; Orquin, Perkovic, & Grunert, 2018; Wedel & Pieters, 2008). What is important to our discussion is that top-down factors have been shown to dominate bottom-up factors. Some studies have shown that top-down control is up to 1.5 times more powerful in guiding consumers' attention compared to bottom-up control (Orquin & Lagerkvist, 2015). Some scholars have suggested that top down control account for 2/3 of attention (Wedel & Pieters, 2006) or even that bottom-up factors such as salience play no role in natural environments and that attention is entirely a matter of top-down control (Tatler, Hayhoe, Land, & Ballard, 2011). If this holds, it could suggest that humans are, unlike other species, free of their visual ecology. For example, price or health-motivated consumers should be capable of ignoring irrelevant but eye-catching advertising in favor of cheap or healthy products, no matter how dull these products may look like. However, the view is difficult to reconcile with the malleability of consumer attention demonstrated in advertising (Wedel & Pieters, 2008), packaging (Peschel, Orquin, & Mueller Loose, 2019), instore (Otterbring, Wästlund, Gustafsson, & Shams, 2014), or online contexts (Menon, Sigurdsson, Larsen, Fagerstrøm, & Foxall, 2016).

The visual ecology of product packaging

If consumers are free of their visual ecology thanks to top-down control, how then do we explain visual marketing practices? Marketers not only believe in the power of bottom-up factors, they are willing to pay large amounts of money for the right visual marketing mix. A classic example is the higher price for differently colored ads in yellow pages books. The different color makes the ad more salient and more likely to be noticed (Lohse, 1997). In retailing, the shelf placement of products is determined by how much marketers are willing to pay for a central position in the middle of the shelf. More shelf facings, which increase the surface size, also cost more money. Both shelf location and size influence consumer attention and choice and are therefore worth paying for (Chandon et al., 2009). In online marketing, advertisers pay more for sponsored search results closer to the top of the page, which increases the chance of browsers seeing and clicking on the ad (Ghose & Yang, 2009). A similar position effect is also found on restaurant menus where dishes at the top of the menu are chosen more often (Dayan & Bar-Hillel, 2011). Naturally, other factors than bottom up attention may contribute to these examples, for instance, due to a limited cognitive capacity consumers may rely on heuristics about color ads or product positions to simplify the search process. Wästlund and colleagues provide evidence from instore eye tracking studies suggesting that such heuristics play an important role in consumer attention (Wästlund, Otterbring, Gustafsson, & Shams, 2015). The exact balance between bottom up and top down control remains an open question in many cases, but it seems plausible that marketers intuitively understand bottom-up factors and that it is worth paying for more salient, larger, and better positioned ads and products. At the very least, those marketers who have followed the marketing literature on these topics should understand these mechanisms (for reviews see Wedel & Pieters, 2006, 2008). It seems plausible then, that marketers use this knowledge when designing large-scale visual environments such as the shelf layout as well as small-scale environments such as product packaging. In the micro-ecology of product packaging, we might expect marketers to prioritize packaging elements, making some more visually conspicuous than others. It would, for instance, be reasonable to prioritize brand-related elements that drive the purchase (Klimchuk & Krasovec, 2012). If marketers converge in their priorities, we would consequently expect the visual ecology of product packaging to display certain predictable characteristics. Most notably, we would expect elements that are central to the positioning of the brand, like the brand name and key brand features, to be more salient, larger, and centrally positioned. In comparison, we would expect packaging elements that are more peripheral to the brand positioning or that have been added because they are viewed as socially desirable, to be less salient, smaller and more peripherally positioned. This would apply for credence characteristics like health and sustainability properties of the product, which have increasingly been added to packages in product categories like food (Fernqvist & Ekelund, 2014).

In this article, we address this issue with the following research questions: (i) does the visual ecology of product packaging have a predictable structure, (ii) does this structure influence consumer attention or are consumers free from their visual ecology thanks to top-down control, and (iii) what would happen if we changed the structure of the visual ecology according to a policy intervention?

Study 1

In Study 1, we use a representative design to examine the visual ecology of product packaging and its effects on consumer attention. We select 158 consumer products from different categories within dairy products and take high-resolution images of each product. We then categorize each packaging element as an area of interest (AOI) and measure each AOI on the three bottom-up factors discussed above: its relative visual salience, its surface size, and its distance to the center of the product. We then conduct an eye-tracking study mimicking a shopping trip, in which participants make choices from different product categories. In each category, participants first see an overview of the available products and then evaluate each product individually before making their decision.

Method

Participants. We recruited a representative sample of 123 Danish consumers (35.77 % men), age ranging from 21 to 59 (M = 37.85, SD = 11.61). We excluded participants who were not responsible for household shopping or who had a professional background in marketing or the food industry. From the total sample, we excluded 32 participants from the analysis due to low data sampling and the final sample included 91 participants. Participants had normal or corrected-to-normal vision and signed a consent form before beginning the study.

Materials and measures. The stimuli consisted of product images taken in a photo laboratory using a high-resolution digital camera. Each product was photographed from all four sides. The total stimulus sample contained 158 products from twelve different dairy product categories. We chose dairy products because it is a broad category (e.g. milk, butter, cheese, yoghurt etc.) and all products in the category are packaged. The study was based on four- and six-alternative choices. The study used an incomplete randomized block design with 24 versions. Each product was shown three times within the 24 versions. All products were grouped into choice sets of four or six products within the same category of foods, and each version consisted of five choice sets. For a complete description of the experimental versions and blocks see Supplementary Information 1. For each product, we defined eight areas of interest (AOIs) located on the front-of-pack (brand, category, fat percentage, organic label, Keyhole label, Guideline Daily Amount label, picture, logo). The organic label is a Danish sustainability/production method label (Ministry of Food, 2015) and the Keyhole (Ministry of Food, 2013) and Guideline Daily Amount (GDA) (Boztuğ, Juhl, Elshiewy, & Jensen, 2015) labels are nutrition labels. We defined the AOIs using Tobii Studio software with zero AOI margins in order to avoid assigning false positive fixations (Orquin, Ashby, & Clarke, 2016). We recorded eye movements using a Tobii 2150 eye-tracker (21 inches, 50 frames per sec) with accuracy = .5° and precision = .35°. For each AOI on each product, we measured the surface size of the AOI, its distance to the center of the product, and its visual salience. We extracted surface size information using the Tobii Studio software, which provides relative surface size measures and we measured distance from center as the Euclidean distance between the center of the product and the center of the AOI. We computed the visual salience of AOIs using a Matlab implementation of the Itti-Koch algorithm (Itti & Koch, 2001). The algorithm processes an input image at the pixel level based on color, contrast, and orientation, and outputs a ranking of the most salient locations in the image. The algorithm predicts that the highest ranked and hence most salient location is fixated first followed by the second highest ranked location etc. We transformed the salience ranks assigned to each AOI into a variable ranging from zero to one, where zero was the lowest visual salience and one was the highest visual salience. To ease the interpretation and comparability of the variables in the analyses, we range-standardized surface size and distance to center to a range between zero and one.

Procedure. We received participants individually in the laboratory and after completing the consent form, we seated them in front of the eye-tracker and assigned them randomly to one of the 24 experimental versions. Participants were not placed in a chin rest, but were instructed to minimize head movements. After calibration, participants completed two practice trials in which they were required to select their preferred product from a choice set of either four or six products. The practice trials used a different product category than the critical trials. After the practice trials, participants completed the critical trials which consisted of five choice sets from the twelve product categories. The critical trials followed a three-step protocol: overview, evaluation, and choice. In the overview phase, participants were presented with an image of the complete choice set to get an overview of all products. In the evaluation phase, participants had the possibility to inspect each product in detail. Participants could turn products on the screen to see the sides and the back of the product or skip products, using the keyboard. In the choice phase, participants were shown the same image as in the overview phase and were asked to choose their preferred product using the mouse (for an overview of the experiment phases see SI 2).

Results

Analysis of the visual ecology. We begin by analyzing the structure of the visual ecology of product packaging. We use the packaging element (categorical) to predict salience (metric), size (metric), and distance to center (metric) using generalized linear mixed models (GLMM). All models were estimated using the lme4 package in R. We fit models with and without packaging element as the independent variable using a step-up approach based on BIC. The packaging element was retained as a predictor for both salience, $F(7, 570) = 40.99$, $p < .001$, BIC = 412.58, size, $F(7, 501) = 94.37$, $p < .001$, BIC = 1048.25, and distance to center, $F(7, 480) = 30.47$, $p < .001$, BIC = 156.85. All models had a random intercept grouped by product. To better understand the structure of the environment, we illustrate the distribution of packaging elements in Figure 1 with box plots.

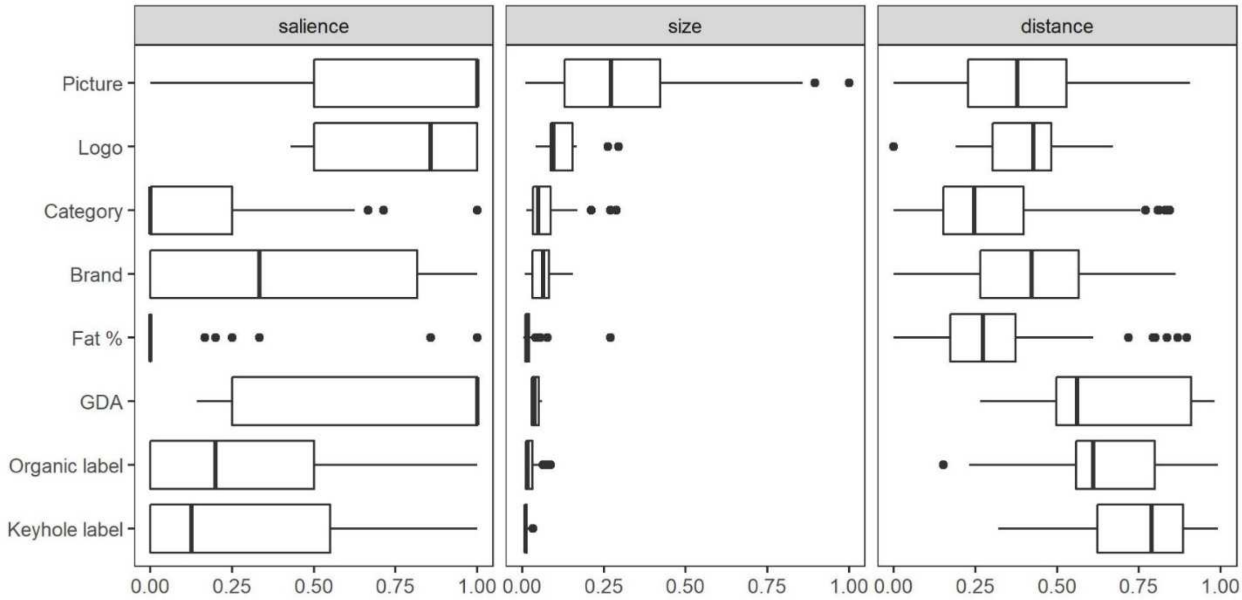

Figure 1. Box plot of the distribution of salience, size, and distance to center for each packaging element (578 data points). 'GDA' is a nutrition information label widely used in Europe. 'Keyhole' is a government-endorsed health symbol used on food products in the Nordic countries. The x-axis shows the range-standardized scores for salience, surface size, and distance respectively.

Analysis of fixation likelihood. We analyze the likelihood of participants fixating a packaging element during the product evaluwith a similar approach as above. The dependent variable (fixation selection) is a binary variable with the value one if an AOI is fixated and zero otherwise. The independent variables are packaging element size (metric), salience (metric), and distance to center (metric). The final model includes main effects of all variables and random intercepts grouped by participant, choice set, product, and packaging element. Table 1 shows the parameter and variance estimates for the final model.

Table 1. Parameter and variance estimates for fixation likelihood analysis in Study 1.

Parameter	Estimate	SE	*z*	*p*
Intercept	0.353	0.284	1.241	.214
Surface size	3.353	0.333	10.070	<.001
Distance	-2.512	0.133	-18.879	<.001
Salience	0.417	0.077	5.395	<.001
Number of observations = 9918				
BIC = 10864.4				
Variance (participant) = 0.380				
Variance (choice set) = 0.068				
Variance (product) = 0.308				
Variance (packaging element) = 0.500				

The analysis shows that the effects of salience, surface size, and distance to center are in the expected direction. More salient, larger, and more centrally positioned packaging elements are more likely to be fixated. Because the factors are additive, we compute a predicted fixation likelihood for each packaging element based on its average salience, size, and distance. We illustrate the predicted fixation likelihood against the observed fixation likelihood in Figure 2 together with a summary figure of the structure of the visual ecology.

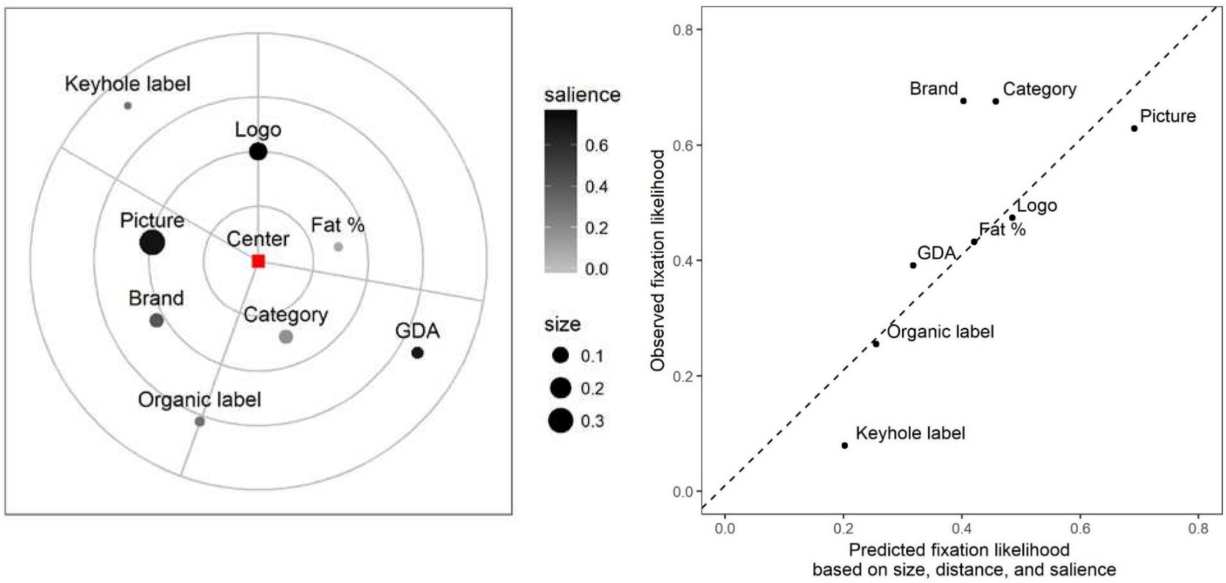

Figure 2. On the left, an illustration of the salience, surface size, and distance to center for each packaging element (578 data points). The salience, surface size, and distance to the center in the figure correspond to the average values for the eight packaging elements. The angular position of packaging elements is arbitrary. On the right, an illustration of the predicted vs. observed fixation likelihood based on the combined effects of salience, surface size, and distance to center for each packaging element (9,926 data points).

Discussion

Study 1 shows that the visual ecology of product packaging has a predictable structure. Packaging elements central to the brand positioning such as the logo, brand, and picture are consistently more salient, larger, and more centrally positioned than packaging elements that relate to socially desirable credence characteristics like health and sustainability. Thus, the Keyhole (a government endorsed health symbol) and organic labels are consistently the least salient, smallest, and least centrally positioned packaging elements. We also show that this ecological structure plays a large role in determining consumer attention. All three bottom-up factors—salience, size, and distance to center—influence the probability of consumers fixating a product packaging element. The combined effects of the bottom-up factors explain consumer attention well, but Figure 1 suggests that there are additional factors that contribute to consumer attention. Specifically, the brand, category, and Keyhole label all deviate from the predicted level of attention shown as the dotted line. This is most likely due to top-down processes, such as consumers perceiving the brand and category as important and the Keyhole label as unimportant, which could facilitate attention to the former and suppress attention to the latter packaging element. Previous research has shown that consumers generally consider the brand as more important and the Keyhole label as less important. Specifically, previous studies have shown that this difference in subjective importance is associated with more attention to the brand and less to the Keyhole label, even when controlling for bottom-up factors such as size and salience (Orquin, Bagger, & Mueller Loose, 2013) or position on the package (Orquin et al., 2017). Two questions arise from this finding. First, is the deviation in attention due to interference from top-down control and second, is it possible, even in the case of interference, to guide consumers to attend the organic and Keyhole labels if these are prioritized in terms of salience, size, and distance to center? In Study 2, we examine the interaction of top-down and bottom-up processes more directly and whether it is possible to increase attention to functionally related packaging elements by enhancing their salience, size, and distance to center.

Study 2

Based on Study 1, we know that the visual ecology operationalized in terms of salience, size, and distance to center of packaging elements play a large role in determining how much attention a packaging element receives. The study also suggests that top-down factors, such as the perceived importance of packaging elements, may interfere with these bottom-up factors. An important question is therefore to what extent top-down control interferes with bottom-up control. Research on eye movement control processes is divided with regard to whether top-down control interferes with bottom-up control (Nordfang, Dyrholm, & Bundesen, 2013; Orquin & Lagerkvist, 2015; Tatler et al., 2011) which makes it difficult to make specific predictions. If top-down control processes interfere with bottom-up processes, this could attenuate the effects of salience, surface size, and distance to center under high top-down control due to, for instance, a ceiling or floor effect. Alternatively, top-down and bottom-up control could interact to facilitate the effects of bottom-up control (Bagger, 2016). In Study 2, we examine this question by manipulating the same bottom-up factors, salience, size, and distance to center of packaging elements and, a top-down factor, consumer health motivation, in a full-factorial experimental design. The three bottom-up factors are defined operationally as in Study 1 and the top-down factor is manipulated in three conditions: a control condition where participants are instructed to choose their preferred product, a health goal condition in which participants are instructed to choose the healthiest product, and a health priming condition in which participants are exposed to health information and instructed to choose their preferred product. Participants make choices between two toast bread products with a varying number of packaging elements, some of which are health-relevant (target labels) and some which are not (distractor labels). We use toast bread due to its ambiguous healthiness. If top-down control interferes with bottom-up control, we would expect either an attenuation or facilitation of salience, size, and distance to center under high top-down control, i.e. higher top-down interference in the health goal condition followed by the health priming condition and lastly by the control condition. We also expect participants' choices to conform to the top-down condition so that higher health motivation leads to more choices in favor of healthier products.

Method

Stimulus development. In order to generate target and distractor labels, we conduct a stimulus development study to identify labels relevant for forming health judgments of food products. The study uses a within-subjects design, in which participants assess whether a product with a given label is healthier than a product without that particular label (N = 225, M_{age} = 45.58, SD_{age} = 15.60, 52% females). Responses are binary with a value of zero indicating that the product is considered healthier and a value of one indicating that the product is not considered healthier with that label. Labels are presented individually and participants judge 39 labels in total. We compute mean judgments by averaging participants' health judgments with a score of zero indicating perfect agreement that a label implies healthiness and a score of one that it does not imply healthiness. We classify labels with a mean score < .4 as targets, and labels with a mean score > .7 as distractors. We exclude two labels with mean scores in the interval [.4 - .7] due to their ambiguity. Consequently, we identify four target and 33 distractor labels.

Participants. We recruit 76 participants with the help of a market research company (M_{age} = 44.84, SD_{age} = 13.25, 34% female). We exclude four participants due to imperfect vision, eye-tracker calibration problems, or being intoxicated. The final sample consists of 72 participants. Participants have normal or corrected to normal vision and provide informed consent before participating in the study.

Experimental design. We conduct a two-alternative choice experiment with a full factorial mixed within-between subjects design manipulating health motivation (control, health goal, and health priming) as a between-subjects factor, and target label salience (high, low), target label surface size (small, large), and target label distance to center (ranging from 463.42 to 208.22 pixels) as within-subjects factors. The position of target and distractor labels on each product is randomly sampled from 15 possible locations. The random positions ensure that participants have to actively search and fixate on labels rather than rely on peripheral vision which has been shown to play a large role in consumer behavior (Wästlund et al., 2018). Target labels are assigned as follows: A target product is chosen with an equal probability between the left and the right side. A target label is then drawn from the set of four target labels with the following probabilities P = (.8, .07, .07, .07). The target label with the highest validity in terms of healthiness is drawn with a probability of .8. To avoid that participants search for a single target, there is a .2 probability of the target not discriminating, i.e. being present on both products. In the event of the target not discriminating, a new target is drawn from the remaining set of targets and assigned to the target product. Two brands are then drawn from a set of seven brands and assigned to each product. Distractor labels are drawn from a set of 33 labels. In order to increase the external validity of each choice set, we vary the number of distractor labels presented in each choice set. The number of distractor labels is equal for products in the same choice set (either 2, 4, 6, 8, 10, 12, 14 distractors per product). The total number of labels (set size) per choice set therefore varies between six and 30 labels. All levels are presented twice, resulting in 140 trials.

Materials and measures. To avoid prior preferences influencing the results, the stimuli are images of mock toast bread. Products are presented on the left and right side of the screen. The salience of target labels is manipulated by controlling the contrast (transparency = 0% vs. 60%). The target label size is manipulated by increasing the surface size from 1.5×1.5 to 3.0×3.0 degrees of visual angle. All distractors are small (1.5×1.5) and have 0% transparency (for an example, see Figure 3). The experimental stimuli are presented using PsychoPy 2 (Peirce, 2009, 2007). We conduct a pre-test to ensure that all labels are readable at a distance of 60 cm from the screen. To prevent participants from foveating more than one label at a time, labels are separated horizontally and vertically by two degrees of visual angle. Eye movements are recorded using a desk-mounted EyeLink 1000 eye tracker with a monocular sampling rate of 1000 Hz and a screen resolution of 1920×1200 pixels. The screen subtends a visual angle of 46.5 degrees horizontally and 30.1 degrees vertically. Participants use a chinrest at approximately 60 cm viewing distance from the screen. Fixations are detected using a velocity, acceleration and motion-based algorithm (SR Research, 2008; Holmqvist et al., 2011) with velocity, acceleration, and motion thresholds of 30°/sec, 8,000°/sec^2, and 0.15° respectively. An area of interest (AOI) is drawn around each label. To avoid false positive fixations, the AOIs are the same size as the object.

Procedure. Upon entering the laboratory, participants are tested for color blindness, visual acuity and eye dominance. Participants failing either the color blindness or the acuity test are excluded from the experiment, but receive full payment for their inconvenience. We randomly assign participants to one of the three top-down conditions and they receive a short questionnaire corresponding to that condition. Participants in the health condition (N = 26) and the health priming condition (N = 26) receive the same questionnaire, which contain four vignettes concerning the four target labels and eight questions to ensure that participants have read the vignettes. Participants in the control condition (N = 24) receive a control questionnaire of similar length about shopping habits. After completing the questionnaire, participants are seated in front of the eye tracker and their head movements are restrained using a chin rest. Participants are calibrated using a 9-point calibration procedure performed at the beginning of the experiment followed by a 9-point drift validation test. A calibration offset < 1 degrees of visual angle is considered acceptable. After the calibration, participants in the health goal condition are instructed to choose the healthier product, while participants in the health priming and control conditions are instructed to choose the product they prefer. To control the location of the first fixation, every trial is preceded by a fixation cross presented at the center of the screen for 2000 ms. Participants complete 140 trials by indicating their choice of either the left or the right product by pressing the left or right arrow key. Trials last as long as participants need to make a choice. To test the validity of target and distractor labels, participants complete a post study questionnaire similar to the one in the stimulus development study.

Results

Manipulation check. To ensure the validity of the target and distractor labels we first inspect participants' responses to the post-experimental questionnaire. The results indicate that target labels have a stronger association with healthiness than distractor labels in all conditions. Table 2 shows the means and confidence intervals for targets and distractors in all conditions.

Table 2. Means and confidence intervals for target and distractor labels in the stimulus development and the three experimental conditions.

Condition	M_{target}	CI 95	$M_{distractor}$	CI 95
Stimulus development study	.33	[.29, .38]	.89	[.87, .91]
Health goal condition	.06	[.00, .12]	.85	[.79, .91]
Health priming condition	.04	[.01, .07]	.80	[.74, .86]
Control condition	.08	[.02, .14]	.80	[.76, .84]

Eye movement analysis. The likelihood of participants fixating target labels is analyzed in a similar way as in Study 1. The dependent variable (fixation selection) is a binary variable with the value one if the target label was fixated and zero otherwise. The independent variables are target label salience (binary), target label size (binary), target label distance to center (metric, 14 levels), set size (metric), and condition (categorical). The final model includes main effects of all variables except condition, and random intercepts grouped by participant and target label type. Table 3 shows the parameter and variance estimates for the final model.

Table 3. Parameter and variance estimates for fixation likelihood analysis in Study 2.

Parameter	Estimate	SE	*z*	*p*
Intercept	-0.245	0.215	-1.143	.253
Size	1.352	0.040	33.664	<.001
Salience	0.333	0.039	8.582	<.001
Distance	-0.445	0.055	-8.037	<.001
Set size	-0.017	0.002	-7.020	<.001
Number of observations = 14896				
BIC = 16299.4				
Variance (participant) = 0.380				
Variance (target label type) = 0.046				

Choice analysis. We then analyze the likelihood of participants choosing the target product across conditions. The dependent variable (target choice) is a binary variable indicating whether a participant chose the target product in a given trial. Fixation to the target label (binary) and condition (categorical) are used as independent variables. We use the same model selection approach as in Study 1. The final model includes main effects of fixation to the target label, condition, and an interaction between fixation and condition. The model includes a random intercept grouped by participant and by target label type. Table 3 shows the parameter and variance estimates for the final model. Figure 4 illustrates the effect of condition and fixation of the target label on the probability of choosing the healthier target product.

Table 4. Parameter estimates for choice likelihood analysis in Study 2.

Parameter	Estimate	SE	*z*	*p*
Intercept	2.041	0.236	8.630	<.001
Condition (health goal)	-1.397	0.328	-4.259	<.001
Condition (health priming)	-0.898	0.322	-2.791	.005
Fixation	0.891	0.105	8.505	<.001
Condition (health goal) × fixation	-0.591	0.128	-4.632	<.001
Condition (health primed) × fixation	-0.623	0.129	-4.820	<.001
Number of observations = 14896				
BIC = 13990.2				
Variance (participant) = 1.22				
Variance (target label type) = 0.01				

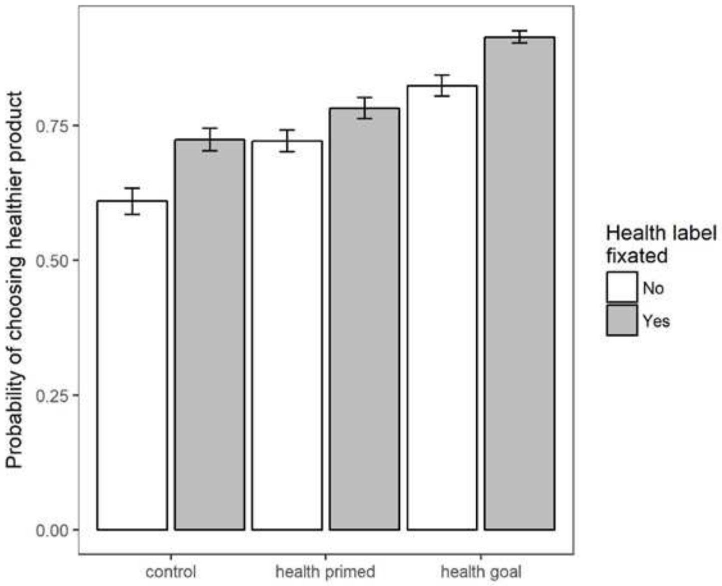

Figure 3. The probability of choosing the heathier target product depending on the condition and whether the target label was fixated. Error bars represent 95% confidence intervals (10,640 data points).

Follow up analysis. It is a common concern in consumer research that repeated measures designs create demand or learning effects which result in low external validity. Since Study 2 contains 140 trials per participant, we test the same model selection procedure on the first 10 trials for both the eye movement and choice data. The first 10 trials are less likely to be influenced by learning effects and therefore indicate whether the results are biased by the repeated measures experimental design. For the eye movement data, the final model for the first 10 trials is similar to the one on the complete data set, although all estimates are slightly larger, $\beta_{size} = 1.725$, $p < .001$, $\beta_{salience} = 0.474$, $p < .01$, $\beta_{distance} = -0.613$, $p = .01$ $\beta_{set\ size} = -0.040$, $p < .001$. For the choice data the final model for the first 10 trials retains the main effects of condition and fixation, but not their interaction – presumably because 760 are too few observations to adequately fit the interaction term. The estimates for the two main effects fall within the 95% confidence interval of the original estimates, $\beta_{condition\ (health\ goal)} = 1.172$, $p < .001$, $\beta_{condition\ (health\ priming)} = 0.314$, $p = .272$, $\beta_{fixation} = 0.795$, $p < .001$. A model free inspection of trial 1 and trials 1-5 reveal similar data patterns for both eye movement and choice data. The follow up analysis suggests that the repeated measures design does bias the results for the eye movement analysis, but not the choice analysis. For a more externally valid, albeit less precise, estimate of bottom up effects readers may therefore refer to the estimates in the follow up analysis.

Discussion

In Study 2, we examine the effects of the same bottom-up factors as in Study 1 (salience, surface size, and distance to center) under different levels of top-down control. We find that all bottom-up factors, including set size, influence fixation likelihood. Regarding top-down factors, we find no effect of health goal or health priming on fixation likelihood, either as main or interaction effects with bottom-up factors. Without the choice results, it would seem that the manipulation of the choice condition was unsuccessful, but the choice data reveal otherwise. The probability of participants choosing the healthier target product is highest in the health goal condition followed by the health priming and finally the control condition. In all three conditions, fixating the target label has a positive effect on choosing the target product. Interestingly, choice accuracy is above chance level in all conditions both when the target label is fixated and when it is not. This might be due to covert (peripheral) attention, i.e., participants fixating a point in proximity to a target allowing for indirect detection of the target (Wästlund et al., 2018). Overall, the results suggest that, in this study, top-down control does not interfere with bottom-up control. This could be due to a generally low level of top-down control. Orquin, Chrobot and Grunert showed that randomizing label positions suppresses top-down control so that participants are less capable of ignoring subjectively irrelevant labels and attending to subjectively relevant labels (Orquin et al., 2017). In this study we randomized label positions to mimic naturalistic packaging, and this might have suppressed the effect of health motivation on fixation likelihood. However, similar findings have been demonstrated in eye tracking studies conducted in supermarkets (Gidlöf et al., 2017). To conclude, our findings suggest that top-down control does not interfere with bottom-up processes to the extent previously assumed (Orquin & Lagerkvist, 2015; Tatler et al., 2011; Wedel & Pieters, 2006). Consumers are therefore not free from their visual ecology, but subject to its particular structure as we saw in Study 1. The influence of bottom-up factors is the basis for visual marketing practices (Wedel & Pieters, 2006, 2008) or it can, as Study 2 shows, be the basis for visually oriented behavioral interventions (Münscher, Vetter, & Scheuerle, 2016).

Predictions for a different visual ecology

Study 1 and 2 both show that the visual ecology plays an important role in determining consumer attention to product packaging elements. Furthermore, what consumers see influences what they choose. By combining the insights from both studies, it is possible to make predictions about what might happen if policy makers or producers decided to change the visual ecology of product packaging by enhancing the visibility of, for instance, sustainability or nutrition labels. Based on the fixed effect estimates from Study 1, we compute the expected fixation likelihood for the Keyhole label given a one or two standard deviation improvement in salience, surface size, and distance to center. We make the predictions for the Keyhole label because it is a simple behavioral intervention that helps consumers identify healthy foods within a category of food products. Noticing and incorporating the Keyhole label in consumer choices therefore has a great potential for enhancing healthy foods choice. Table 5 summarizes the levels of salience, size, and distance to center and the predicted fixation likelihood. Enhancing all three factors by 2 SD would result in a 42.4% fixation likelihood. One challenge related to enhancing salience, size, and distance to center of a packaging element is that it changes the entire visual micro-ecology of the product. Both salience and size are relative to other elements, and centralizing elements creates a competition with other packaging elements since there is only a limited amount of space in the middle of the product.

Table 5. Predictions for consumer attention to the Keyhole label in an enhanced visual ecology.

Setting	distance	size	salience	fixation likelihood
Current situation	0.746	0.012	0.264	15.7%
1 SD distance	0.549	0.012	0.264	21.3%
1 SD surface	0.746	0.018	0.264	17.9%
1 SD salience	0.746	0.012	0.627	18.0%
1 SD all	0.549	0.018	0.627	27.1%
2 SD all	0.352	0.023	0.991	42.4%

Another challenge related to these predictions is that producers might be concerned about crowding out brand-related packaging elements like the brand, logo or pictures on the product. While it is true that any change to a single packaging element is likely to influence all other elements, producers must keep in mind that brand-related packaging elements, particularly the brand itself, are close to ceiling in terms of consumer attention. Naturally, further studies might reveal how to strike an optimal balance in packaging design that benefits both the producer and the consumer in terms of attention to brand and functionally related elements.

Discussion

In this article, we have introduced the concept of visual ecology in consumer research. We have raised the question of whether the visual ecology of product packaging contains predictable structures and whether these structures influence consumer attention. In Study 1, we show that the visual ecology of product packaging does have a predictable structure and that packaging elements central to the brand are more conspicuous in terms of salience, size, and distance to center whereas elements referring to socially desirable credence characteristics such as sustainability or nutrition are the least conspicuous. This structure is probably due to marketers converging on the same priorities, namely to visually promote those packaging elements that drive purchases. We also show that the visual ecology explains consumer attention well, although some packaging elements—including the brand, category, and Keyhole label—are relatively over- and under-attended according to the predicted effects of the bottom-up factors. This over- and under-attendance is probably due to interference from top-down factors such as the perceived importance of the packaging element.

In Study 2, we examine the influence of top-down control on the effects of salience, size, and distance to center by manipulating consumer heath goals. Surprisingly, we find that in this study consumer goals do not interfere with the effect of the bottom-up factors on attention. Participants do, however, make different decisions depending on their goals. Participants instructed or primed with health goals are more likely to choose the healthier of the two products. Finally, we combine these insights to predict the effect of a policy intervention. We show that relatively small changes in the visual ecology of product packaging can lead to much higher levels of consumer attention to, for instance, sustainability or nutrition information.

To conclude, our findings show that the visual ecology of product packaging has a predictable structure favoring brand-related elements and that this leads consumers to largely ignore sustainability and nutrition-related elements. We believe that the concept of visual ecology has a lot to offer in consumer research, and with this article we take a first step in this direction. Future studies should extend the scope to other ecological features such as visual clutter and location predictability and address the limitations of the current studies. To examine a sufficiently wide range of products and maintain internal validity, it was necessary to conduct both Study 1 and Study 2 in the laboratory. Studies with mobile eye-tracking would be helpful to generalize the findings to a natural and incentivized environment. Currently such studies remain limited because the data quality of mobile eye-trackers makes it difficult to detect fixations to small objects such as packaging elements (Orquin & Holmqvist, 2017). These limitations introduce uncertainty in the parameter estimates in both studies and we must allow for this uncertainty when interpreting the predictions. Despite the limitations, we believe the studies present a strong case for studying the visual ecology of consumers. Understanding the visual ecology of consumers helps us explain why consumers regularly ignore sustainability and nutrition information (Graham, Orquin, & Visschers, 2012; Grunert, Wills, & Fernández-Celemín, 2010). Rather than blaming consumers for a lack of motivation, it would be more helpful to design policy interventions that address the visual ecology of consumers, for instance by increasing the visual conspicuity of sustainability and nutrition information.

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Supplementary information

SI 1.1 Overview of versions, blocks and categories. Each experiment version samples five blocks, one from each category of products. The products shown in each block are represented in SI 1.2 to 1.6.

Version	Milk	Cheese	Grated cheese	Yoghurt	Butter
Version 1	Milk 0.1% 1	Sliced - Mild 1	Grated 1	Neutral 1	Hard 1
Version 2	Milk 0.1% 2	Sliced - Mild 2	Grated 2	Strawbery 3	Hard 2
Version 3	Milk 0.1% 3	Sliced - Medium 1	Grated 3	Pear/Banana 1	Hard 3
Version 4	Milk 0.1% 4	Hard - Mild 1	Grated 4	Neutral 2	Hard 4
Version 5	Milk 0.1% 1	Hard - Medium 1	Grated 5	Pear/Banana 2	Liquid 1
Version 6	Milk 0.1% 2	Hard - Medium 2	Grated 6	Strawbery 1	Liquid 2
Version 7	Milk 0.5% 1	Sliced - Mild 3	Grated 7	Strawbery 2	Hard 5
Version 8	Milk 0.5% 2	Sliced - Medium 1	Grated 8	Pear/Banana 3	Hard 6
Version 9	Milk 0.5% 3	Sliced - Medium 2	Grated 1	Neutral 3	Hard 7
Version 10	Milk 0.5% 4	Hard - Mild 1	Grated 2	Neutral 4	Hard 8
Version 11	Milk 0.5% 1	Hard - Mild 2	Grated 3	Pear/Banana 4	Liquid 3
Version 12	Milk 0.5% 2	Hard - Medium 1	Grated 4	Strawbery 4	Liquid 4
Version 13	Milk 1.5% 1	Sliced - Mild 1	Grated 5	Pear/Banana 1	Hard 1
Version 14	Milk 1.5% 2	Sliced - Mild 2	Grated 6	Neutral 3	Hard 2
Version 15	Milk 1.5% 3	Sliced - Medium 2	Grated 7	Strawbery 1	Hard 3
Version 16	Milk 1.5% 4	Hard - Mild 2	Grated 8	Pear/Banana 2	Hard 4
Version 17	Milk 1.5% 1	Hard - Medium 3	Grated 1	Neutral 4	Liquid 1
Version 18	Milk 1.5% 2	Hard - Medium 4	Grated 2	Strawbery 2	Liquid 2
Version 19	Milk 3.5% 1	Sliced - Mild 4	Grated 3	Neutral 1	Hard 5
Version 20	Milk 3.5% 2	Sliced - Medium 3	Grated 4	Neutral 2	Hard 6
Version 21	Milk 3.5% 3	Sliced - Medium 4	Grated 5	Strawbery 3	Hard 7
Version 22	Milk 3.5% 4	Hard - Mild 3	Grated 6	Strawbery 4	Hard 8
Version 23	Milk 3.5% 1	Hard - Mild 4	Grated 7	Pear/Banana 3	Liquid 3
Version 24	Milk 3.5% 2	Hard - Medium 2	Grated 8	Pear/Banana 4	Liquid 4

SI 1.2 Milk category blocks showing the product ID combinations for each block.

Category	Block 1	Block 2	Block 3	Block 4
Milk 0.1%	1000	1005	1000	1001
	1001	1006	1002	1003
	1002	1007	1004	1005
	1003	1008	1006	1007
	1004	1009	1008	1009
Milk 0.5%	1100	1106	1100	1101
	1101	1107	1102	1103
	1102	1108	1104	1105
	1103	1109	1106	1107
	1104	1110	1108	1109
	1105	1111	1110	1111
Milk 1.5%	1200	1206	1200	1201
	1201	1207	1202	1203
	1202	1208	1204	1205
	1203	1209	1206	1207
	1204	1210	1208	1209
	1205		1210	
Milk 3.5%	1300	1305	1301	1300
	1301	1306	1303	1302
	1302	1307	1305	1304
	1303	1308	1307	1306
	1304			1308

SI 1.3 Cheese category blocks showing the product ID combinations for each block.

Category	Block 1	Block 2	Block 3	Block 4
Medium	2401	2408	2401	2403
	2403	2411	2404	2405
	2404	2416	2406	2407
	2405	2417	2408	2411
	2406	2418	2416	2417
	2407	2419	2418	2419
Mild	2301	2305	2302	2301
	2302	2306	2304	2303
	2303	2307	2306	2305
	2304	2308	2308	2307
Sliced Medium	2100	2106	2101	2100
	2101	2107	2103	2102
	2102	2108	2105	2104
	2103	2109	2107	2106
	2104	2110	2109	2108
	2105	2111	2111	2110
Sliced Mild	2000	2004	2000	2001
	2001	2005	2002	2003
	2002	2006	2004	2005
	2003	2007	2006	2007

SI 1.4 Grated cheese category blocks showing the product ID combinations for each block.

Category	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7	Block 8
Grated cheese	2600	2605	2610	2616	2612	2600	2601	2611
	2601	2606	2611	2617	2614	2602	2603	2613
	2602	2607	2612	2618	2616	2604	2605	2615
	2603	2608	2613	2619	2618	2606	2607	2617
	2604	2609	2614	2620	2620	2608	2609	2619
			2615			2610		

SI 1.5 Yoghurt category blocks showing the product ID combinations for each block.

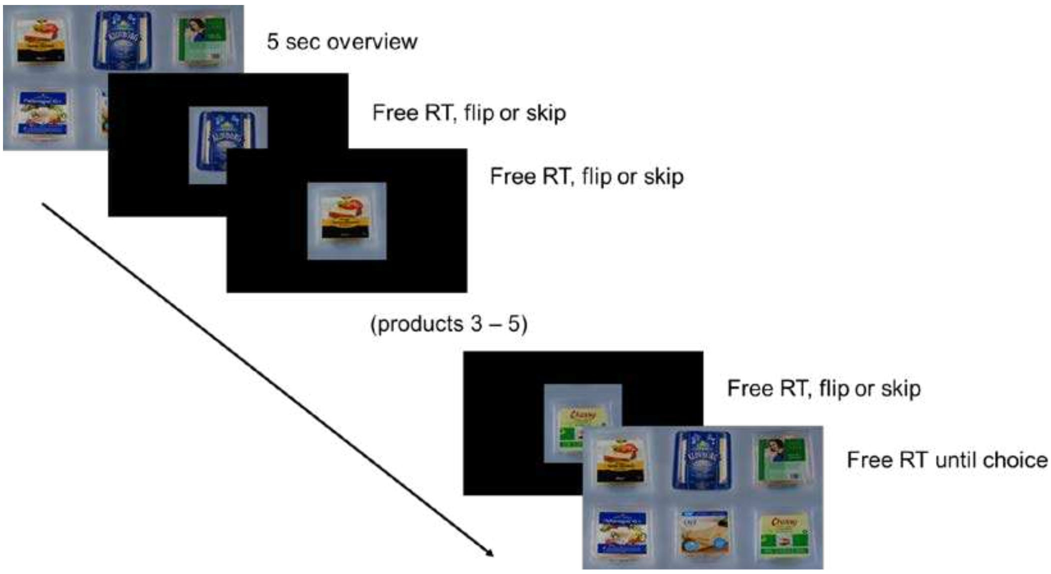
Category	Block 1	Block 2	Block 3	Block 4
Plain	3000	3007	3000	3001
	3001	3008	3002	3003
	3002	3010	3004	3005
	3003	3011	3007	3008
	3004	3012	3010	3011
	3005	3013	3012	3013
Pear-banana	3200	3205	3200	3201
	3201	3206	3202	3203
	3202	3207	3204	3205
	3203	3208	3206	3207
	3204	3209	3208	3209
Strawberry	3100	3105	3100	3101
	3101	3106	3102	3103
	3102	3107	3104	3105
	3103	3108	3106	3107
	3104	3109	3108	3109

SI 1.6 Butter category blocks showing the product ID combinations for each block.

Category	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7	Block 8
Hard	4000	4004	4000	4001	4008	4012	4008	4009
	4001	4005	4002	4003	4009	4013	4010	4011
	4002	4006	4004	4005	4010	4014	4012	4013
	4003	4007	4006	4007	4011	4015	4014	4015
Liquid	4100	4104	4100	4101				
	4101	4105	4102	4103				
	4102	4106	4104	4105				
	4103	4107	4106	4107				

SI 1.7 Examples of product images used in Study 1. From left to right: liquid butter/margerine, skimmed milk, and fruit yoghurt.

SI 1.8. Experimental flow in Study 1



SI 2.1 Examples of product stimuli in Study 2. On the left a product with a single target (Keyhole label), brand, and no distractors. On the right a product with the same target label and brand and 13 distractor labels.

SI 2.2 Experimental flow in Study 2