Colouring perception

Emphasising attractiveness through packaging

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Thesis committee

Promotor
Prof. Dr Kees de Graaf
Professor of Sensory Science and Eating Behaviour
Wageningen University & Research

Co-promotors
Dr Gerry Jager
Associate professor, Division of Human Nutrition and Health
Wageningen University & Research

Prof. Dr Elizabeth H. Zandstra
Special Professor Food Reward and Behaviour
Wageningen University & Research
&
Science Leader Reward & Behaviour
Unilever R&D Vlaardingen

Other members
Prof. Dr Cees Leeuwis, Wageningen University & Research
Prof. Dr Lisette C.P.G.M. de Groot, Wageningen University & Research
Dr Hendrick N.J. Schifferstein, Delft University of Technology
Prof. Dr Koert van Ittersum, University of Groningen

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Emphasising attractiveness through packaging

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Thesis

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"Colour does not add a pleasant quality to design – it reinforces it"

(Pierre Bonnard, 1867 – 1947)

Contents

Chapter 1

General Introduction

Take a moment to closely look at both of these products...

What do you *expect* from each of these products, in terms of healthiness, attractiveness and flavour...?

Which product would you choose, and why?

People should eat more healthily.
Governmental and industrial partners as well as consumers have a responsibility to align in a joint effort to make *healthy* choices *easy* choices. This complex problem needs to be tackled in order to improve the populations dietary patterns and contain the obesity epidemic.

Currently, the strategy to promote healthier foods is based on highlighting the healthiness of products. The food industry is taking responsibility by restructuring its operations towards healthier product offerings and are communicating health aspects of the products through packaging. The marketplace includes an increasing number of reformulated, healthier alternatives, *i.e.,* food products containing less sugar, fat and salt (called healthy foods from now on). Within almost all product categories, a reformulated, healthier alternative is present containing information emphasising sugar, fat and salt reductions and health aspects. Complementary to this, government initiatives have been employed to increase awareness and knowledge of healthy dietary patterns and a healthy lifestyle, for example, by developing and distributing educational information regarding healthy foods to primary schools (www.jonglereneten.nl 2018) and providing clear dietary guidelines (Brink, Postma-Smeets et al. 2016).

Focussing on health aspects of products is thought to be an effective strategy because consumers themselves state that health is an important motivation for their food choices (Carrillo, Varela et al. 2011). However, despite their best efforts, the majority of the population does not adhere to recommended dietary guidelines, and we are still facing rising obesity rates (Centraal Bureau voor de Statistiek 2017). Therefore, additional strategies and measures should be explored to make the healthy choice the easy choice. We propose to make healthier foods more attractive through subtle cues in package design.

Healthier foods are often inherently less attractive, mainly in terms of macronutrients, sensory properties and hedonic perceptions. A product's attractiveness is an important driver of food preferences, choice and consumption behaviour (de Graaf, Kramer et al. 2005). Thus, healthier foods are at a sensory disadvantage and may be seen as less rewarding compared to their regular counterparts (*i.e.,* energy-dense foods high in fat and/or sugar; called unhealthy foods from now on). Furthermore, focussing on the health aspects of healthier products may signal healthiness, but may also signal a loss of taste (Raghunathan, Walker Naylor et al. 2006, Liem, Toraman Aydin et al. 2012, Mai and Hoffmann 2015). Focussing on health aspects of these healthier foods may additionally make them stand out, indirectly implying the unhealthy option is the default. Opting for the healthier choice in that sense would require actively avoiding the unhealthy default, thereby relying on self-control. Making healthier foods more attractive could bridge the gap and help overcome the perceived or inferred shortcomings of healthy foods. Closing this gap implies that the unhealthy option is no longer expected to be tastier and more attractive, and therefore less tempting. Consequently, resisting the unhealthy option would require less self-control. Most food behaviours are made mindlessly, automatically and without conscious deliberation over the consequences (Bargh 2002, Verhoeven, Adriaanse et al. 2012). Thus, making healthier foods more attractive could be an effective strategy for the general population.

Simple cues in the environment can be an effective, simple and cost-effective way to enhance the attractiveness of healthier products. A product's attractiveness is pivotal during the stages of product choice and purchase. At point of purchase, vision is the most important sensory modality when it comes to conscious and subconscious determinants of choice and behaviour (Schifferstein, Fenko et al. 2013). As such, vision plays a key role to capture and direct consumers' attention and create product-related expectations that drive behaviour. Visual package information is an important driver of product expectations and choice. For example, package colour is one of the most potent and intuitive visual cues, and is often used in marketing to direct consumers' attention or signal sensory and affective product properties (Aslam 2006).

The aim of the research described in this thesis is to explore the effectiveness of simple cues in the environment, specifically packaging cues, to positively impact product perception in terms of flavour, attractiveness and liking. This introduction will further elaborate on the formation and drivers of food choice and preference behaviour, the formation of expectations and their effect on evaluation, and on the opportunities of extrinsic cues to influence perception. Following this, we touch upon the biology of vision and communicative properties of package colour. Lastly, the aim and outline of the thesis will be introduced.

The nature of human food choice behaviour

Human behaviour is generally not driven by deliberation over the consequences of one's actions, but is often automatic, habitual and cued by environmental stimuli, resulting in actions that are largely unaccompanied by conscious reflection (Kahneman 2012). This applies to food choice behaviour as well. The requirement and use of cognitive resources in choice behaviour, and deliberations over the consequences of this behaviour depend on the level of involvement required when making a decision *e.g.,* food choice decisions are often considered low involvement decisions, whereas *e.g.,* buying a car is considered a high involvement decision (Priluck Grossman and Wisenblit 1999, Silayoi and Speece 2004). Thus, involvement level is an important factor in decision making processes and consequent behaviour. The higher the involvement level, the more cognitive thought and deliberation over the consequences go into making a decision (Beatty, Homer et al. 1988). Not surprisingly, most choices about purchasing and consuming foods involve little conscious deliberation and are thus made automatically and habitually (Bargh 2002, Wansink 2004, Dijksterhuis, Smith et al. 2005).

Resisting temptations

Resisting unhealthy foods requires effort and conscious decision making, even when people hold a healthy lifestyle in high regards (Marteau, Hollands et al. 2012, Dohle, Diel et al. 2018). Unfortunately, cognitive resources to engage in such effortful decisions are limited and not sufficiently used as a result of the habitual nature of food choice behaviour (Bargh 2002, Dijksterhuis, Smith et al. 2005, De Ridder, Lensvelt-Mulders et al. 2012, Friese and Hofmann 2016, Baumeister, Tice et al. 2018). Consequently, consumers may end up eating too much, or choosing unhealthy foods despite their explicit intention and expressed desire of consuming healthier foods (Weijzen, de Graaf et al. 2009).

Consumer preferences

Food preferences are well-established determinants of food choice, intake and eating behaviour (de Graaf, Kramer et al. 2005). Though preference is often translated somewhat narrowly into "liking" for a food or even more specifically into "taste preference", it encompasses a much broader function of both product intrinsic as well as extrinsic aspects (Raghunathan, Walker Naylor et al. 2006, Ng, Chaya et al. 2013, Gutjar, de Graaf et al. 2014, Piqueras-Fiszman and Spence 2015). *Intrinsic aspects* refer to aspects that physically belong to the food itself (*e.g.,* flavour, taste, odour, texture, colour). These aspects cannot be changed without changing the physical properties of the food itself. *Extrinsic aspects,* by contrast, are those that are somewhat related to the product, but not physically a part of the product (*e.g.,* packaging, labelling, location of sale or consumption, any other sources of information provided by marketing communications). These aspects have great potential to direct consumer preferences.

Some aspects of food preferences are innate, such as a liking for sweetness as it signals energy, necessary for survival. Other aspects of food preferences are malleable and learned over time. This flexibility suggests an evolved capacity to learn which foods are safe and provide adequate energy to survive and is therefore a lifelong process (Birch 1998, Ventura and Mennella 2011). A majority of food preferences revolve around the familiarity of intrinsic properties such as the taste, and the related post-ingestive consequences (for a review see Birch (1999)). Familiarity is a result of repeated exposure to a taste or food product. Recurring exposure to the same food environment can lead to routine or habitual behaviour, which is mostly automatic, sub/unconscious and non-cognitive, and leads to preferences for some actions or choices (Cohen and Babey 2012). The more often an action is performed under the same circumstances (*e.g.,* eating behaviour), the more habitual the behaviour becomes (Verplanken and Wood 2006). Thus, past consumption can predict future behaviour and preferences to a certain degree.

Extrinsic information can also influence food preferences. Brands, claims, labelling, advertising and packaging can all direct preferences in a similar way as intrinsic information, by creating familiar and positive associations and expectations (Okamoto and Dan 2013, Li, Jervis et al. 2015, Piqueras-Fiszman and Spence 2015). As preferences are important determinants of food choice behaviour, it is not surprising that the fast moving consumer goods (FMCG) industry aims to mobilise, enhance and create food preferences through the means of both extrinsic and intrinsic product information. For example, unhealthy sweet and confectionary products are formulated to exploit the innate preferences for sweetness and energy density (Chandon and Wansink 2012). Increasing portion sizes encourages consumers to eat beyond their satisfactory appetite boundaries, which subsequently become normalised and preferred (Ledikwe, Ello-Martin et al. 2005). Cartoon characters are used to influence product preferences of pre-school children (Ülger 2008). However, making healthier foods the preferred choice, seems to be a more difficult and complex task.

Food preferences also relate to a consumer's motivation to eat. About 50-63% of the western population have the explicit goal to limit their energy intake (Rideout and Barr 2009, Fayet, Petocz et al. 2012, de Ridder, Adriaanse et al. 2014). For these individuals, food choices and preferences may differ from those who do not share this explicit goal. Food preferences can thus be seen in light of consumers' behavioural intentions, where the immediate goal of eating enjoyment is more/less salient than the longer-term goal of being slim, or healthy. This goal consequently influences product expectations, perception, preference, choice and intake (Cavanagh and Forestell 2013, Huang and Lu 2015, Mai and Hoffmann 2015).

Expectation formation and influences on evaluation

When interacting with food cues (*e.g.,* packaging) our brain interprets and integrates relevant stored information with immediately available (sensory) cues. Think of learned associations, stored information regarding prior consumption moments, orthonasal olfactory cues, visual appearance, everything up to the context in which we happen to be eating or drinking. This interpretation relies on information consumers have and use considering the situation, context, present cues and attitudes and beliefs related to this. As a result, the interpretation leads to *expectations* about what is to be experienced (Woods, Lloyd et al. 2011, Piqueras-Fiszman and Spence 2015).

These expectations are not static, but rather dynamic and are updated with every encounter of the product (Figure 1.1). For example, visual package information is an important source of expectations when initially evaluating a novel product within a purchase setting. However, over repeated consumption, the familiarity with (intrinsic) properties of the product increases, therefore, expectations will likely be based less on visual package information, and more on past experiences with the product (Clark 2013).

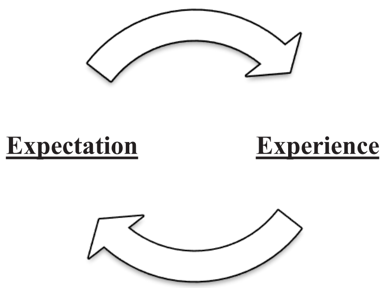

Figure 1.1 The dynamic influences of expectation on evaluation over repeated encounters.

There may be a discrepancy between the expected experience based on (*e.g.,*) visual package information and the actual *evaluation i.e.,* a disconfirmation in expectation. Multiple theories arise as to how extrinsic sources create expectations and in turn influence product evaluation (for a detailed review and empirical evidence see Piqueras-Fiszman and Spence (2015)). We rely on the assimilation/contrast theory to explain effects of (dis)confirmation of expectation on actual evaluation. The assimilation/contrast theory gives an intuitive and plausible explanation of what happens when expectations, *e.g.,* from package based information, do not match with actual experience (Figure 1.2).

When actual experience does not match the predicted expectations, the latter including interpretation of package information, a tactic of the brain is to implement processes to correct for this discrepancy (*i.e.,* error in prediction). If the discrepancy (in the eyes of the consumer) is small enough *i.e.,* when it falls into the 'latitude of acceptance', evaluation is altered towards what is expected to minimize the error in prediction. This is referred to as *assimilation.* However when the discrepancy is too large *i.e.,* when it falls outside the 'latitude of acceptance', surprise of this unexpected event exaggerates the disparity between predicted expectation and actual evaluation. This is referred to as *contrast*. (Anderson 1973, Cardello and Sawyer 1992, Deliza and MacFie 1996, Davidenko, Delarue et al. 2015, Piqueras-Fiszman and Spence 2015).

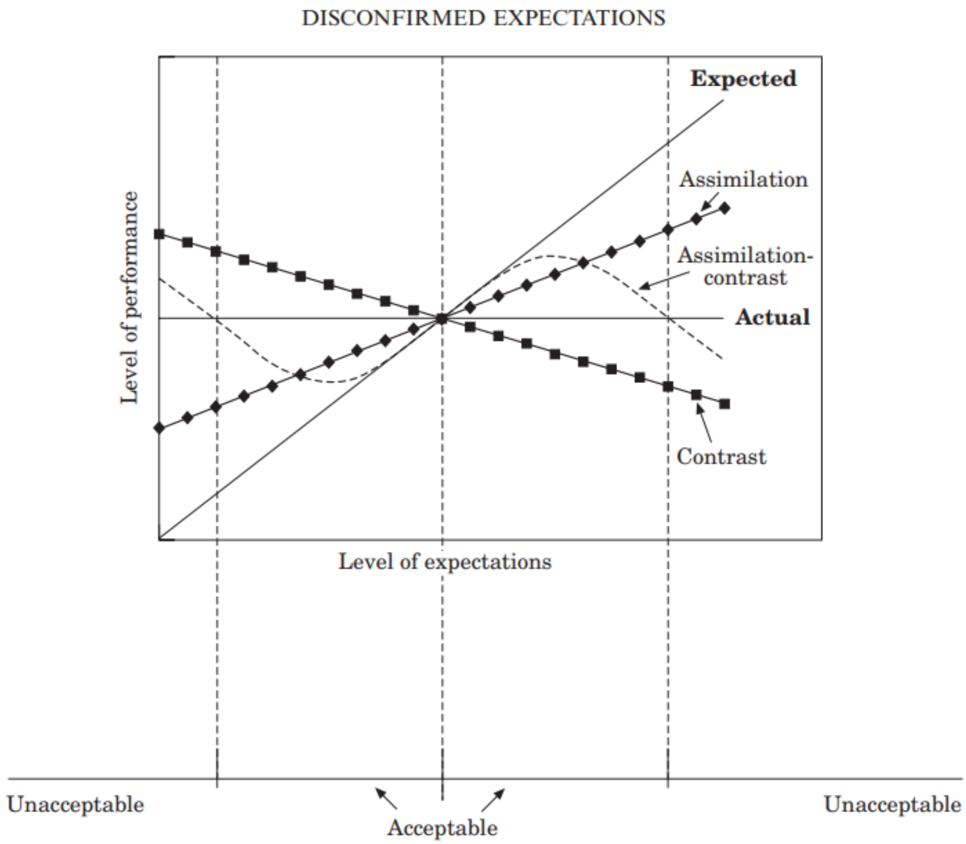

Figure 1.2 Schematic representation of the source and predictions of Assimilation-Contrast theory. The upper part gives the response predicted by Assimilation, Contrast and Assimilation-Contrast theory for a labelled product. The lower part shows the section of the underlying, subjective continuum used in the latter theory to classify a stimulus after an expectation has been formed. Source: Schifferstein, Fenko et al. (2013).

Influence of extrinsic information

Environment

Extrinsic cues in the environment such as retail shelf positioning, discounts, and serving size all have been shown to influence product expectations, choice, perception and intake. For example, placing unhealthy menu items on the back of the menu decreased the likelihood of being chosen (Downs, Loewenstein et al. 2009). Placing an expensive item next to a lower priced item is said to increase the sale of the lower-priced item (Poundstone 2010). Discounts on healthy items have been shown to increase purchase and consumption (French 2003). In a cafeteria setting, ice cream consumption reduced when the ice cream was placed more in the back of the room, and when the lid was on the ice cream cooler (Rozin, Scott et al. 2011). Lastly, an increased serving size can enhance intake (Rolls, Morris et al. 2002, Rolls, Roe et al. 2004). The abovementioned cues are very potent influences on food choice, preference and consumption behaviour. However, investigating the influence of environmental context is outside of the scope of the research described in this thesis. Contextual cues more directly related to food products themselves, such as package cues, have also been shown to have a profound impact on food choice behaviour through expectations and perception. Therefore, we have focussed on the role of packaging design on expectations and perception, with a strong focus on the influence of package colour on product expectation and evaluation.

Package

Package elements can influence expectations and perception (for a review see Piqueras-Fiszman and Spence (2015)). For example, brand labels influence pleasantness ratings and reward processing in the brain (Kuhn and Gallinat 2013). Packaging products in larger containers (regardless of the actual volume or content) enhanced preference compared to smaller containers (Meier, Robinson et al. 2008). Reduced salt labels generated negative taste expectation and experience in terms of liking and saltiness (Liem, Toraman Aydin et al. 2012). Health labels enhance a product's healthiness expectations and influence hedonic expectations (Liem, Toraman Aydin et al. 2012, Tarancón, Sanz et al. 2014, Mai, Symmank et al. 2016, van Rompay, Deterink et al. 2016, Tijssen, Zandstra et al. 2017). Angular product shapes influence taste intensity (Becker, van Rompay et al. 2011), while upward rounded labels on the front of pack are preferred over downward angular labels (Coulthard, Hooge et al. 2017). Similarly, the shape and colour of a yoghurt container influenced liking, where round shape and yellow colour enhances liking compared to a square shape and white/black colour (Ares and Deliza 2010). Colour and label properties influence sensory perception, where brown coloured M&M's as well as M&Ms labelled "dark chocolate" were more chocolatey than green coloured, or "milk-chocolate" labelled M&M's (Shankar, Levitan et al. 2009). For a detailed review on influences of colour on expectations and perception see Spence and Velasco (2018).

The influence of package cues on perception can depend on consumer characteristics such as their eating goals, health knowledge and eating style. For example, branded cookies named "kashi" (associated with healthy products) increased ratings on flavour, satisfaction and overall liking compared to cookies branded as "nabisco" (not associated with healthy products). Restrained eaters consumed more of the cookie when branded with the healthful "kashi" compared to the less healthful "nabisco" brand (Cavanagh and Forestell 2013). Similarly, Mai, Symmank et al. (2016) showed that package colour signalled either healthiness, in health conscious consumers, or a loss of taste in less health conscious consumers. Huang and Lu (2015) showed that package colour affected sensory and healthiness expectations depending on a consumers level of external eating.

As demonstrated, package design and colour aspects have the potential to steer food choices, expectations and preferences. To date, most research uses explicit measurements tools relying on conscious reflection and has focussed on effects of package cues with respect to specific sensory or hedonic aspects of the product. Next to this, majority of research investigated the effects of package cues that signal *healthiness* on product perception and preference. Very few studies investigated the effects of package design and colour aspects with the specific goal to enhance the overall hedonics and *attractiveness* of healthier products, thereby combatting the 'healthy is not tasty' intuition. Furthermore very few studies incorporate measurements that capture both conscious as well as less conscious aspects of food evaluation and preference behaviour, initially, as well as in the longer term. The research described in this thesis specifically focusses on the ability of package information to influence overall product attractiveness of healthier products, thereby closing the sensory, hedonic and associative gap with less healthy products. Package design and colour aspects could be a simple and effective way to make healthier foods more attractive, in turn making a healthier choice an easier choice.

Colour

Colour is often referred to as a sensation rather than a physical property of a stimulus (Gegenfurtner 2003). The colour of a stimulus can be described in multiple dimensions, using various colour systems. One of these systems is the "Munsell colour system". This system describes three dimensions of colour; the *hue*, (*i.e.,* colour category), the *brightness* (*i.e., value*), the degree of black or white mixed with a given hue, and the *saturation* (*i.e., chroma*), the intensity and purity of a hue (Nickerson 1940). Figure 1.3 shows the relation between the three colour dimensions.

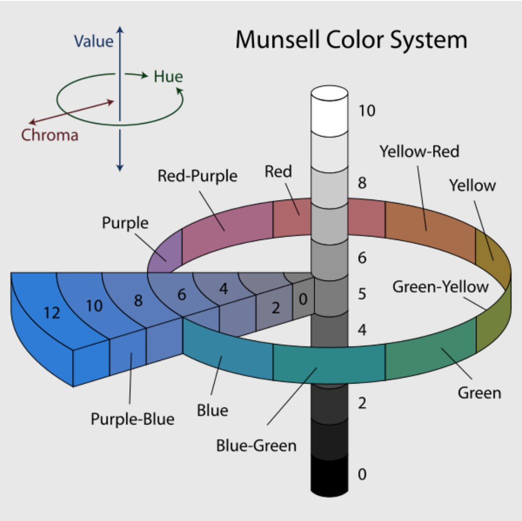

Figure 1.3 Schematic diagram of the Munsell color system. Brightness (*i.e.,* value) is on the vertical axis, from black to white; the hues run in a circle around the vertical axis, and the saturation (*i.e.,* chroma) scale extends outward perpendicular to the value axis. Image by Jacob Rus, 2007.

Colour communication

Evolutionarily, colour vision is proposed to be used to locate edible parts of plants such as flowers and fruits. Colour in certain situations in nature can signal 'approach' (*e.g.,* in flowers) or 'avoid' signals (*e.g.,* of poisonous/dangerous insects) (Humphrey 1976, Palmer and Schloss

2010). Hence, these colourful signals could be used for communication and are in turn important for survival and evolution (Humphrey 1976, Gegenfurtner 2003). For instance, one can identify a strawberry, and determine the ripeness of a strawberry by using the colour of the food. Although some inconsistent opinions about the role of colour in flavour and taste perception exist, a body of research has demonstrated that the colour of a food can communicate associated sensory properties (for a review on this topic see Spence, Levitan et al. (2010)).

Most colour associations with stimuli or concepts manifest themselves as co-occurrences during experiences. We learn to associate certain colours with certain cues in nature, the sky is blue, water is blue, grass is green, the sun is yellow. These colours are not only associated with features in nature but also with related experiences in certain situations. When seeing a strawberry, and its colour, one may associate this with existing memories associated with the strawberry *e.g.,* the consumption context, the social context, the mood one was in when encountering this strawberry. Thus, the communication of colour goes far beyond its mere physical and sensory properties. As *Carl Jung* puts it so elegantly "*colours are the mother tongue of the subconscious*".

These learned associations can be broadly generalised into concepts. For example, 'cool colours', often referred to as colours in the blue/green colour spectrum are broadly associated with concepts such as 'organic', 'nature', 'health', 'calmness' and 'trust'. 'Warm colours', often referred to as colours in the yellow/red spectrum are broadly associated with concepts such as 'love', 'sun', 'summer', 'happiness', 'danger' and 'fire'. Similarly, lighter colour intensities can be associated with concepts such as 'lightness', 'daylight', whereas darker colour intensity can be associated with concepts of 'heaviness', 'night' (Pinkerton and Humphrey 1974, Humphrey 1976, Valdez and Mehrabian 1994, Palmer and Schloss 2010, Mohammad 2011). Although colour associations can vary between consumer groups and cultures, these associations are rather universal, especially within Western societies.

Colour in the marketplace

Colour communication is widely used in the market space *e.g.,* on packaging. Some trends in the Dutch supermarkets are worthwhile to discuss:

1. The use of more 'cool' colours for fresh produce, dairy, as well as organic products isles compared to the use of more 'warm' and bright colours in cookie, candy and sauce isles (Figures 1.4, 1.5, 1.6).

Figure 1.4 Dairy isle in a Dutch supermarket

Figure 1.5 Organic food isle in a Dutch supermarket

Figure 1.6 Sweets and candy isle in a Dutch supermarket

2. The use of package colours of product ranges within a category. Package colours decrease in darkness and intensity as nutritional ingredients in a range decrease (*e.g.,* full 3% fat yoghurt - dark green, semi 1.5% fat yoghurt - medium green, and low 0.5% fat yoghurt - light green yoghurt products Figures 1.7) .

3. The specific light blue colour accompanying the "light" claim. (see images on Page 7).

Figure 1.7 Dutch yoghurt packages ranging from full fat (3%) to low fat (0.5%)

Package colour is perhaps the most important and intuitive visual information at point of purchase and choice. Package colour is the first thing consumers see, and it triggers an immediate response, *i.e.,* expectations (Swientek 2001). Singh (2006) argues that colour drives a majority of all consumer purchasing decisions. Colour can attract attention and convey messages that create feelings or qualities which may increase purchase likelihood. Package colour is important for conspicuousness, because it can be used as a differentiation tool for products. Package colour is thus an important design element that can influence expectations and subsequent evaluation/experience (Strugnell 1997, Ares and Deliza 2010, Huang and Lu 2015, Huang and Lu 2015, Wąsowicz, Styśko-Kunkowska et al. 2015, Mai, Symmank et al. 2016, Tijssen, Zandstra et al. 2017, Spence and Velasco 2018). According to Singh (2006), Piqueras-Fiszman and Spence (2014), Spence and Velasco (2018) it may even be the most potent element in the design of packaging in the FMCG industry. Taken together, colour is widely used in the FMCG industry and Dutch market place.

Aim of the thesis

The research described in this thesis is part of a broader project from the Netherlands Organization for Scientific Research, entitled NUDGIS - *Novel Understanding of the Design for Good Intervention Strategies in the food environment.* The overall objective of this project is to examine the effectiveness of subtle rearrangements of the choice context to gently suggest healthier food choices. The research frame contains four investigatory areas addressing, 1) the role of social context, 2) the role of awareness and salience, 3) the robustness and long-lasting effectiveness of multiple contextual choice context rearrangements, and 4) the role of emotional reinforcement (*i.e.,* this thesis). The program aims to formulate rules to design effective intervention strategies to help make healthy food choices easy and preferred food choices. Four partners are involved in the project: Utrecht University, Wageningen University, Unilever R&D Vlaardingen, The Netherlands, and FrieslandCampina, Amersfoort, The Netherlands.

In this thesis we investigate the role of emotional reinforcement to make the *healthy* choice the *easy* and *preferred* choice, by making healthier products more attractive products. Emotional reinforcement of healthier products can potentially close the gap in hedonics and preference between products and their healthier counterparts, and have the potential to combat the "healthy is not tasty" intuition. Here we investigate the potential of package design, predominantly package colour, as emotional reinforcement to enhance product expectations regarding attractiveness, and in turn enhance product evaluation at point of consumption.

Thesis outline

Package design and package colour are considered important sources of communication to consumers. However, the manner of using package design and colour to make healthier products more attractive, has not yet been elucidated.

The following research objectives are addressed in this thesis:

- To examine the influence of package design and package colour aspects on product expectations and evaluations.
- To research the underlying mechanisms and conditions under which package colour aspects elicit their effects.
- To determine what package colours communicate with regard to associations of healthiness and attractiveness.
- To investigate the long lasting effects of package design on product evaluation.

We first examined whether package colour aspects influence product expectations and consequently evaluations upon consumption (**Chapter 2**). Following up on this, we explored the mechanisms and conditions under which package colour cues elicit their effects on expectation and evaluation (**Chapter 3**). Next to this, we examined the implicit associations of a multitude of colour aspects with regard to healthiness and attractiveness (**Chapter 4**). We continued our research in a real-life context, at home, to more realistically investigate the long lasting effects of package design on product expectation and evaluation (**Chapter 5**). In the final chapter of this thesis, the main findings are interpreted and discussed, implementations of the research are described and recommendations for future research are given (**Chapter 6**). See Table 1.1 for an overview of the research chapters including setting, period, method, aim and outcome measures.

With the results of these studies we can create a better understanding of package colour communication as an intervention strategy to make healthier foods more attractive and healthy choices easier choices.

Table 1.1 Overview of the research chapters, including setting, period, method, aims and outcome measures.

Chapter	Setting	Period	Method	Aim	Outcome measure
Chapter 2	Lab-context	Single exposure	Explicit evaluation (VAS) Implicit associations (IAT)	Effect of package colour on **expectation**, **evaluation**, **implicit associations**	Sensory and liking expectations and evaluations upon tasting Healthiness and attractiveness associations
Chapter 3	Lab-context	Single exposure	Neural correlates (BOLD fMRI)	**Mechanism** underlying effects of package colour on evaluation	Neural correlates upon viewing packages and tasting product
Chapter 4	Lab-context	Single exposure	Implicit associations (IAT)	Establish robustness of **implicit attitudes** of package colour aspects	Healthiness and attractiveness associations
Chapter 5	At home and lab-context	Repeated exposure	Explicit evaluation (VAS) Implicit associations (IAT)	**Long lasting** effects of package design on **expectation, evaluation** and **implicit associations**	Sensory, healthiness, attractiveness, liking expectations and evaluations over repeated consumption Healthiness and attractiveness associations

References

Anderson, R. E. (1973). "Consumer Dissatisfaction: The Effect of Disconfirmed Expectancy on Perceived Product Performance." Journal of Marketing Research 10(1): 38-44.
Ares, G. and R. Deliza (2010). "Studying the influence of package shape and colour on consumer expectations of milk desserts using word association and conjoint analysis." Food Quality and Preference 21(8): 930-937.
Aslam, M. M. (2006). "Are You Selling the Right Colour? A Cross-cultural Review of Colour as a Marketing Cue." Journal of Marketing Communications 12(1): 15-30.
Bargh, J. A. (2002). "Losing Consciousness: Automatic Influences on Consumer Judgment, Behavior, and Motivation." Journal of Consumer Research 29(2): 280-285.
Baumeister, R. F., D. M. Tice and K. D. Vohs (2018). "The strength model of self-regulation: Conclusions from the second decade of willpower research." Perspectives on Psychological Science 13(2): 141-145.
Beatty, S. E., P. Homer and L. R. Kahle (1988). "The Involvement Commitment Model - Theory and Implications." Journal of Business Research 16(2): 149-167.
Becker, L., T. J. L. van Rompay, H. N. J. Schifferstein and M. Galetzka (2011). "Tough package, strong taste The influence of packaging design on taste impressions and product evaluations." Food Quality and Preference 22(1): 17-23.
Birch, L. L. (1998). "Development of food acceptance patterns in the first years of life." Proceedings of the Nutrition Society 57(4): 617-624.
Birch, L. L. (1999). "DEVELOPMENT OF FOOD PREFERENCES." Annual Review of Nutrition 19(1): 41-62.
Brink, L., A. Postma-Smeets, A. Stafleu and D. Wolvers (2016). Richtlijnen schijf van vijf, Voedingscentrum Nederland.
Cardello, A. V. and F. M. Sawyer (1992). "Effects of disconfirmed consumer expectations on food acceptibility." Journal of Sensory Studies 7(4): 253-277.
Carrillo, E., P. Varela, A. Salvador and S. Fiszman (2011). "MAIN FACTORS UNDERLYING CONSUMERS'FOOD CHOICE: A FIRST STEP FOR THE UNDERSTANDING OF ATTITUDES TOWARD “HEALTHY EATING”." Journal of Sensory Studies 26(2): 85-95.
Cavanagh, K. V. and C. A. Forestell (2013). "The effect of brand names on flavor perception and consumption in restrained and unrestrained eaters." Food Quality and Preference 28(2): 505-509.
Centraal Bureau voor de Statistiek, C. (2017). Trends in Nederland 2017. C. B. v. d. Statistiek. Den Haag, The Netherlands, Centraal Bureau voor de Statistiek.
Chandon, P. and B. Wansink (2012). "Does food marketing need to make us fat? A review and solutions." Nutr Rev 70(10): 571-593.
Clark, A. (2013). "Whatever next? Predictive brains, situated agents, and the future of cognitive science." Behavioral and Brain Sciences 36(3): 181-204.
Cohen, D. A. and S. H. Babey (2012). "Contextual influences on eating behaviours: heuristic processing and dietary choices." Obesity Reviews 13(9): 766-779.
Coulthard, S., I. Hooge, M. Smeets and E. Zandstra (2017). "Nudging food into a healthy direction: The effects of front-of-pack implicit visual cues on food choice." International Journal of Food Design 2(2): 225-240.
Davidenko, O., J. Delarue, A. Marsset-Baglieri, G. Fromentin, D. Tome, N. Nadkarni and N. Darcel (2015). "Assimilation and Contrast are on the same scale of food anticipated-experienced pleasure divergence." Appetite 90: 160-167.
de Graaf, C., F. M. Kramer, H. L. Meiselman, L. L. Lesher, C. Baker-Fulco, E. S. Hirsch and J. Warber (2005). "Food acceptability in field studies with US army men and women: relationship with food intake and food choice after repeated exposures." Appetite 44(1): 23-31.
de Ridder, D., M. Adriaanse, C. Evers and A. Verhoeven (2014). "Who diets? Most people and especially when they worry about food." Appetite 80: 103-108.
De Ridder, D. T., G. Lensvelt-Mulders, C. Finkenauer, F. M. Stok and R. F. Baumeister (2012). "Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors." Personality and Social Psychology Review 16(1): 76-99.
Deliza, R. and H. J. H. MacFie (1996). "The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: a review." Journal of Sensory Studies 11(2): 103-128.
Dijksterhuis, A., P. K. Smith, R. B. van Baaren and D. H. J. Wigboldus (2005). "The Unconscious Consumer: Effects of Environment on Consumer Behavior." Journal of Consumer Psychology 15(3): 193-202.
Dohle, S., K. Diel and W. Hofmann (2018). "Executive functions and the self-regulation of eating behavior: A review." Appetite 124: 4-9.
Downs, J. S., G. Loewenstein and J. Wisdom (2009). "Strategies for promoting healthier food choices." American Economic Review 99(2): 159-164.
Fayet, F., P. Petocz and S. Samman (2012). "Prevalence and correlates of dieting in college women: a cross sectional study." International journal of women's health 4: 405.

French, S. A. (2003). "Pricing effects on food choices." The Journal of nutrition 133(3): 841S-843S.
Friese, M. and W. Hofmann (2016). Passion Versus Reason: Impulsive and Reflective Determinants of Self-Control Success and Failure. Reflective and Impulsive Determinants of Human Behavior, Routledge: 131-148.
Gegenfurtner, K. R. (2003). "Cortical mechanisms of colour vision." Nature Reviews Neuroscience 4(7): 563.
Gutjar, S., C. de Graaf, A. Palascha and G. Jager (2014). "Food choice: The battle between package, taste and consumption situation." Appetite 80: 109-113.
Huang, L. and J. Lu (2015). "Eat with your eyes: Package color influences the expectation of food taste and healthiness moderated by external eating." Marketing Management 25(2): 71-87.
Huang, L. and J. Lu (2015). "The Impact of Package Color and the Nutrition Content Labels on the Perception of Food Healthiness and Purchase Intention." Journal of Food Products Marketing: 1-29.
Humphrey, N. (1976). The Colour Currency of Nature.
Kahneman, D. (2012). Thinking, fast and slow, Farrar, Straus and Giroux.
Kuhn, S. and J. Gallinat (2013). "Does Taste Matter? How Anticipation of Cola Brands Influences Gustatory Processing in the Brain." Plos One 8(4).
Ledikwe, J. H., J. A. Ello-Martin and B. J. Rolls (2005). "Portion sizes and the obesity epidemic." The Journal of nutrition 135(4): 905-909.
Li, X. E., S. M. Jervis and M. A. Drake (2015). "Examining Extrinsic Factors that Influence Product Acceptance: A Review." Journal of Food Science 80(5): R901-R909.
Liem, D. G., N. Toraman Aydin and E. H. Zandstra (2012). "Effects of health labels on expected and actual taste perception of soup." Food Quality and Preference 25(2): 192-197.
Mai, R. and S. Hoffmann (2015). "How to combat the Unhealthy = tasty intuition: the influencing role of health consciousness." Journal of Public Policy & Marketing 34(1): 63-68.
Mai, R., C. Symmank and B. Seeberg-Elverfeldt (2016). "Light and Pale Colors in Food Packaging: When Does This Package Cue Signal Superior Healthiness or Inferior Tastiness?" Journal of Retailing 92(4): 426-444.
Marteau, T. M., G. J. Hollands and P. C. Fletcher (2012). "Changing human behavior to prevent disease: the importance of targeting automatic processes." science 337(6101): 1492-1495.
Meier, B. P., M. D. Robinson and A. J. Caven (2008). "Why a big mac is a good mac: Associations between affect and size." Basic and applied social psychology 30(1): 46-55.
Mohammad, S. (2011). Colourful language: Measuring word-colour associations. Proceedings of the 2nd Workshop on Cognitive Modeling and Computational Linguistics, Association for Computational Linguistics.
Ng, M., C. Chaya and J. Hort (2013). "The influence of sensory and packaging cues on both liking and emotional, abstract and functional conceptualisations." Food Quality and Preference 29(2): 146-156.
Nickerson, D. (1940). "History of the Munsell color system and its scientific application." JOSA 30(12): 575-586.
Okamoto, M. and I. Dan (2013). "Extrinsic information influences taste and flavor perception: a review from psychological and neuroimaging perspectives." Semin Cell Dev Biol 24(3): 247-255.
Palmer, S. E. and K. B. Schloss (2010). "An ecological valence theory of human color preference." Proceedings of the National Academy of Sciences 107(19): 8877-8882.
Pinkerton, E. and N. K. Humphrey (1974). "The apparent heaviness of colours." Nature 250(5462): 164.
Piqueras-Fiszman, B. and C. Spence (2014). "Colour, pleasantness, and consumption behaviour within a meal." Appetite 75: 165-172.
Piqueras-Fiszman, B. and C. Spence (2015). "Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts." Food Quality and Preference 40: 165-179.
Poundstone, W. (2010). Priceless: The myth of fair value (and how to take advantage of it), Hill and Wang.
Priluck Grossman, R. and J. Z. Wisenblit (1999). "What we know about consumers' color choices." Journal of marketing practice: Applied marketing science 5(3): 78-88.
Raghunathan, R., R. Walker Naylor and W. D. Hoyer (2006). "The unhealthy is tasty intuition an its effect on taste inferences enjoyment and choice of food products." Journal of Marketing 70: 170-184.
Rideout, C. A. and S. I. Barr (2009). "“Restrained eating” vs “trying to lose weight”: how are they associated with body weight and tendency to overeat among postmenopausal women?" Journal of the Academy of Nutrition and Dietetics 109(5): 890-893.
Rolls, B. J., E. L. Morris and L. S. Roe (2002). "Portion size of food affects energy intake in normal-weight and overweight men and women." The American journal of clinical nutrition 76(6): 1207-1213.
Rolls, B. J., L. S. Roe, T. V. Kral, J. S. Meengs and D. E. Wall (2004). "Increasing the portion size of a packaged snack increases energy intake in men and women." Appetite 42(1): 63-69.

Rozin, P., S. Scott, M. Dingley, J. K. Urbanek, H. Jiang and M. Kaltenbach (2011). "Nudge to nobesity I: Minor changes in accessibility decrease food intake." Judgment and Decision Making 6(4): 323.
Schifferstein, A. Fenko, P. M. Desmet, D. Labbe and N. Martin (2013). "Influence of package design on the dynamics of multisensory and emotional food experience." Food Quality and Preference 27(1): 18-25.
Shankar, M. U., C. A. Levitan, J. Prescott and C. Spence (2009). "The Influence of Color and Label Information on Flavor Perception." Chemosensory Perception 2(2): 53-58.
Silayoi, P. and M. Speece (2004). "Packaging and purchase decisions." British Food Journal 106(8): 607-628.
Singh, S. (2006). "Impact of color on marketing." Management Decision 44(6): 783-789.
Spence, C., C. A. Levitan, M. U. Shankar and M. Zampini (2010). "Does Food Color Influence Taste and Flavor Perception in Humans?" Chemosensory Perception 3(1): 68-84.
Spence, C. and C. Velasco (2018). "On the multiple effects of packaging colour on consumer behaviour and product experience in the ‘food and beverage’and ‘home and personal care’categories." Food Quality and Preference.
Strugnell (1997). "Colour and its Role in Sweetness Perception." Appetite 28(1): 85.
Swientek, B. (2001). "Uncanny developments." Beverage Industry 92(12): 38-39.
Tarancón, P., T. Sanz, S. Fiszman and A. Tárrega (2014). "Consumers' hedonic expectations and perception of the healthiness of biscuits made with olive oil or sunflower oil." Food research international 55: 197-206.
Tijssen, I., E. H. Zandstra, C. de Graaf and G. Jager (2017). "Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar- and fat-reduced products." Food Quality and Preference 59: 46-58.
Ülger, B. (2008). "Packages with cartoon trade characters versus advertising: an empirical examination of preschoolers' food preferences." Journal of Food Products Marketing 15(1): 104-117.
Valdez, P. and A. Mehrabian (1994). "Effects of color on emotions." Journal of experimental psychology: General 123(4): 394.
van Rompay, T. J. L., F. Deterink and A. Fenko (2016). "Healthy package, healthy product? Effects of packaging design as a function of purchase setting." Food Quality and Preference 53: 84-89.
Ventura, A. K. and J. A. Mennella (2011). "Innate and learned preferences for sweet taste during childhood." Current Opinion in Clinical Nutrition and Metabolic Care 14(4): 379-384.
Verhoeven, A. A. C., M. A. Adriaanse, C. Evers and D. T. D. de Ridder (2012). "The power of habits: Unhealthy snacking behaviour is primarily predicted by habit strength." British Journal of Health Psychology 17(4): 758-770.
Verplanken, B. and W. Wood (2006). "Interventions to break and create consumer habits." Journal of Public Policy & Marketing 25(1): 90-103.
Wansink, B. (2004). "Environmental factors that increase the food intake and consumption volume of unknowing consumers." Annu Rev Nutr 24: 455-479.
Wąsowicz, G., M. Styśko-Kunkowska and K. G. Grunert (2015). "The meaning of colours in nutrition labelling in the context of expert and consumer criteria of evaluating food product healthfulness." Journal of health psychology 20(6): 907-920.
Weijzen, P. L., C. de Graaf and G. B. Dijksterhuis (2009). "Predictors of the consistency between healthy snack choice intentions and actual behaviour." Food Quality and Preference 20(2): 110-119.
Woods, A. T., D. M. Lloyd, J. Kuenzel, E. Poliakoff, G. B. Dijksterhuis and A. Thomas (2011). "Expected taste intensity affects response to sweet drinks in primary taste cortex." Neuroreport 22(8): 365-369.
www.jonglereneten.nl. (2018). "Jong Leren Eten." Retrieved 01-06-2018, 2018, from https://www.jonglereneten.nl/.

Chapter 2

Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar- and fat-reduced products

Irene O.J.M. Tijssen
Elizabeth H. Zandstra
Cees de Graaf
Gerry Jager

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Abstract

Healthier foods (*e.g.,* '*light*' products with low fat or sugar content) often lead to lower hedonic evaluation and decreased satiating properties, putting these products at a sensory disadvantage compared to their regular counterparts. Nudging consumers towards healthy foods by making healthy foods more attractive may facilitate healthier food choices. Package colour communicates product properties and could be used to make a healthy product more attractive. Healthier alternatives are typically packaged in less vibrantly coloured, watered-down packages compared to their regular counterparts. Does this communicate the intended message?

The aim was to investigate effects of package colour on perceived healthiness, attractiveness and sensory expectations and perception of food products both explicitly and implicitly.

We investigated effects of package *hue* (green/purple, blue, red), *brightness* and *saturation* on expected (experiment 1) and perceived (experiment 2) product properties after tasting, for a low-sugar dairy drink (n=148) and low-fat sausage (n=140). Implicit Association Tests (IATs) were used to measure strength of associations between package colouring cues and perceived attractiveness and healthiness of the products.

Effects of package colour were stronger for sensory expectations than for perceptions after tasting. A combination of colour properties (*hue*, *brightness* and/or *saturation*) rendered packaging more attractive and increased sensory evaluation. Implicitly, watered-down coloured 'healthier' package versions were strongly associated with *healthiness* whereas 'regular' packages were strongly associated with *attractiveness.*

Packaging healthier alternatives in warmer, *saturated*, less *bright* coloured packages (more similar to regular products) explicitly enhances sensory expectations and perceptions, and implicitly improves attractiveness, potentially making them more appealing to consumers.

1. Introduction

In this paper we discuss the use of affective cues in packaging as a way to facilitate (*i.e.,* nudge) healthier food choices for consumers.

Most health awareness initiatives to improve population health have focussed their efforts on educating individuals about the benefits of a healthy food choice and lifestyle, thus trying to establish behaviour change via effortful decision making. However, human behaviour in general is not driven by deliberation over the consequences of actions but is to a large extent automatic, cued by environmental stimuli, resulting in actions that are largely unaccompanied by conscious reflection (Kahneman, 2012).

Choices for which the cognitive effort in decision making is low, *i.e.,* food choices, are considered low involvement choices, they involve little conscious deliberation (Priluck, Grossman & Wisenblit, 1999; Silayoi & Speece, 2004). Involvement level is an important factor in decision making processes *e.g.,* conscious/deliberate versus subconscious/automatic (Beatty, Homer, & Kahle, 1988). The higher the involvement level, the more cognitive thought often goes in to making a decision.

Nudging interventions acknowledge the automatic nature of low involvement decisions and make automaticity work for health awareness, rather than fight against it as in many traditional health awareness interventions (Arno & Thomas, 2016; Blumenthal-Barby & Burroughs, 2012; Bucher et al., 2016; Johnson et al., 2012; Kosters & Van der Heijden, 2015; Marteau, 2011; Oliver, 2011; Selinger & Whyte, 2011; Sugden, 2009; Thaler & Sunstein, 2009; Vallgarda, 2012; Wilson, Buckley, Buckley, & Bogomolova, 2016). A nudge is a small and subtle rearrangement of the decision context that makes the desired (here: healthy) choice the easy choice, while leaving consumers' freedom of choice unaffected (Thaler & Sunstein, 2008; Selinger & Whyte, 2011).

In order to make the healthy choice the easy choice, the nudge should increase salience of important food choice determinants/features. Important determinants of food choice and preference are attractiveness of both intrinsic (flavour, taste, odour, texture) and extrinsic (package, brand, context) properties of food products (Gutjar, de Graaf, Palascha, & Jager, 2014; Ng, Chaya, & Hort, 2013; Piqueras-Fiszman & Spence, 2015; Raghunathan, Walker Naylor, & Hoyer, 2006).

Healthier foods (*e.g.,* reformulated products) with low salt, fat or sugar content, often lead to lower hedonic evaluation and decreased satiating properties putting these products at a disadvantage compared to their full salt, fat and sugar counterparts (Raghunathan et al., 2006; Lee, Shimizu, Kniffin, & Wansink, 2013; Schuldt & Hannahan, 2013). Thus intrinsically healthier foods are perceived as less rewarding and are often less tasty but healthier compared to their regular counterparts. This intuition may be mediated by a consumers' eating goal. (Mai & Hoffmann, 2012; Papies, 2012; Roininen et al., 2001; Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013). It seems that healthier foods are less associated with pleasantness and satisfaction but may be consumed predominantly from a more utilitarian point of view (healthier diets, losing weight, managing metabolic disease *e.g.,* blood pressure, diabetes - Hamilton, Knox, Hill, & Parr, 2000). Hence there seems to be a gap in sensory and reward properties between healthier and regular foods that needs to be bridged to make the healthy choice the easy choice. One way to bridge this gap may be to render other properties of healthier foods more rewarding.

At the point of food choice and purchase in a shopping environment, extrinsic factors are leading determinants since intrinsic (sensory/nutritional) factors have not yet been evaluated at this stage. These extrinsic factors give rise to expectations regarding intrinsic properties. Expectations are formed based on first impressions, previous experiences and memory, and in turn can influence present perception and experience (Deliza & MacFie, 1996). Sight is the most important sense for product evaluation at the buying stage (Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013) and Van der Laan et al. (2011) argues that "the first taste is always with the eyes". Extrinsic factors, such as product packaging, can influence expectations and may be a good vehicle to nudge consumers towards healthier food choices.

In the Dutch market, but in many other markets as well, it is common practice to package healthier alternatives in less vibrantly coloured, watered-down versions of the packaging of regular variants. To illustrate this: Dutch yoghurt packaging ranges from dark green to watered-down light green, where a decrease in colour vibrancy of packaging is related to a decrease in fat percentage of the product. Next to that healthier products tend to be packaged in 'cool' (green, blue) coloured packages whereas more indulgent products are often packaged in 'warm' or 'luxury' coloured packages (red, purple, black).

In line with our market observations regarding package colour communication, Huang et al. (2015) found that blue coloured packages are perceived to be healthier than red ones. Similarly green (a 'cool') colour is often associated with health related attributes/products whereas red (a 'warm') colour symbolises less healthy attributes/products (Schuldt, 2013; van Rompay, Deterink, & Fenko, 2016). Mai et al. (2016) found that light colour intensity in packaging was associated with healthiness.

Surprisingly little research has examined the relationship between package colour and consumers product experience *e.g.,* perceived attractiveness (Ares & Deliza, 2010; Gardner, Hyatta, & Starr, 2003; Kauppinen-Räisänen & Luomala, 2010; Piqueras-Fiszman & Spence, 2012a; van Rompay et al., 2016). For low involvement decisions, colour becomes critical (Grossman & Wisenblit, 1999) and (Singh, 2006) argues that product expectations and evaluations are predominantly based on colour. Packaging colour can therefore be seen as an important source of sensory and hedonic expectations and associations for/with the product.

Traditional colour research in relation to attractiveness focusses mainly on emotional associations related to certain colours, where 'colour' is restricted to *hue e.g.,* 'warm' and 'cool' colours like red and blue respectively (Hogg, 1969; Wexner, 1954). However, affective properties of colour as humans perceive it consist of a combination of *hue, brightness* and *saturation* aspects. *Brightness* is the amount of black/white added to the *hue* and *saturation* is the intensity of the *hue* (Clarke & Costall, 2008; Wright & Rainwater, 1962). Besides, it is obvious that the impact of colour partly depends on culture and social context (Aslam, 2006;

Piqueras-Fiszman & Spence, 2012a; Shankar, Levitan, & Spence, 2010; van Rompay et al., 2016) and product category appropriateness (Bottomley, 2006).

Better insight in how combined effects of product package colouring influence product perception is important. Packaging colour, as a means of signalling product attractiveness, could be a route via which sensory and reward properties of healthier alternatives can be boosted. A schematic framework of influences of package colour on expected and experienced product properties is shown in Figure 2.1.

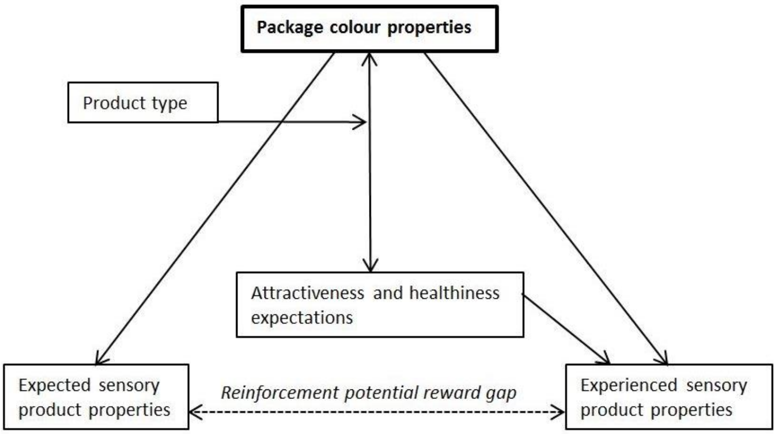

Figure 2.1 Schematic framework of influences of package colour on expected and experienced product properties.

The aim of the present study was to investigate the effects of *hue, brightness* and *saturation* aspects of package colour on healthiness, attractiveness and sensory expectations and perceptions of food product properties. In two separate experiments we distinguished between 1) the expected healthiness, attractiveness and sensory properties (based on viewing packages without consumption of the product), and 2) sensory perception directly after tasting the product (based on viewing packages combined with consumption of the product).

For experiment 1 a set of 2D package images of existing commercially available products (low sugar dairy drink and a low fat sausage) were created. Package colouring was systematically varied in *hue, brightness* and *saturation* without altering any other package characteristics *e.g.,* shape, size, font, label or ingredient information. Packages were evaluated on expected product healthiness, attractiveness and expected sensory properties, *e.g.,* expected flavour intensity and creaminess. For experiment 2 a set of 3D animations (based on 2D images) were created and package viewing was accompanied by sensory evaluation of the products after tasting on sensory properties such as flavour intensity, creaminess.

We expected all colour dimensions (*hue, brightness* and *saturation*) would influence expectations and actual perception of healthiness, attractiveness and sensory properties. We expected lower *brightness* levels, more *saturated* packages and warmer *hues* to be more attractive, tasty and perceived as less healthy compared to *brighter*, less *saturated* packages and cooler *hues*.

2. Experiment 1

2.1. Materials and Methods

Implicit (implicit association test) and explicit (questionnaire) measurement tools were used to investigate effects of colour cues on expected product properties. Data were collected at Wageningen University (The Netherlands) and the experimental protocol was submitted and exempted from ethical approval by the Medical Ethical Committee of Wageningen University.

2.1.1. Participants

Participants were native Dutch speakers from the city of Wageningen and surrounding, were not colour blind (as tested by Ishara's colour blindness test Ishihara, (1951)) and had normal taste and smell abilities (self-reported). Participants gave written consent, received monetary reimbursement for their participation and received no training prior to the experiments. In total, 208 consumers of the target products (mean BMI 21.7±1.8 kg/m^2), aged between 18 and 45 years old, were divided among two product conditions; the dairy drink (*n*=112, 27 male) condition and the sausage (*n*=95, 21 male) condition. Due to a technical malfunction with data logging some data were incomplete. For the dairy drink condition, 112 consumers evaluated expected sweetness, flavour intensity and liking. Data from 30 consumers (*n*=6 male) regarding creaminess was recovered. For the sausage condition, 95 consumers evaluated saltiness, flavour intensity and liking. Data from 29 consumers (*n*=5 male) regarding fattiness was recovered. Despite small (recovered) sample sizes for fattiness and creaminess, data was sufficiently powered and deemed trustworthy based on found effect sizes and critical F-values.

2.1.2 Packages and products

Our primary research focus was to investigate the effects of package colour aspects on expected healthiness and attractiveness of the product. Therefore, colour images of in-market packaged food products were used. Two products were chosen as stimuli: a low-sugar dairy drink (In Dutch: Optimel Puur 'rode vruchten') and a low-fat sausage (in Dutch: Unox 'extra magere rookworst'). In a 3x2x2 design, three colour aspects of the package were altered, *i.e., hue* (dairy drink: blue, purple, red; sausage: blue, green, red), *brightness* level (high, low) and *saturation* level (high, low) resulting in 12 package images per product condition. In total, 4 package images per *hue* were developed. One that was congruent with a more 'healthy alternative' with a less vibrantly coloured, watered-down packaging (*e.g.,* high *brightness* and low *saturation*), one congruent with a more 'regular product' (*e.g.,* low *brightness* and high *saturation*), and two 'in-between' package versions in order to investigate interaction effects of *brightness* and *saturation* more systematically (*e.g.,* high *brightness* & high *saturation* and low *brightness* & low *saturation* versions). These images were specifically designed for this experiment by a professional graphic design agency (Sinot Branding & Design, Eemnes, The Netherlands). Examples of the package images can be found in Figure 2.2 and 2.3.

Figure 2.2 Low sugar dairy drink "Optimel Puur Rode Vruchten" product package images

Figure 2.3 Low fat sausage "Unox extra magere rookworst" product package images

2.1.3 Implicit associations

To investigate implicit associations between product package colour aspects and 'attractiveness' or 'healthiness' concepts two Implicit Association Tests (IATs) were conducted (Greenwald, McGhee, & Schwartz, 1998; Greenwald, Nosek, & Banaji, 2003). The IAT is a classification task where attribute stimuli and target stimuli are sorted into the correct categories by using keyboard response keys that correspond to both an attribute as well as target category[1]. Attribute stimuli for the IAT 'Attractiveness' included attractive versus unattractive terms and for the IAT 'Healthiness' healthy versus unhealthy terms. The target stimuli for both IAT's included images of 'healthy alternatives' (*i.e.,* high *brightness*, low *saturation*) and 'regular products' (*i.e.,* low *brightness*, high *saturation*). Terms used to represent attribute categories (Table 2.1) were selected based on literature and synonyms (Chapman & Maclean, 1993; Chrysochou, Askegaard, Grunert, & Kristensen, 2010; Croll, Neumark-Sztainer, & Story, 2001; Povey, Conner, Sparks, James, & Shepherd, 1998; Raghunathan et al., 2006). A screenshot of the IAT 'Healthiness' is shown in Figure 2.4. Participant performance for strongly associated target and attribute categories (measured in reaction time) was expected to be enhanced (shorter reaction time) compared to performance for weaker associated categories. The difference in performance is used as a measure of association strength and is calculated using a scoring algorithm by Greenwald et al. (2003), resulting in effect sizes 'D' which can be interpreted similar to Cohen's *d* effect sizes.

Table 2.1 Stimuli terms used for IAT

IAT 'Attractiveness'		**IAT 'Healthiness'**	
ATTRACTIVE	UNATTRACTIVE	HEALTHY	UNHEALTHY
Yummy	Yukky	Light	Too filling
Appetizing	Unappetizing	0% fat	Full fat
Like	Dislike	Low caloric	High caloric
Delicious	Disgusting	Sugar free	Rich in carbohydrates
Flavourful	Flavourless	Salt reduced	Source of sodium

2.1.4 Explicit sensory evaluation

Explicit information on expected liking and sensory expectations (sweetness and creaminess for the dairy drink; saltiness and fattiness for the sausage; flavour intensity for both) was collected twice using a Visual Analogue Scale (VAS) of 100 mm. Hedonic anchors included "dislike extremely" (left) and "like extremely" (right). Sensory anchors included "not at all" (left) and "extremely" (right).

[1] The IAT consists of five blocks. The third and fifth blocks are the two most critical blocks. Participants are presented with target images and attribute words. During the third block, participants had to press a key on the left keyboard whenever a 'healthy alternative' target image or a 'healthy' attribute word appeared on the screen. Whenever a 'regular product' target image or 'unhealthy' attribute word appeared, participants had to press the right key. Throughout the task, the target and attribute category words/images stayed on the screen. Because here the 'healthy alternative' and the 'healthy' terms shared a response key, this is seen as the congruent IAT block. During the fifth block the attribute words switched response keys. 'Healthy alternative' images and 'unhealthy' words now shared the left response key. This is seen as the incongruent IAT block.

Figure 2.4 Example of a screenshot of the IAT 'Healthiness' during the third block where participants had to press a key on the left keyboard (S) whenever a 'healthy alternative' target image or a 'healthy' attribute word appeared on the screen. Whenever a 'regular product' target image or 'unhealthy' attribute word appeared, participants had to press the right key (L) to sort the images and words.

2.1.5 Procedure

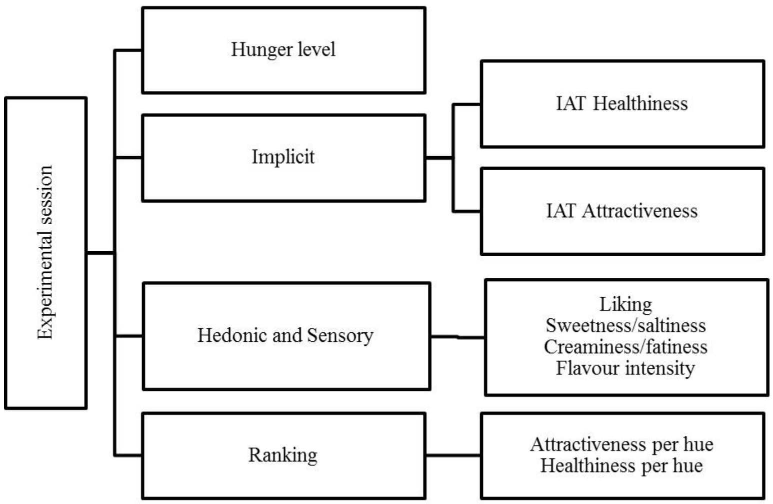

Figure 2.5 Schematic overview of a session experiment 1

Figure 2.5 shows an overview of the experimental procedure. Sessions took approximately 1 hour and were scheduled on a product consumption appropriate time of day *i.e.,* dairy drink during morning hours, sausage during afternoon hours. Participants received a monetary reward of €10.00 upon completion of the experiment. Participants indicated how hungry they were on a 100 mm Visual Analogue Scales (anchors "not at all" to "extremely"). Next, they performed the IAT presented on a PC using E-Prime2.0 software (Psychology Software Tools, Inc.). Implicit associations were collected through the 'Attractiveness' IAT (dairy drink *n*=83; sausage *n*=66) or 'Healthiness' IAT (dairy drink *n*=30; sausage *n*=29). Following the IAT, explicit information regarding liking and sensory expectations was collected by using Visual Analogue Scales (anchors: "not at all" to "extremely"), using Logic8 EyeQuestion software (version 3.16.14). Product packages were individually displayed in randomized order using a complete block design per product category. Liking and sensory questions were positioned below the package images.

2.1.6 Data analysis

Statistical analyses were carried out using SPSS (version 23; SPSS Inc., Chicago, IL, USA).
Effect sizes for IATs were calculated per participant. To investigate implicit associations between package images representing 'healthy alternatives/regular products' and words representing 'healthiness' (healthy versus unhealthy words) or 'attractiveness' (attractive versus unattractive words) response latencies and error rates were calculated. An effect size measure according to Greenwald et al. (2003) scoring algorithm and t-tests was used to test and compare strength of implicit associations.
To investigate effects of colour properties on expected hedonic and sensory responses, General Linear Model (GLM) analyses were carried out per product with *hue, brightness* and *saturation* as main factors in a 3 factor analysis of variance model. A Bonferroni correction was applied to avoid the inflated chance of a type-1 error. Participant was added as a random factor. The assumption of normal distribution of dependent variables was not violated as indicated by Kolmogorov-Smirnov and Levene's tests. Additionally controlling for BMI, gender and hunger levels at baseline did not change any of the reported findings. Therefore these variables were not further included in the reported analyses. Tukey post-hoc tests were conducted to further assess significant differences within each factor/interaction. Tests were performed two-sided and *p*-values below 0.05 were considered significant.

2.2. Results

2.2.1 Implicit associations

2.2.1.1 IAT Attractiveness

Response latencies for both product conditions (dairy drink, sausage) were faster when unattractive terms were combined with images of packages representing 'healthy alternatives', *i.e.,* packages coloured high in *brightness* and low in *saturation* (dairy drink mean: 771.85 milliseconds; sausage mean: 742.16 milliseconds) compared to combination of attractive terms and pictures of packages representing 'healthy alternatives' (dairy drink mean: 904.13; sausage mean: 1027.25 milliseconds). The effect size (D) was significantly different from zero for both product conditions (dairy drink: D=0.57, SD±0.78, t(82)=6.64, $p<0.001$; sausage: D=1.26 SD±0.76, t(64)=13.40, $p<0.001$).

2.2.1.2 IAT Healthiness

Faster response latencies were seen when healthy terms were combined with pictures of packages representing 'healthier alternatives' (dairy drink mean: 849.46 milliseconds; sausage mean: 946.70 milliseconds) compared to the combination of unhealthy terms and pictures representing 'healthy alternatives' (dairy drink mean: 1053.90; sausage mean: 994.51 milliseconds). Here the effect size (D) was significantly different from zero for the dairy drink but not for the sausage (dairy drink: D=0.67, SD±0.52, t(29)=7.12, $p<0.001$; sausage: D=0.12 SD±0.56, t(28)=1.11, $p=0.27$).

Results from both IATs suggest that participants have stronger implicit associations between package colouring in congruence with 'regular products', and 'attractiveness' and 'unhealthiness' than with 'unattractiveness' and 'healthiness'. For package colouring congruent with 'healthier alternatives', implicit associations were stronger with 'unattractiveness' and 'healthiness' than vice versa.

2.2.2 Explicit sensory and hedonic evaluation

Mixed model analysis (dependent variable: sensory attributes, fixed factors: *hue, brightness, saturation*, random factor: participant) yielded significant main effects for *hue*, *brightness* and *saturation* as well as significant 2-way interactions. Results are shown in Table 2.2. *Hue* affected all sensory properties, in that a red *hue* (a 'warmer' colour) yielded higher scores compared to blue (a 'cooler' colour) and purple *hue* for expected creaminess (F(2,308)=6.04, $p=0.003$), sweetness (F(2,1900)=337.57, $p<0.001$), and flavour intensity (F(2,1900)=133.57, $p<0.001$) for the dairy drink, and expected fattiness (F(2,309)=21.49, $p<0.001$) and flavour intensity (F(2,1486)=3.71, $p=0.025$) for the sausage. Increasing *brightness*[2] significantly decreased expected sweetness (F(1,1900)=30.226, $p<0.001$) and flavour intensity (F(1,1900)=68.23, $p<0.001$) for the dairy drink, and expected flavour intensity for the sausage (F(1,1486)=59.01, $p<0.001$). Increasing *saturation*[3] increased expectations of sweetness (F(1,1900)=260.15, $p<0.001$), and flavour intensity (F(1,1900)=398.33, $p<0.001$) for the dairy drink, and flavour intensity for the sausage (F(1,1486)=196.31, $p<0.001$).

For the dairy drink, an interaction effect was found for *hue*brightness*. Expected sweetness and flavour intensity were affected by *hue* and decreasing *brightness* levels. Red *hue* combined with low *brightness* yielded highest sweetness expectations (F(2,1900)=5.79, $p=0.003$). Regarding the dairy drink's expected flavour intensity, red *hue* combined with low *brightness* scored highest whereas the blue *hue* scored lowest (both high and low *brightness*) (F(2,1900)=6.54, $p=0.001$). In a similar way, red *hue* with high *saturation* affected expected sweetness (F(2,1900)=58.33, $p<0.001$) and flavour intensity (F(2,1900)=32.37, $p<0.001$) for the dairy drink, and expected flavour intensity for the sausage (F(2,1486)=27.15, $p<0.001$). Two-way interaction effects between *brightness*saturation* also reached statistical significance (sweetness (F(1900)=36.99, $p<0.001$); flavour intensity (F(1900)=47.50, $p<0.001$) dairy drink; , however these are hypothetical constructs that carry little meaning on its own, as the direction of the effect may differ depending on *hue*. No significant three-way interaction effects of *hue*brightness*saturation* were found.

[2] Brightness is the amount of white added to the image. High brightness is more closely related to 'healthy alternatives'.
[3] Saturation is the intensity of the colour in the image. High saturation is more closely related to 'regular products'.

Table 2.2 Means (±SD) of expected sensory attributes and liking per product and condition.

	Dairy drink ("Optimel Puur")								Sausage ("UNOX Extra magere rookworst")							
	Creaminess		Flavour intensity		Sweetness		Liking		Fattiness		Flavour intensity		Saltiness		Liking	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hue																
Blue	**46.00**^{a}	**(18.1)**	**45.55**^{a}	**(15.8)**	**39.99**^{a}	**(15.4)**	**51.17**^{b}	**(15.2)**	**29.21**^{a}	**(14.2)**	**47.01**^{a}	**(16.4)**	**25.21**^{a}	**(15.3)**	**48.15**^{b}	**(17.2)**
Purple/Green	**47.36**^{a}	**(15.5)**	**52.30**^{b}	**(16.3)**	**49.55**^{b}	**(16.8)**	**49.26**^{a}	**(16.1)**	**29.78**^{a}	**(14.0)**	**46.89**^{a}	**(17.3)**	**24.26**^{a}	**(14.6)**	**41.44**^{a}	**(18.7)**
Red	**50.79**^{b}	**(17.7)**	**55.50**^{c}	**(16.7)**	**56.75**^{c}	**(18.3)**	**52.16**^{b}	**(16.7)**	**36.43**^{b}	**(16.8)**	**48.59**^{b}	**(18.0)**	**27.93**^{b}	**(15.9)**	**47.46**^{b}	**(18.1)**
Brightness																
Low	48.57	(16.6)	**53.21**^{b}	**(16.6)**	**50.22**^{b}	**(18.6)**	**49.64**^{a}	**(16.0)**	32.49	(15.5)	**49.69**^{b}	**(17.0)**	25.74	(15.3)	**47.68**^{b}	**(18.0)**
High	47.53	(17.8)	**49.02**^{a}	**(16.7)**	**47.31**^{a}	**(17.7)**	**52.09**^{b}	**(16.0)**	31.11	(15.2)	**45.31**^{a}	**(17.3)**	25.86	(15.3)	**43.69**^{a}	**(18.3)**
Saturation																
Low	47.22	(17.0)	**46.05**^{a}	**(15.7)**	**45.50**^{a}	**(16.4)**	51.14	(15.7)	30.84	(15.2)	**43.51**^{a}	**(16.8)**	**25.39**^{a}	**(14.9)**	45.20	(17.5)
High	48.88	(17.4)	**56.18**^{b}	**(16.2)**	**53.03**^{b}	**(18.9)**	50.59	(16.2)	32.77	(15.5)	**51.49**^{b}	**(16.8)**	**26.22**^{b}	**(15.7)**	46.17	(19.0)
Hue * Brightness																
BlueLow	46.99	(18.1)	**46.45**^{a}	**(15.2)**	**40.17**^{a}	**(15.4)**	50.28	(14.7)	31.12	(15.0)	48.61	(16.7)	25.10	(15.0)	49.98	(16.8)
BlueHigh	45.00	(18.2)	**44.65**^{a}	**(16.3)**	**39.81**^{a}	**(15.4)**	52.07	(15.6)	28.29	(13.3)	45.40	(16.0)	25.33	(15.7)	46.31	(17.4)
Purple/GreenLow	47.52	(15.6)	**55.43**^{b}	**(15.8)**	**51.60**^{b}	**(17.0)**	48.36	(15.9)	31.66	(15.5)	49.20	(16.3)	24.35	(14.6)	42.96	(18.8)
Purple/GreenHigh	47.20	(15.5)	**49.18**^{c}	**(16.2)**	**47.50**^{c}	**(16.4)**	50.16	(16.3)	27.90	(12.3)	44.59	(17.9)	24.17	(14.6)	39.93	(18.5)
RedLow	51.19	(16.1)	**57.76**^{d}	**(15.5)**	**58.87**^{d}	**(18.3)**	50.28	(17.2)	35.69	(15.7)	51.25	(17.8)	27.78	(16.2)	50.09	(17.3)
RedHigh	50.39	(19.3)	**53.24**^{e}	**(16.5)**	**54.63**^{e}	**(18.1)**	54.05	(15.9)	37.17	(17.9)	45.94	(17.8)	28.09	(15.6)	44.83	(18.5)
Hue * Saturation																
BlueLow	45.30	(18.0)	**42.53**^{a}	**(14.7)**	**38.26**^{a}	**(14.7)**	**52.62**^{c}	**(14.5)**	27.90	(14.6)	**45.31**^{b}	**(16.2)**	25.11	(15.2)	**48.69**^{d}	**(16.8)**
BlueHigh	46.69	(18.3)	**48.57**^{b}	**(16.2)**	**41.72**^{b}	**(15.9)**	**49.72**^{a}	**(15.7)**	30.51	(13.7)	**48.70**^{c}	**(16.5)**	25.32	(15.4)	**47.33**^{d}	**(17.5)**
Purple/GreenLow	47.31	(14.6)	**47.98**^{b}	**(16.5)**	**46.75**^{c}	**(16.2)**	**50.12**^{ab}	**(16.0)**	29.03	(13.8)	**43.38**^{ab}	**(16.1)**	23.65	(13.9)	**44.78**^{c}	**(17.7)**
Purple/GreenHigh	47.41	(16.4)	**56.63**^{c}	**(14.9)**	**52.36**^{e}	**(17.1)**	**48.40**^{a}	**(16.2)**	30.52	(14.3)	**50.41**^{c}	**(17.6)**	24.88	(15.2)	**38.10**^{a}	**(19.1)**
RedLow	49.06	(18.3)	**47.65**^{b}	**(15.4)**	**48.50**^{d}	**(16.6)**	**50.67**^{b}	**(16.8)**	35.58	(16.0)	**41.82**^{a}	**(17.8)**	27.41	(15.3)	**41.84**^{b}	**(17.2)**
RedHigh	52.53	(17.0)	**63.35**^{d}	**(14.0)**	**65.00**^{f}	**(16.0)**	**53.65**^{c}	**(16.4)**	37.28	(17.6)	**55.36**^{d}	**(15.5)**	28.46	(16.4)	**53.08**^{e}	**(17.3)**
Brightness * Saturation																
LowLow	48.37	(15.1)	**49.90**^{b}	**(15.9)**	**47.56**^{b}	**(17.0)**	49.64	(15.9)	31.67	(15.1)	46.09	(16.6)	25.63	(15.0)	47.17	(17.5)
LowHigh	48.77	(18.1)	**56.53**^{c}	**(16.6)**	**52.87**^{c}	**(19.7)**	49.64	(16.1)	33.30	(15.9)	53.28	(16.5)	25.85	(15.7)	48.18	(18.4)
HighLow	46.08	(18.8)	**42.21**^{a}	**(14.6)**	**41.44**^{a}	**(15.3)**	52.64	(15.6)	30.00	(15.3)	40.92	(16.5)	25.14	(14.8)	43.22	(17.2)
HighHigh	48.98	(16.6)	**55.83**^{c}	**(15.9)**	**53.18**^{c}	**(18.1)**	51.55	(16.4)	32.24	(15.2)	49.69	(16.9)	25.58	(15.8)	44.17	(19.4)

Significant at $p<0.05$ effects visualized in **BOLD**

2.3. Discussion

The aim of experiment 1 was to investigate the effects of package colour cues (*hue, brightness* and *saturation*) on expected 'healthiness', 'attractiveness' and sensory expectations of food product properties.

In line with our hypotheses, package colour cues affected product expectations. Packages with less vibrantly, watered-down colouring as used for 'healthier alternatives' (*e.g.,* blue *hue*, high *brightness* and low *saturation*) were implicitly and explicitly perceived as healthier but less attractive than more vibrantly coloured packages representing 'regular products' (*e.g.,* red *hue*, low *brightness* and high *saturation*). Sensory expectations (*e.g.,* expected sweetness, flavour intensity) for packages representing 'healthier alternatives' were also decreased compared to other package variants.

Results regarding the effects of *hue*, *brightness* and *saturation* on sensory expectations revealed that red package colour (*hue*) created the highest expectations for sweetness, creaminess (dairy drink), fattiness (sausage) and flavour intensity (both products). Decreasing colour *brightness* increased expected sweetness intensity. For expectations regarding flavour intensity, altering *brightness* levels portrayed directional differences with regard to different product conditions. Increasing *brightness* increased expected flavour intensity for the dairy drink, but decreased expected flavour intensity for the sausage. In addition increasing colour *saturation* increased expected sweetness (dairy drink) and expected flavour intensity (both products). Especially combining red *hue* with low *brightness* and/or high *saturation* boosted expectations. Results are in line with (Strugnell, 1997) who also demonstrated that red coloured drinks tended to be judged sweetest, whereas blue coloured drinks were evaluated as least sweet. In general red *hue* generates strong expectations about certain foods *e.g.,* fruit, and this colour is often reported influencing sensory properties (Huang & Lu, 2015; Johnson & Clydesdale, 1982; Wei, Ou, Luo, & Hutchings, 2012). Previous research also confirms that highly *saturated* colours may boost perception of stimulus intensity (Becker, van Rompay, Schifferstein, & Galetzka, 2011; Koch & Koch, 2003; Piqueras-Fiszman & Spence, 2012a; Schifferstein & Tanudjaja, 2004; Schuldt, 2013; Spence, Levitan, Shankar, & Zampini, 2010) as demonstrated here by an effect on perceived flavour intensity. In addition to that (Piqueras-Fiszman & Spence, 2012a) demonstrated that 'warmer' coloured containers (*e.g.,* red/orange *hue*, low *brightness*/high *saturation*) increased sweetness perception and acceptance which is in line with our findings regarding sensory expectations. Results imply that not a single factor determines the impact of colour on sensory perception, but rather a combination of the three colour properties *hue*, *brightness* and *saturation*. These effects are however complex and may be product or sensory attribute specific.

Implicit results from the IATs reveal that package colouring representing 'healthier alternatives' was associated stronger with healthy terms and package colouring representing 'regular products' was associated stronger with attractive terms. These results indicate that certain package colour cues (*i.e.,* high *brightness,* low *saturation)* signal implicit associations regarding health, whereas other colour cues (*i.e.,* low *brightness,* high *saturation)* signal implicit associations regarding attractiveness.

3. Experiment 2

Experiment 2 investigated the effects of package colour properties on expected product evaluation by extending it to actual sensory evaluation (tasting) of the products.

3.1. Materials and Methods

Data were collected at Wageningen University (The Netherlands) and the experimental protocol was submitted and exempted from ethical approval by the Medical Ethical Committee of Wageningen University.

3.1.1 Participants

Participants (not participants of experiment 1) met the same in- and exclusion criteria as mentioned for experiment 1 (see 2.1.1.). In total, eighty-one consumers aged between 18 and 45 years old (mean BMI 21.8±1.8 kg/m^2) were selected and divided among 2 product conditions, 36 consumers (*n*=9 male) evaluated sweetness, creaminess, fruitiness and flavour intensity directly after tasting in the dairy drink condition, and 45 consumers (*n*=13 male) evaluated saltiness, fattiness and flavour intensity in the sausage condition.

3.1.2 Packages and products

Our primary research focus here was to investigate the effects of package colour cues on sensory perceptions of a product. For this purpose we selected a subset of eight packages (2D images) used in experiment 1, and transformed these into 3D 360 degrees rotating animations of the low-sugar yoghurt drink (in Dutch: Optimel Puur 'rode vruchten') and the low-fat sausage (In Dutch: Unox 'extra magere rookworst') by a professional graphic design agency (MisterWilson, Art Direction & Design, Amsterdam, The Netherlands). A 2x2x2 design was used for *hue* (blue and red for dairy drink and sausage), *brightness* level (high, low) and s*aturation* level (high, low). The same products were used as shown in the 3D animations, *i.e.,* a low-sugar dairy drink (In Dutch: Optimel Puur 'rode vruchten') and a low-fat sausage (in Dutch: Unox 'extra magere rookworst'). Two dummy products per product category were added to avoid boredom and suspicion towards the true research aim (dairy drink condition: Vifit 'Rode vruchten', Optimel Puur 'Bosvruchten'; sausage condition: Unox 'Gelderse rookworst, Slagershuis 'Gelderse rookworst').

3.1.3 Explicit sensory evaluation

Explicit information regarding actual sensory perception was collected in duplicate using a VAS of 100 mm. Sensory evaluation consisted of a sweetness, creaminess, fruitiness and flavour intensity evaluation for the dairy drink, and saltiness, fattiness, and flavour intensity evaluation for the sausage. Sensory anchors included "not at all" (left) and "extremely" (right). Product packages were displayed one by one, in randomized order and sensory questions were positioned below the package animations.

3.1.4 Procedure

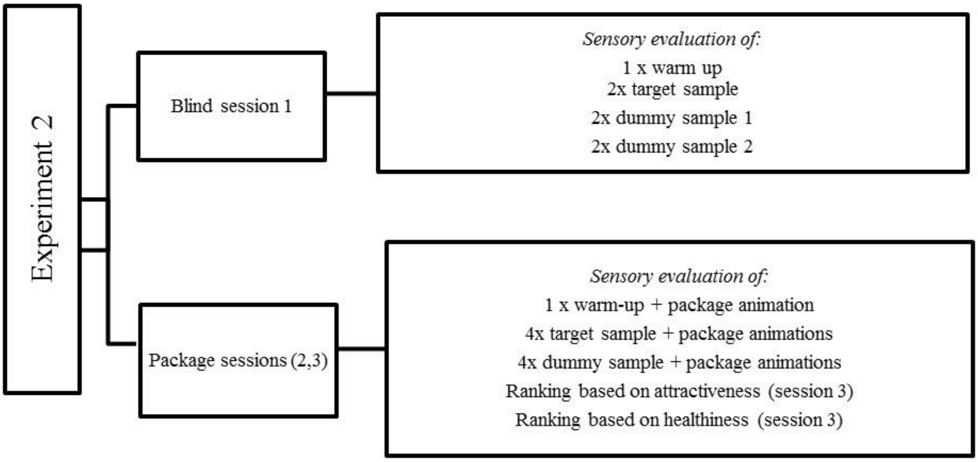

Figure 2.6 schematic overview of sessions of experiment 2

Figure 2.6 shows an overview of the experimental procedure. Three experimental tasting sessions (duration of 1 hour each) were conducted in the sensory lab of “Restaurant of the Future” located at Wageningen University. Sessions were scheduled on consumption appropriate times of day *i.e.,* dairy drink during morning hours, sausage during afternoon hours. Participants were instructed to refrain from eating, drinking coffee and smoking up to 2 hours before each session. Each session was separated by at least a two day period to avoid sensory fatigue and memory influences. Data were collected using Logic8 EyeQuestion software (version 3.16.14). Prior to session 1 participants were told a cover story (product reformulation combined with redesigned packaging) to prevent the true aim being uncovered. Participants were debriefed after the experiment and we checked to see whether participants uncovered the true aim using a questionnaire. If the true aim was uncovered, the participants’ data were excluded from all data analysis (less than 5%). Next to debriefing the participants, they also received a monetary reward of €40.00 after completing the experiment. At the beginning of each session hunger ratings were collected on a 100 mm VAS (anchors: “not at all” to “extremely”). Dairy drink samples (30 ml) were served in transparent cups (60 ml cups) at 7 °C. Participants were instructed to stir the samples with a plastic spoon before tasting. Packaged sausages were unpackaged and sliced (20 g), samples were served on small aluminium plates at 60°C and presented with a small plastic fork. All samples were coded (3-digit codes), served one by one in a randomized way using a complete block design, and could be consumed at libitum. Session 1 involved a blind tasting session where participants received target and dummy products in duplicate. Sessions 2 and 3 involved a combined package viewing and product tasting session where participants received the target product combined with all eight 3D package animations, as well as two dummy products with four out of the eight package animations each. Explicit information regarding actual sensory evaluations was collected using VAS in all sessions. The product sample was served, tasted and participants were asked to evaluate sensory attributes presented on the screen (session 1) or participants were instructed to look closely at the animation presented on the screen while tasting the product sample and afterwards evaluate sensory attributes positioned below the animation (sessions 2 and 3). Between each sample, during at least a 10 s break, participants were asked to clean their palate using water and/or crackers to avoid sensory fatigue and carry over effects.

3.1.5 Data analysis

Statistical analyses were carried out using SPSS (version 23; SPSS Inc., Chicago, IL, USA). The assumption of normal distribution of dependent variables was not violated, as indicated by Kolmogorov-Smirnov and Levene's tests. Additionally controlling for BMI, gender and hunger levels at baseline did not change any of the reported findings. Therefore these variables were not included further in the reported analyses.

To investigate effects of colour properties on actual sensory responses General Linear Model (GLM) analyses were carried out per product with *hue, brightness* and *saturation* as main factors in a 3 factor analysis of variance model. A Bonferroni correction was applied to avoid the inflated chance of a type-1 error. Participant was added as a random factor. Tukey post-hoc tests were conducted to further assess significant differences within each factor/interaction. Tests were performed two-sided and *p*-values below 0.05 were considered significant.

3.2. Results

Mixed model analysis (dependent variable: sensory attributes, fixed factors: *hue, brightness, saturation*, random factor: participant) yielded significant main effects for *hue*, *brightness* and *saturation* as well as significant 2-way interactions. Results are shown in Table 2.3. *Hue* significantly affected the dairy drinks' creaminess perception ($F(1,245)=5.00$, $p=0.03$) where red *hue* (a 'warmer' colour) scored lower on creaminess perception compared to blue *hue* (a 'cooler' colour). Increasing *brightness*[4] significantly decreased the sausages' perceived fattiness ($F(1,308)=4.50$, $p=0.05$) and flavour intensity ($F(1,308)=3.91$, $p=0.05$) while it increased dairy drinks' creaminess perception ($F(1,245)=4.72$, $p=0.03$). Increasing *saturation*[5] increased the dairy drinks' sweetness perception ($F(1,245)=5.01$, $p=0.03$).

A significant interaction effect for *hue*brightness* was found. Interestingly, red *hue* combined with high *brightness* increased perceived creaminess ($F(1,245)=5.71$, $p=0.02$) as well as perceived sweetness ($F(1,245)=8.59$, $p<0.01$) for the dairy drink. Directional differences were seen between *hue's* when *saturation* was increased with an increase in perceived creaminess for red *hue*, but decrease for blue *hue* ($F(1,245)=6.66$, $p=0.01$). A similar effect was observed for perceived flavour intensity of the dairy drink ($F(1,245)=4.87$, $p=0.03$). No significant interaction effects were observed in the sausage condition ($p>0.05$). Two-way interaction effects between *brightness*saturation* also became significant regarding flavour intensity of the sausage ($F(1,308)=4.11$, $p=0.04$), however these are hypothetical constructs that carry little

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[4] Brightness is the amount of white added to the image. High brightness is more closely related to 'healthy alternatives'.
[5] Saturation is the intensity of the colour in the image. High saturation is more closely related to 'regular products'.

meaning on its own, as they depended on the *hue*. No significant three-way interaction effects of *hue*brightness*saturation* were found.

3.3. Discussion

In experiment 2 we investigated effects of package colour cues (*hue, brightness, saturation*) on perceived sensory perception after tasting food products.

Consistent with our hypotheses, packages coloured congruently with 'regular products' (*i.e.,* red *hue*, low *brightness* and high *saturation*) were perceived more sweet, creamy and flavour intense in the dairy drink condition. A similar trend was seen in the sausage condition, however effects did not reach significance. Results regarding *hue, brightness* and *saturation* on sensory perception revealed that all factors influenced actual sensory perception of the dairy drink, while mainly *brightness* affected sensory perception of the sausage.

Interestingly altering *brightness* levels mainly influenced texture perception, in an inconsistent way. Less *bright* packages were actually perceived more fatty (sausage) and more *bright* packages were actually perceived more creamy (dairy drink). The latter association of higher *brightness* and creaminess seems plausible given that creaminess is a key attribute of dairy products, which are generally white or light coloured (Antmann, Ares, Salvador, Varela, & Fiszman, 2011). However, for the sausage product the texture association of lower *brightness* and fattiness is less clear.

Next to *brightness*, an effect of *saturation* on perceived flavour intensity was expected but not found. Literature states that highly *saturated* colours may boost perception of stimulus intensity (Becker et al., 2011; DuBose, Cardello, & Maller, 1980; Koch & Koch, 2003; Pangborn, 1960; Piqueras-Fiszman & Spence, 2012a; Schuldt, 2013; Spence et al., 2010; Zellner & Durlach, 2003). However, we did find an effect of *saturation* on sweetness, *i.e.,* increasing *saturation* increased sweetness perception. As 'flavour intensity' may be more difficult to grasp for consumers than 'sweetness', confusion or halo dumping effects may have occurred here.

In addition, red *hue* combined with high *saturation* increased perceived flavour intensity as well as sweetness and creaminess in the dairy drink. Schifferstein et al. (2013) suggested that consumers transfer packaging experience aspects directly to its content. Since flavour of the dairy drink is "red fruits" the fact that the more intensely (high *saturated*) red coloured packages boosted sensory perception was expected. Strangely this effect was not observed for the fruitiness perception. This could again indicate a 'halo-dumping' effect of fruitiness and flavour intensity perception on sweetness perception. Overall this package version (red *hue* and high *saturation*) was perceived differently from all other variants.

Results imply that not a single factor influences the impact of colour on sensory perception, but rather a combination of the colour properties. If one wants to boost sensory perception using external colour aspects, this combination of red *hue* and high *saturation* was most promising, this is in line with expectation data from experiment 1.

Table 2.3 Means (SD) of perceived sensory attributes per product and condition after tasting.

	Dairy drink ("Optimel Puur")								Sausage ("UNOX Extra magere rookworst")					
	Creaminess		Flavour intensity		Sweetness		Fruitiness		Fattiness		Flavour intensity		Saltiness	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hue														
Red	**50.26^{b}**	**(15.85)**	52.93	(13.79)	50.77	(15.85)	49.35	(14.82)	47.12	(15.75)	54.31	(16.22)	51.14	(17.06)
Blue	**46.73^{a}**	**(16.38)**	54.09	(15.25)	49.00	(15.86)	51.10	(16.42)	45.12	(15.26)	54.42	(14.65)	52.49	(16.08)
Brightness														
Low	**46.77^{a}**	**(14.48)**	53.40	(14.72)	49.17	(16.30)	50.13	(15.89)	**47.37^{b}**	**(15.54)**	**55.64^{b}**	**(15.21)**	51.82	(17.10)
High	**50.21^{b}**	**(14.61)**	53.62	(14.38)	50.60	(15.01)	50.32	(15.43)	**44.88^{a}**	**(15.44)**	**53.09^{a}**	**(15.60)**	51.80	(16.08)
Saturation														
Low	49.38	(16.17)	53.24	(15.10)	**48.21^{a}**	**(16.31)**	49.24	(16.31)	45.94	(15.53)	54.89	(14.70)	51.54	(16.55)
High	47.61	(16.21)	53.77	(13.98)	**51.56^{b}**	**(14.84)**	51.21	(14.92)	46.31	(15.54)	53.83	(16.17)	52.08	(16.64)
Hue * Brightness														
BlueLow	**46.90^{a}**	**(15.87)**	53.79	(15.91)	49.28	(16.72)	51.87	(16.93)	45.57	(14.41)	55.44	(14.22)	53.42	(16.64)
BlueHigh	**46.56^{a}**	**(16.98)**	54.50	(14.67)	49.06	(15.07)	50.34	(15.97)	44.68	(16.13)	53.39	(15.09)	51.55	(15.54)
RedLow	**46.65^{a}**	**(13.06)**	43.00	(13.54)	49.07	(15.99)	48.39	(14.69)	49.16	(16.47)	55.83	(16.22)	50.23	(17.48)
RedHigh	**53.87^{b}**	**(17.58)**	52.85	(14.14)	52.47	(14.83)	50.30	(14.99)	45.08	(14.80)	52.78	(16.17)	52.04	(16.68)
Hue * Saturation														
BlueLow	**49.65^{b}**	**(16.27)**	**55.92^{b}**	**(16.21)**	**49.51^{a}**	**(16.91)**	50.68	(17.76)	45.81	(15.70)	54.93	(13.93)	53.01	(15.67)
BlueHigh	**43.80^{a}**	**(16.07)**	**52.87^{ab}**	**(14.23)**	**48.48^{a}**	**(14.83)**	51.53	(15.07)	44.44	(14.85)	53.90	(15.40)	51.96	(15.55)
RedLow	**49.10^{b}**	**(16.18)**	**51.17^{a}**	**(13.70)**	**46.90^{a}**	**(15.70)**	47.80	(14.71)	46.07	(15.43)	54.85	(15.51)	50.07	(17.34)
RedHigh	**51.42^{b}**	**(15.53)**	**54.68^{ab}**	**(13.76)**	**54.63^{b}**	**(14.30)**	50.90	(14.87)	48.17	(16.07)	53.76	(16.98)	52.20	(16.81)
Brightness * Saturation														
LowLow	47.45	(14.77)	52.82	(15.84)	47.46	(17.55)	49.31	(16.69)	47.00	(15.18)	**57.47^{b}**	**(13.10)**	51.96	(16.72)
LowHigh	46.09	(14.25)	54.21	(13.58)	50.88	(14.88)	50.95	(15.12)	47.73	(15.96)	**53.80^{a}**	**(16.94)**	51.69	(17.56)
HighLow	51.30	(17.34)	53.91	(14.30)	48.96	(15.07)	49.17	(16.04)	44.87	(15.88)	**52.31^{a}**	**(15.79)**	51.12	(16.45)
HighHigh	49.13	(17.93)	53.34	(14.45)	52.24	(14.88)	51.48	(14.82)	44.89	(15.07)	**53.87^{a}**	**(15.45)**	52.47	(15.75)

Significant at $p<0.05$ effects visualized in **BOLD**

4. General Discussion

In this study we demonstrated that package colour properties influence consumers' product expectations as well as sensory perceptions of a product after tasting. More specifically, certain combinations of *hue, brightness* and *saturation* corresponding with less vibrantly, watered-down package colouring (*e.g.,* a whitish blue) were associated stronger in the minds of consumers with 'healthiness' as compared to 'attractiveness', and this influenced both sensory expectations and perceptions of the food products.

Overall, when looking at data from both experiments simultaneously it was clear that effects of the package colour were stronger for sensory expectations than for perceptions. It was also apparent that not a single colour property (*i.e., hue, brightness* or *saturation*) but rather a combination of these properties rendered packaging more attractive and/or increased sensory perception. Effects of package colour on product expectations and perceptions are however complex and may be product category specific (*e.g.,* effect of *brightness* on perceived flavour intensity for sausage, but not for the dairy drink) or sensory attribute specific (*e.g., brightness* increased creaminess expectations but not perceptions after tasting).

Where expectations are only based on visual stimuli and associations, perceptual data are also influenced by actual tasting of the product. Thus (visual) effects of package colour properties on sensory data may have been overruled by actual flavour perceptions, which explain the overall decreased effects of colour when it comes to actual perception. Since product choice in supermarkets is mainly based on visual cues, as tasting is often not possible at this stage, effects of expectations are initially important for product choice (Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013).

After this initial visual product evaluation, sensory evaluation follows. Here differences between sensory expectations and perceptions were large for some sensory attributes (*e.g.,* expected fattiness was higher than perceived fattiness for the sausage), while similar for others (*e.g.,* expected sweetness was similar to perceived sweetness for the dairy drink). Small differences between expectations and perception often tip the balance towards expectations (assimilation effect) which could be beneficial for the product image and brand. However, if the discrepancy between expectations and perception is too large, contrast effects can occur, which often result in disappointment (Davidenko et al., 2015; Sherif & Hovland, 1961; Deliza & MacFie, 1996).

A key aspect of expectations are learned associations, which come from previous experiences with similar products/situations and related memories (Higgs, 2015). Consumers learn to associate extrinsic cues (*e.g.,* package colour) with intrinsic product properties (*e.g.,* taste, flavour, mouthfeel) and post ingestion consequences. Several publications have mentioned that healthier *i.e.,* '*light'* products are considered less tasty than their regular variants (Hamilton et al., 2000; Mai & Hoffmann, 2014; Schuldt, 2013; Zandstra, De Graaf, & Van Staveren, 2001). Hence, the use of less vibrant, watered-down package colouring (as associated by the consumer with '*light*' or healthy products) may serve as a warning sign, albeit unconscious, for those who are focused on the immediate sensory pleasantness/reward of the product rather than healthiness (Liem, Toraman Aydin, & Zandstra, 2012; Mai et al., 2016). Using the learned associations regarding 'regular product' packaging to improve expectations/associations related to 'healthier alternatives' may (1) improve product expectations and (2) could be used to get around existing learned associations. However, the results of the present study are based on single exposures only and future research should investigate long term (repeated exposure) effects as well. Marketing could, and sometimes already does, apply these kinds of associative principles when designing packaging that communicates a certain message (here: attractiveness).

There are some strengths and limitations of the two studies reported here that are worthwhile to discuss. To our knowledge this is the first study that systematically investigated the effects of three different colour dimensions (*hue, brightness and saturation*) on both expectations with regard to specific product properties, as well as product perception in terms of taste, flavour, perceived healthiness and perceived attractiveness. Previous studies either focused on colour (read *hue*) as a unitary concept or on sensory expectations and perception after tasting separately, overlooking potential (mis)matches between expectations and perception (Bottomley, 2006; DuBose et al., 1980; Gutjar et al., 2014; Huang & Lu, 2015; Koch & Koch, 2003; Pangborn, 1960; Piqueras-Fiszman & Spence, 2012a; Schuldt, 2013; Maya U. Shankar, Levitan, Prescott, & Spence, 2009; Shankar et al., 2010; Spence et al., 2010; Zellner, 2013; Zellner & Durlach, 2003). The approach that we followed resulted in better insights in the interrelationship between expected and perceived product properties, although the design of the experiments does not allow us to directly assess if perceptions were influenced by expectations in this particular case as we used a between-subjects design. In addition, we assessed product expectations and associations related to healthiness and attractiveness using both implicit and explicit measures. This clarifies potential discrepancies between consumers' conscious and unconscious associations, attitudes and motivations that shape preferences and food choice behaviour.

To investigate implicit associations, we used commercially available products, since real brands may better capture and predict product perception (Ares, Mawad, Giménez, & Maiche, 2014). Similarly consumers of the products were included to capture existing learned implicit associations even though these users may not have benefited the most from this 'nudge'. They often already consider healthier alternatives of foods irrespective of their product properties (due to active health goals), and are familiar with the product category and therefore depend less on external cues when evaluating the product (Deliza & MacFie, 2001). Nevertheless we were interested in existing associations and for this reason chose consumers rather than non-consumers who may be more susceptible to this 'nudge'. Additionally, our population was skewed towards females with a normal BMI, and may be more health oriented than other populations due to these participant characteristics and for that reason may hold less strong intuitions that 'healthy is not tasty'. Still, based on the present results in this population, one might expect the effects will be similar or stronger in less health oriented populations who may be more in need of nudges towards healthier choices, but this clearly needs further investigation.

Finally, we used a between-subjects design in both experiments. This has the disadvantage of being less powerful than a within-subjects design in which the same group of subjects serves in more than one condition. However, we decided to use two independent groups to avoid carry-over effects of expectations on actual perception, which would have confounded the results.

For future studies it would be interesting to investigate expectations as well as perception using a within-subject design.

As stated previously, the findings of the present study have implications for the use of package colouring as a nudge to make the healthier choice the easier one or more attractive one. There are, however, some important remaining questions regarding persistency, robustness and consistency. The first, persistency, relates to the question whether effects remain stable across product types or over repeated exposure or choice, or fade out over time. The second, robustness relates to the universality of the nudge across product categories. It would also be interesting to investigate if '*light*' or healthier products are perceived less healthy, or for instance, are less easily recognized and identified as 'light' products by consumers when packages are coloured vibrantly compared to an existing less vibrantly coloured package version. Similarly, investigating if opposite effects of the nudge also occur when using regular products would also aid robustness of the effects and would thus be an interesting future research topic. The third, consistency, refers to what extent colour dimensions such as *hue, brightness* and *saturation*, have universal meaning, and to what extend other package elements affect colour influences. To illustrate this, colour (*hue*) can carry different meanings in different cultures (Amsteus, Al-Shaaban, Wallin, & Sjöqvist, 2015; Kauppinen - Räisänen, 2014; Singh, 2006; Wąsowicz, Styśko-Kunkowska, & Grunert, 2015), and is likely product (category) or context specific (van Rompay et al., 2016). However, there seem to be some general patterns in use of colouring in package design as well, where moving towards a less vibrantly coloured, watered-down versions of the packaging of regular variants is common practice. As shown in this study, this affects consumers' product expectations and perception in a manner that seems undesirable. Other elements, *e.g.,* shape, brand, materials, price and labels can also affect product expectations (Ares & Deliza, 2010; Aschemann-Witzel et al., 2013; Huang & Lu, 2015; Piqueras-Fiszman & Spence, 2012,b; Spence & Gallace, 2011) and since product evaluation is not merely based on colour cues alone we believe other elements may interact with colour cues in defining the ultimate message that the package is signalling. For example; packaging material can aid to credence of a health message. Where cardboard packaging (*i.e.,* yoghurt drink) may aid to the credence of healthy packaging cues, a plastic packaging (*i.e.,* sausage) may actually diminish credence of this same cue. This is certainly an area for future research.

5. Conclusion

Package colour cues appear to communicate a certain message to the consumer, where use of less vibrant, watered-down colouring is more strongly associated with 'healthiness' compared to 'attractiveness'. Presenting product packages that mimic colouring of 'regular products' *i.e.,* warmer, less *bright* and more *saturated* coloured packages while consumers sample healthier (low sugar and low fat) products, explicitly enhanced sensory expectations and implicitly improves attractiveness, rendering products more appealing to consumers. Although these results may not apply to all products or packages our findings highlight the potential of package colour cues as *nudges* to make the healthier alternative more attractive and provide important implications for the design and experience of packages.

References

Amsteus, M., Al-Shaaban, S., Wallin, E., & Sjöqvist, S. (2015). Colors in Marketing: A Study of Color Associations and Context (in) Dependence. International Journal of Business and Social Science, 6(3).

Antmann, G., Ares, G., Salvador, A., Varela, P., & Fiszman, S. M. (2011). Exploring and Explaining Creaminess Perception: Consumers' Underlying Concepts. Journal of Sensory Studies, 26(1), 40-47.

Ares, G., & Deliza, R. (2010). Studying the influence of package shape and colour on consumer expectations of milk desserts using word association and conjoint analysis. Food Quality and Preference, 21(8), 930-937.

Ares, G., Mawad, F., Giménez, A., & Maiche, A. (2014). Influence of rational and intuitive thinking styles on food choice: Preliminary evidence from an eye-tracking study with yogurt labels. Food Quality and Preference, 31, 28-37.

Arno, A., & Thomas, S. (2016). The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis. BMC Public Health, 16(1), 676.

Aschemann-Witzel, J., Grunert, K. G., van Trijp, H. C., Bialkova, S., Raats, M. M., Hodgkins, C., Koenigstorfer, J. (2013). Effects of nutrition label format and product assortment on the healthfulness of food choice. Appetite, 71, 63-74.

Aslam, M. M. (2006). Are You Selling the Right Colour? A Cross-cultural Review of Colour as a Marketing Cue. Journal of Marketing Communications, 12(1), 15-30.

Beatty, S. E., Homer, P., & Kahle, L. R. (1988). The Involvement Commitment Model - Theory and Implications. Journal of Business Research, 16(2), 149-167.

Becker, L., van Rompay, T. J. L., Schifferstein, H. N. J., & Galetzka, M. (2011). Tough package, strong taste: The influence of packaging design on taste impressions and product evaluations. Food Quality and Preference, 22(1), 17-23.

Blumenthal-Barby, J. S., & Burroughs, H. (2012). Seeking Better Health Care Outcomes: The Ethics of Using the "Nudge". The American Journal of Bioethics, 12(2), 1-10.

Bottomley, P. A. (2006). The interactive effects of colors and products on perceptions of brand logo appropriateness. Marketing Theory, 6(1), 63-83.

Bucher, T., Collins, C., Rollo, M. E., McCaffrey, T. A., De Vlieger, N., Van der Bend, D., . . . Perez-Cueto, F. J. (2016). Nudging consumers towards healthier choices: a systematic review of positional influences on food choice. Br J Nutr, 115(12), 2252-2263.

Chapman, G., & Maclean, H. (1993). "Junk food" and "healthy food": meanings of food in adolescent women's culture. Journal of Nutrition Education, 25(3), 108-113.

Chrysochou, P., Askegaard, S., Grunert, K. G., & Kristensen, D. B. (2010). Social discourses of healthy eating. A market segmentation approach. Appetite, 55(2), 288-297.

Clarke, T., & Costall, A. (2008). The emotional connotations of color: A qualitative investigation. Color Research and Application, 33(5), 406-410.

Croll, J. K., Neumark-Sztainer, D., & Story, M. (2001). Healthy eating: what does it mean to adolescents? Journal of Nutrition Education, 33(4), 193-198.

Davidenko, O., Delarue, J., Marsset-Baglieri, A., Fromentin, G., Tome, D., Nadkarni, N., & Darcel, N. (2015). Assimilation and Contrast are on the same scale of food anticipated-experienced pleasure divergence. Appetite, 90, 160-167.

Deliza, R., & MacFie, H. (2001). Product packaging and branding. Food, people and society (pp. 55-72). Springer Berlin Heidelberg.

Deliza, R., & MacFie, H. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: A review. Journal of Sensory Studies, 11(2), 103-128.

DuBose, C.N., Cardello, A. V., & Maller, O. (1980). Effects of Colorants and Flavorants on Identification, Perceived Flavor Intensity, and Hedonic Quality of Fruit-Flavored Beverages and Cake. Journal of Food Science, 45(5), 1393-1399.

Garber, L.L., Hyatt, E. M., & Starr, R. G. (2003). Measuring consumer response to food products. Food Quality and Preference, 14(1), 3-15.

Greenwald, A. G., McGhee, D. E., & Schwartz, L. K. (1998). Measuring individual differences in implicit cognition: The implicit association task. Journal of Personality and Social Psychology, 74(6), 1464-1480.

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the Implicit Association Test: An improved scoring algorithm. Journal of Personality and Social Psychology, 85(2), 197-216.
Grossman, R. P., & Wisenblit, J. Z. (1999). What we know about consumers' color choices. Journal of Marketing Practice: Applied Marketing Science, 5(3), 78-88.
Gutjar, S., de Graaf, C., Palascha, A., & Jager, G. (2014). Food choice: The battle between package, taste and consumption situation. Appetite, 80, 109-113.
Hamilton, J., Knox, B., Hill, D., & Parr, H. (2000). Reduced fat products – Consumer perceptions and preferences. British Food Journal, 102(7), 494-506.
Higgs, S. (2015). Cognitive processing of food rewards. Appetite, 104, 10-17.
Hogg, J. (1969). Psychology and the visual arts: selected readings. Harmondsworth, Penguin.
Huang, L., & Lu, J. (2015). The Impact of Package Color and the Nutrition Content Labels on the Perception of Food Healthiness and Purchase Intention. Journal of Food Products Marketing, 1-29.
Ishihara, S. (1951). Tests for colour-blindness (10th completely rev. ed.). Tokyo: Nippon Isho Shuppan Co.
Johnson, J. & Clydesdale, F. (1982). Perceived Sweetness and Redness in Colored Sucrose Solutions. J Food Science, 47(3), 747-752.
Johnson, J., Shu, S., Dellaert, B., Fox, C., Goldstein, D., Häubl, G.,Weber, E. (2012). Beyond nudges: Tools of a choice architecture. Marketing Letters, 23(2), 487-504.
Kahneman, D. (2012). Thinking, fast and slow: Farrar, Straus and Giroux.
Kauppinen-Räisänen, H. (2014). Strategic use of colour in brand packaging. Packaging Technology and Science, 27(8), 663-676.
Kauppinen-Räisänen, H., & Luomala, H. T. (2010). Exploring consumers' product-specific colour meanings. Qualitative Market Research: An International Journal, 13(3), 287-308.
Koch, C., & Koch, E. C. (2003). Preconceptions of taste based on color. The Journal of Psychology, 137(3), 233-242.
Kosters, M., & Van der Heijden, J. (2015). From mechanism to virtue: Evaluating Nudge theory. Evaluation, 21(3), 276-291
Lee, W., Shimizu, M., Kniffin, K. M., & Wansink, B. (2013). You taste what you see: Do organic labels bias taste perceptions? Food Quality and Preference, 29(1), 33-39.
Liem, D. G., Toraman Aydin, N., & Zandstra, E. H. (2012). Effects of health labels on expected and actual taste perception of soup. Food Quality and Preference, 25(2), 192-197.
Mai, R., & Hoffmann, S. (2014). How to combat the Unhealthy = tasty intuition: the influencing role of health consciousness. Journal of Public Policy & Marketing, 34(1), 63-68.
Mai, R., & Hoffmann, S. (2012). Taste lovers versus nutrition fact seekers: How health consciousness and self-efficacy determine the way consumers choose food products. Journal of Consumer Behaviour, 11(4), 316-328.
Mai, R., Symmank, C., & Seeberg-Elverfeldt, B. (2016). Light and Pale Colors in Food Packaging: When Does This Package Cue Signal Superior Healthiness or Inferior Tastiness? Journal of Retailing.
Marteau, T. C. F. p. d. J. (2011). Judging nudging: can nudging improve population health? BMJ: British Medical Journal, 342(7791), 263-265.
Ng, M., Chaya, C., & Hort, J. (2013). The influence of sensory and packaging cues on both liking and emotional, abstract and functional conceptualisations. Food Quality and Preference, 29(2), 146-156.
Oliver, A. (2011). Is nudge an effective public health strategy to tackle obesity? Yes. BMJ, 342, d2168.
Pangborn, R. M. (1960). Influence of color on the discrimination of sweetness. The American journal of psychology, 73(2), 229-238.
Papies, E. K. (2012). Goal Priming in Dieters: Recent Insights and Applications. Curr Obes Rep, 1(2), 99-105.
Piqueras-Fiszman, B., & Spence, C. (2012a). The Influence of the Color of the Cup on Consumers' Perception of a Hot Beverage. Journal of Sensory Studies, 27(5),
Piqueras-Fiszman, B., & Spence, C. (2012b). The influence of the feel of product packaging on the perception of the oral-somatosensory texture of food. Food Quality and Preference, 26(1), 67-73.
Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. Food Quality and Preference, 40, 165-179.

Povey, R., Conner, M., Sparks, P., James, R., & Shepherd, R. (1998). Interpretations of healthy and unhealthy eating, and implications for dietary change. Health Education Research, 13(2), 171-183.
Priluck Grossman, R., & Wisenblit, J. Z. (1999). What we know about consumers' color choices. Journal of Marketing Practice: Applied Marketing Science, 5(3), 78-88.
Raghunathan, R., Walker Naylor, R., & Hoyer, W. D. (2006). The unhealthy is tasty intuition and its effect on taste inferences enjoyment and choice of food products. Journal of Marketing, 70, 170-184.
Roininen, K., Tuorila, H., Zandstra, E., De Graaf, C., Vehkalahti, K., Stubenitsky, K., & Mela, D. (2001). Differences in health and taste attitudes and reported behaviour among Finnish, Dutch and British consumers: a cross-national validation of the Health and Taste Attitude Scales (HTAS). Appetite, 37(1), 33-45.
Selinger, E., & Whyte, K. (2011). Is There a Right Way to Nudge? The Practice and Ethics of Choice Architecture. Sociology Compass, 5(10), 923-935
Schifferstein, Fenko, A., Desmet, P. M., Labbe, D., & Martin, N. (2013). Influence of package design on the dynamics of multisensory and emotional food experience. Food Quality and Preference, 27(1), 18-25.
Schifferstein, H. N. J., & Tanudjaja, I. (2004). Visualising fragrances through colours: The mediating role of emotions. Perception, 33(10), 1249-1266.
Schuldt, J. P. (2013). Does green mean healthy? Nutrition label color affects perceptions of healthfulness. Health Communication, 28(8), 814-821.
Schuldt, J. P., & Hannahan, M. (2013). When good deeds leave a bad taste. Negative inferences from ethical food claims. Appetite, 62, 76-83.
Shankar, M. U., Levitan, C. A., Prescott, J., & Spence, C. (2009). The Influence of Color and Label Information on Flavor Perception. Chemosensory Perception, 2(2), 53-58.
Shankar, M. U., Levitan, C. A., & Spence, C. (2010). Grape expectations: the role of cognitive influences in color-flavor interactions. Consciousness and Cognition, 19(1).
Sherif, M., & Hovland, C. I. (1961). Social judgment: Assimilation and contrast effects in communication and attitude change.
Silayoi, P., & Speece, M. (2004). Packaging and purchase decisions. British Food Journal, 106(8), 607-628.
Singh, S. (2006). Impact of color on marketing. Management Decision, 44(6), 783-789.
Spence, C., & Gallace, A. (2011). Tasting shapes and words. Food Quality and Preference, 22(3), 290-295.
Spence, C., Levitan, C. A., Shankar, M. U., & Zampini, M. (2010). Does Food Color Influence Taste and Flavor Perception in Humans? Chemosensory Perception, 3(1), 68-84.
Stroebe, W., Mensink, W., Aarts, H., Schut, H., & Kruglanski, A. W. (2008). Why dieters fail: Testing the goal conflict model of eating. Journal of Experimental Social Psychology, 44(1), 26-36.
Stroebe, W., van Koningsbruggen, G. M., Papies, E. K., & Aarts, H. (2013). Why most dieters fail but some succeed: a goal conflict model of eating behavior. Psychol Rev, 120(1).
Strugnell. (1997). Colour and its Role in Sweetness Perception. Appetite, 28(1), 85.
Sugden, R. (2009). On Nudging: A Review ofNudge: Improving Decisions About Health, Wealth and Happinessby Richard H. Thaler and Cass R. Sunstein. International Journal of the Economics of Business, 16(3), 365-373
Thaler, R. H., & Sunstein, C. R. (2008). Nudge : improving decisions about health, wealth, and happiness. New Haven: Yale University Press.
Thaler, R. H., & Sunstein, C. R. (2009). Nudge : improving decisions about health, wealth, and happiness. New York, NY [etc.]: Penquin Books.
Vallgarda, S. (2012). Nudge: a new and better way to improve health? Health Policy, 104(2), 200-203.
van der Laan, L. N., de Ridder, D. T., Viergever, M. A., & Smeets, P. A. (2011). The first taste is always with the eyes: a meta-analysis on the neural correlates of processing visual food cues. Neuroimage, 55(1), 296-303.
van Rompay, T. J. L., Deterink, F., & Fenko, A. (2016). Healthy package, healthy product? Effects of packaging design as a function of purchase setting. Food Quality and Preference, 53, 84-89.
Wąsowicz, G., Styśko-Kunkowska, M., & Grunert, K. G. (2015). The meaning of colours in nutrition labelling in the context of expert and consumer criteria of evaluating food product healthfulness. Journal of health psychology, 20(6), 907-920.

Wei, S.-T., Ou, L.-C., Luo, M. R., & Hutchings, J. B. (2012). Optimisation of food expectations using product colour and appearance. Food Quality and Preference, 23(1), 49-62
Wexner, L. B. (1954). The degree to which colors (hues) are associated with mood tones. Journal of Applied Psychology, 38(6).
Wilson, A. L., Buckley, E., Buckley, J. D., & Bogomolova, S. (2016). Nudging healthier food and beverage choices through salience and priming. Evidence from a systematic review. Food Quality and Preference, 51, 47-64.
Wright, B., & Rainwater, L. (1962). The Meanings of Color. Journal of General Psychology, 67(1), 89-99.
Zandstra, E., De Graaf, C., & Van Staveren, W. (2001). Influence of health and taste attitudes on consumption of low-and high-fat foods. Food Quality and Preference, 12(1), 75-82.
Zellner, D. A. (2013). Color–Odor Interactions: A Review and Model. Chemosensory Perception, 6(4), 155-169.
Zellner, D. A., & Durlach, P. (2003). Effect of color on expected and experienced refreshment, intensity, and liking of beverages. American Journal of Psychology, 116(4), 633-648.

Chapter 3

Colouring perception: Package colour cues affect neural responses to sweet dairy drinks in reward and inhibition related regions

Irene O.J.M. Tijssen
Paul A.M. Smeets
Robert P.G. Goedegebure
Elizabeth. H. Zandstra
Cees de Graaf
Gerry Jager

Submitted

Abstract

Extrinsic product cues, *e.g.,* package colour, give rise to expectations and may change product perception and perceived reward value during product evaluation. Healthier foods (*i.e.,* 'light', sugar- or fat-reduced) are often differently packaged than regular products (*i.e.,* less vibrantly coloured vs. more vibrantly coloured respectively). People vary in their degree of health interest and self-control and may be affected differently by these package colour cues. The current study aims to assess the extent to which package colour cues and participant characteristics interact and influence product perception and brain responses.

Thirty-four healthy females performed an event-related functional MRI task in which they viewed four differently coloured packages (*i.e.,* regular vs. healthier; subtly differing in brightness and saturation levels) with or without simultaneously tasting two sweet dairy drinks (*i.e.,* regular vs. healthier calorie-reduced drink, incorporating 20% water).

Results indicate enhanced activation in an inhibitory control region (inferior frontal gyrus) and reward related region (striatum) for regular packages compared to the healthier packages, the latter even more so as participants' health interest increased (r = 0.43). Incongruent package-taste combinations decreased reward value (orbitofrontal cortex (OFC) activation) compared to congruent combinations. Tasting the healthier compared to regular product resulted in enhanced activation in inhibitory control (middle, superior frontal gyrus) as well as reward related regions (striatum, OFC), suggesting a cognitively driven preference for the healthier product.

In conclusion, package colour and taste properties may modulate neural correlates of reward and inhibition. Individual differences in health interest and impulsivity influence package and taste related neural correlates and thus underscore the importance of taking participant characteristics into account in food research. This paper provides evidence for the mechanisms and conditions under which these effects operate.

1. Introduction

At the basis of food preference lies the attractiveness of intrinsic food properties such as the taste and flavour of a product (Clark 1998). However, at the point of purchase, extrinsic food properties such as packaging or labelling are leading determinants of food choice since intrinsic food properties cannot be evaluated properly at this stage (Schifferstein, Fenko et al. 2013). There is accumulating behavioural evidence that extrinsic food properties can influence taste perception (Ng, Chaya et al. 2013, Gutjar, de Graaf et al. 2014, Piqueras-Fiszman and Spence 2015, Tijssen, Zandstra et al. 2017).

We recently demonstrated that package colour properties not only influence product expectations but also actual flavour perception of a product after tasting (Tijssen, Zandstra et al. 2017). Certain combinations of hue, brightness and saturation corresponding with more vibrant package colouring (*i.e.,* high saturation, low brightness) were perceived as most attractive and least healthy which influenced both sensory expectations and flavour perception. Effects seen in behavioural studies may be driven by reward and inhibitory control processes in the brain, which is the focus of the present study.

The orbitofrontal cortex (OFC), anterior cingulate cortex (ACC) and amygdala encode reward value of foods and the striatum (putamen, caudate nucleus, nucleus accumbens) and ventral and dorsolateral prefrontal (dlPFC) areas are involved in reward anticipation, inhibitory control and reinforcement learning (Berridge 1996, O'Doherty, Deichmann et al. 2002, Aron 2007, Rolls 2011, Rolls 2015). The frontal operculum and anterior insula, which contain the primary taste cortex have been shown to differentiate between objective qualities of taste, *i.e.,* taste identity and intensity (Rolls 2011).

Little is known about the effect of expectations on the neural correlates of taste perception. Studies that investigate expectation-based effects of (in)congruent verbal labels on taste perception and reward processing using functional magnetic resonance imaging (fMRI) indicate bottom-up (sensory/associative) expectancy driven modulations of verbal taste descriptors (*e.g.,* “very sweet” and “less sweet”) on activation in taste related areas such as the anterior insula and frontal operculum (Nitschke, Dixon et al. 2006, Veldhuizen, Douglas et al. 2011, Woods, Lloyd et al. 2011). Bottom-up expectancy driven modulations of hedonic and health descriptors (*e.g.,* “treat” and “healthy”) is less conclusive (Grabenhorst, Rolls et al. 2008, Veldhuizen, Nachtigal et al. 2013). Evidence for top-down (cognitive) effects of verbal hedonic and health descriptors as well as brand and price cues in reward and attention related areas is growing (*e.g.,* OFC, striatum, ACC, inferior frontal gyrus, amygdala, ventromedial prefrontal cortex (vmPFC)) (McClure, Li et al. 2004, de Araujo, Rolls et al. 2005, Plassmann, O'Doherty et al. 2008, Veldhuizen, Douglas et al. 2011, Grabenhorst, Schulte et al. 2013, Kuhn and Gallinat 2013, Okamoto and Dan 2013).

Research on expectancy driven neural modulations of product perception mostly uses clear, rather obvious, verbal, visual descriptors emphasising taste or hedonic properties. Yet in reality, expectancy driven modulations likely follow less obvious, subconscious and non-verbal cues. It remains to be seen to what extent the abovementioned research findings translate to more unconscious, less obvious non-verbal cues such as package “impression” that is associated with certain degrees of healthiness or attractiveness. Investigating more realistic and subtle expectancy driven modulations can give better insights into the effects of these subtle everyday cues on perception and neural correlates.

The present study primarily aims to explore the neural correlates of subtle extrinsic cues (*i.e.,* healthiness and attractiveness related features signalled through package colour) combined with intrinsic properties (*i.e.,* the flavour of a dairy drink) to determine the neural mechanisms behind expectation influencing taste perception and food hedonics. The study aims to find out to what extent such effects are mediated via bottom-up pathways or via top-down pathways. A priori regions of interest included taste related brain regions, *i.e.,* primary and secondary taste cortex (anterior insula/frontal operculum, OFC), as well as reward, salience and inhibition related regions, including the amygdala, (pre)frontal cortex (including OFC, vmPFC, dlPFC), striatum and anterior cingulate cortex (ACC).

In addition, behavioural and neuroimaging research has shown that health-related product cues affect consumers differently depending on personal characteristics. Neural susceptibility to hedonic or health cues in reward regions (OFC, ACC, striatum) can depend on BMI, inhibitory control and health interest (Zandstra, de Graaf et al. 2001, Guerrieri, Nederkoorn et al. 2007, Veldhuizen, Nachtigal et al. 2013, van Rijn, Wegman et al. 2017). Maintaining a healthy lifestyle may involve a goal of healthy eating. This requires a certain degree of inhibitory-control, *i.e.,* exerting effort to withhold from unwanted behaviour. Having a goal to eat healthy may induce a cognitively driven preference for healthy options as opposed to a stimulus driven preference for unhealthy options (van Rijn, Wegman et al. 2017).

Our secondary aim was to investigate whether neural activation in response to processing of packaging cues is modulated by inhibitory control (Patton and Stanford 1995) and attitudes towards health and taste (Roininen, Lahteenmaki et al. 1999).

Based on the findings described above, we predicted that package colour cues will influence product expectations and taste perception, where more vibrantly coloured packages (*i.e.,* low brightness, high saturation) enhance activation through top-down pathways in reward related brain regions such as the OFC, ACC, striatum and amygdala. We also expected that top-down effects would be different depending on personal characteristics, in particular, health-mindedness may induce a cognitively driven preference for the healthier option in brain regions where integration of cognitive and stimulus driven cues takes place such as the striatum, amygdala, OFC and ACC. The degree of trait impulsiveness may play a role in brain activation, with (‘hard to resist’) vibrantly coloured packages decreasing activation in inhibition related regions (PFC, *i.a.* inferior frontal gyrus) compared to less vibrantly coloured packages.

2. Materials and methods

2.1 Participants, screening and training

39 Dutch healthy (self-report) female participants were recruited to participate in the study. Five participants were excluded because of data loss as result of technical difficulties concerning the MRI. Data of 34 participants (aged 18-35 years, mean=21.7, ±SD=2.4, all right

handed, BMI mean=21.9, ±SD=1.3) were analysed. All participants were familiar with the used product category and not colour blind (tested using Ishihara's colour test (Ishihara 1951)). Participants did not have stomach or bowel diseases, did not have any psychiatric, neurological disorders or other relevant medical history that would affect the results of the study (*e.g.,* chronic diseases such as diabetes, thyroid- or kidney disease, taste or smell disorders, allergies/intolerances for products under study, were not pregnant or lactating), did not use daily medication other than oral contraceptives, paracetamol or H1-antihistaminergic drugs, did not smoke more than one cigarette/cigar a day, did not have a history or current alcohol consumption of more than 21 units per week, did not change in body weight (more than 5 kg) or follow an energy restricted diet during the past two months and had no contra-indications for MRI scanning (*e.g.,* pacemaker). Before enrolment participants were screened on inclusion and exclusion criteria via a questionnaire, gave written informed consent and received monetary reimbursement for their participation (€65,-). The study was conducted in accordance with the Declaration of Helsinki (amendment of Fortaleza) (World Medical 2013), approved by the Medical Ethical Committee of Wageningen University and registered in the Dutch Trial Registry (NTR5899).

2.2 Stimuli

Four package stimuli, adopted from Tijssen et al., (2017) were used. Stimuli were based on a previously commercially available dairy drink 'Optimel Puur Rode Vruchten' (Royal FrieslandCampina, Amersfoort, The Netherlands) and differed in hue (blue and red), brightness (high vs. low) and saturation (high vs. low) levels signalling more/less healthy product properties. Two package stimuli were chosen to represent healthier packages (*e.g.,* 'light', sugar- or fat-reduced) and two to represent regular package*s* (Figure 3.1).

Figure 3.1 Package stimuli, signaling healthy and regular product properties, varying in hue and levels of brightness and saturation. The usage of package stimuli was permitted by, and cleared with, Royal FrieslandCampina, Amersfoort, The Netherlands.

Two tasted product stimuli were used: 1) the regular product taste stimulus was a commercially available sweet (white coloured) dairy drink 'Vifit Rode Vruchten' (Royal FrieslandCampina, Amersfoort, The Netherlands) and 2) the healthier product taste stimulus was a mix of this dairy drink and tap water (ratio of 4:1 g dairy drink to tap water). Due to the decrease in caloric, and sugar content, we perceive this stimulus as healthier. The healthier taste stimulus was selected on the basis of the results from a pilot experiment (n=15) as this diluted drink matched best with the actual dairy drink 'Optimel Puur Rode Vruchten', with respect to taste, flavour and texture properties. This was necessary because the dairy drink 'Optimel Puur Rode Vruchten' was taken of the shelves prior to the experiment. Tap water was used to rinse between taste stimuli, all stimuli were administered at room temperature. The usage of package and taste stimuli was permitted by, and cleared with, Royal FrieslandCampina.

2.3 Participant characteristics and attitudes

The Health and Taste Attitude Scale (HTAS) was employed to measure the importance of health and taste aspects of food in the choice and consumption processes (Roininen, Lahteenmaki et al. 1999). HTAS contains 44 statements (*e.g.,* "*I reward myself by buying something really tasty*") divided among 3 taste related subscales and 3 health related subscales. Participants responded using a 7-point scale ranging from "strongly disagree" to "strongly agree" and responses were averaged per subscale. On average, compared to earlier research (Roininen, Tuorila et al. 2001), our participant group scored medium/high on the health interest subscales (General Health Interest (GHI) mean=4.80, ±SD=0.70, range 3.00-6.00, α=0.67; Light Product Interest (LPI) mean=3.25, ±SD=1.15 range 1.00-6.00, α=0.82; Natural Product Interest (NPI) mean=3.62, ±SD=1.11, range 2.00-6.00, α=0.78) and medium on taste attitude subscales (Food As Reward (FAR) mean=4.25, ±SD=0.84, range 2.00-6.00, α=0.63; Pleasure mean=4.80, ±SD=0.69, range 4.00-7.00, α=0.41; Craving for Sweet (CS) mean=4.01, ±SD=0.77, range 3.00-6.00, α= 0.26).

The Barratt Impulsiveness Scale, version 11, (BIS-11) (Patton and Stanford 1995) was also employed and contains 30 statements (*e.g.,* "*I say things without thinking*") divided into three subscales measuring sub traits of attentional-, motor- and non-planning impulsivity. Attentional impulsiveness represents an inability to focus attention or to concentrate. Motor impulsivity represents acting without thinking and non-planning impulsiveness represents lack of forethought (Barratt 1985). Participants respond using a 4-point scale ranging from "seldom/never" to "almost always" and responses are summed up per (sub)scale, *e.g.,* scores for BIS sum range from 30 to 120. According to Stanford et al., (2009) the following division can be made: low (score <52), medium (score 52-71) or high (score >71) impulsivity. On average, our participant group scored medium on impulsiveness (BIS sum mean=67.74, ±SD=4.29, range 58-77, α=0.21; BIS attention mean=16.27, ±SD=1.96, range 14-21, α=0.12; BIS motor mean=21.53, ±SD=2.88, range 15-27, α=0.38; BIS non-planning mean=29.94, ±SD=2.98, range 25-35, α=0.38).

2.4 Procedure

After the initial screening (session 1) participants completed a training session (session 2) to practice the fMRI procedure and collect data regarding behavioural characteristics (*e.g.,* HTAS, BIS-11). During the fMRI session (session 3), participants arrived between 08.30 and 12.30 h at the test location (Hospital Gelderse Vallei, Ede, The Netherlands) after a fast of at least 2 h (no food, only water). First they reported their hunger level on a 100-unit Visual Analogue Scale (VAS) presented online using an online questionnaire (Logic8 EyeQuestion software, version 4.2.11). After this, participants received verbal instructions and were placed into the MRI scanner where they performed two fMRI tasks; a choice task (data reported elsewhere) and the taste task described below.

During the latter task participants were asked to pay attention to a package image (*i.e.,* package trial) presented using a back-projection screen, which could be viewed by the participants via a mirror positioned on the head coil, or a package image simultaneously accompanied by small sips (2 ml) of the product taste stimulus (*i.e.,* package-taste trial), administered through programmable syringe pumps (New Era Pump System Inc., Wantagh NY) at 50 ml/min.

All package images were presented 20 times (without taste stimuli) resulting in 20 x 4 = 80 package trials, and presented 10 times in combination with each taste stimulus (4 x 2 = 8 unique combinations, of which ½ congruent and ½ incongruent package-taste combinations) resulting in 10 x 8 = 80 package-taste trials. All trials were randomized and divided into three runs. Runs were presented to participants in one of three randomly generated orders. Each stimulus was presented on a light grey background. An intra-trial interval (4 - 6 s) started with a white crosshair (3.5 - 5.5 s) followed by a 0.5 s timeframe where the crosshair either turned blue (cueing a package trial) or red (cueing a package-taste trial) for anticipation purposes. Subsequently a package image was presented for 3 s (package trial) or 7 s (package-taste trial). Following package-taste trials a 2 s ‘swallow’ cue was presented on the screen, followed by a 3.5 s ‘rinse’ cue accompanied by a 2 ml tap water stimulus, again followed by a 2 s ‘swallow’ cue. Once per congruent combination (*i.e.,* healthier package + healthier taste stimulus or regular package + regular taste stimulus) in the package-taste trial participants were asked to rate healthiness and attractiveness using a 7-point scale anchored ‘not at all’ to ‘very’, presented directly after swallowing the tasted stimulus. See Figure 3.2 for an schematic overview of a package, and package-taste trial. Responses were collected via a MRI-compatible button box.

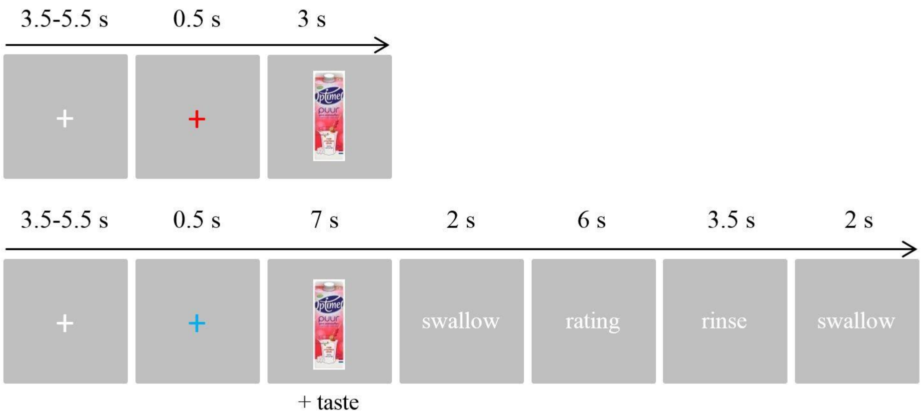

Figure 3.2 Overview of a package trial (top) and a package-taste trial (bottom) during the fMRI task. Note that the 'rating' of either healthiness or attractiveness only occurred once per congruent package-taste trial.

Following the fMRI task, after a 15 minute break, participants evaluated all eight package-taste combinations outside the scanner, one by one, in random order, on hedonic (liking, healthiness, attractiveness) and sensory (sweetness, creaminess, fruitiness, flavour intensity) attributes using a 100-unit VAS (anchored 'not at all' to 'extremely') in an online questionnaire presented via EyeQuestion. Hedonic attributes were followed by sensory attributes and attributes were randomized within the attribute domain. Package images were presented above the questions on the computer screen and taste stimuli were presented at room temperature in white opaque plastic cups (100 ml) containing 40 ml of the taste stimulus, distinguishable by (randomly generated) 3-digit-codes. Participants were instructed to pay attention to the package, take a sip and pay attention to both package and taste when answering the questions. Between each sample, during at least a 10 s break, participants were asked to clean their palate using water and/or crackers to avoid sensory fatigue and carry over effects.

2.5 MRI data acquisition

Each scan session consisted of 3 functional runs in which 1029 functional volumes were acquired using a T_2^*-weighted echoplanar imaging sequence (TR=2140 ms, TE=25 ms, 90° flip angle, FOV=192×192 mm, 43 axial slices acquired in descending order, voxel size=3×3×3 mm) on a 3 T Siemens Magnetom Verio (Siemens, Erlangen, Germany). In addition to this, a T_1-weighted anatomical scan was acquired (MPRAGE, TR=2300 ms, TE=2.98 ms, 9° flip angle, FOV=256×256 mm, 192 sagittal slices, voxel size=1×1×1 mm).

2.6 Data analysis

2.6.1 Behavioural data analysis

To investigate the effects of package colour properties and product properties on perceived hedonic and sensory responses, Linear Mixed Model analyses (LMM) analyses were carried out per hedonic and sensory attribute with package and taste as main factors as well as a package*taste interaction effect. Participant was added as a random factor (including intercept) and the HTAS and BIS-11 subscales were added as covariates. The assumption of normal distribution of dependent variables was not violated. Additionally, controlling for BMI and hunger levels at baseline did not change any of the reported results and these variables were therefore not included in the reported analyses. Least Significant Difference (LSD) post-hoc tests were conducted to further assess significant differences within each factor/interaction. Tests were performed two-sided and *p*-values below 0.05 were considered significant.

Pearson correlation coefficients were calculated to determine the associations between HTAS subscales and BIS-11 subscale scores.

2.6.2 MRI data analysis

fMRI data were pre-processed and analysed using the SPM12 software package (Wellcome Department of Imaging Neuroscience, London, UK) in conjunction with the MarsBar toolbox (http://marsbar.sourceforge.net) run with MATLAB 7.12 (The Mathworks Inc. Natick, MA).

Functional images per participant were slice time corrected, realigned to the mean volume of the first run, coregistered to the anatomical image, normalized to Montreal Neurological Institute space (MNI space), and spatially smoothened with a Gaussian kernel of 6 mm full-with at half maximum. The volume artefact tool from ArtRepair (version 4; http://cibsr.stanford.edu/tools/human-brain-project/artrepair-software.html; 27) was used to detect and repair anomalously noisy volumes. Volumes that moved more than 1mm/TR were repaired and participants with >25% of volumes repaired were excluded from the analyses. On average 3.14% of the volumes were repaired. None of the participants were excluded from the analyses.

For every participant, a statistical parametric map was generated by fitting a boxcar function to each time series, convolved with the canonical hemodynamic response function (HRF). Data were high-pass filtered with a cut-off of 128 s to remove low-frequency noise.

Ten conditions were modelled: viewing healthier package images [P_Healthier], viewing regular package images [P_Regular], tasting healthier taste + viewing healthier package images [PT_HH], tasting healthier taste + viewing regular package images [PT_RH], tasting regular taste + viewing healthier package images [PT_HR], tasting regular taste + viewing regular package images [PT_RR], rest (crosshair), swallowing, rinsing, stimulus rating. Swallowing, rinsing and stimulus rating responses were not included in further analyses. Realignment parameters were added to the model as regressors to account for motion-related variance. Parameters were estimated and T-contrasts were calculated for each participant for every viewing and tasting + viewing condition minus rest (*i.e.,* [P_Healthier-rest], [P_Regular-rest], [PT_HH-rest], [PT_RH-rest], PT_HR-rest], [PT_RR-rest]).

Note that letters P and T in the modelled conditions stand for Package (P) and Taste (T) combinations. Letters H and R in the T-contrasts stand for Healthier (H) or Regular (R) package or product versions.

For group analyses we used a region of interest (ROI) approach. A priori regions of interest were selected from literature (mainly based on the appetitive brain network (Dagher 2012)) and included regions involved in reward (Berridge 1996, Tremblay and Schultz 1999, O'Doherty, Deichmann et al. 2002, Delgado 2007), cognition, salience, inhibition (Corbetta and Shulman 2002, Aron 2007, Zandbelt and Vink 2010, Lenartowicz, Verbruggen et al. 2011) and tasting (Nitschke, Dixon et al. 2006, Rolls 2015): striatum (caudate nucleus, putamen, nucleus accumbens), pallidum, amygdala, OFC, frontal gyri, opercula, hippocampal gyri and the insula. ROIs from the Automated Anatomical Labelling (AAL) atlas were bundled to create one ROI mask using the Wake Forest University Pickatlas toolbox (Tzourio-Mazoyer, Landeau et al. 2002, Maldjian, Laurienti et al. 2003). A mean grey matter image of all participants was calculated and multiplied with the ROI mask to obtain a grey matter analysis mask.

To test and visualise the effects of package, taste and package*taste interactions on brain activation, a flexible factorial was performed (on all viewing + tasting conditions minus rest) including factors participant, package, taste, package*taste interaction. Average parameter estimates were extracted for significant clusters with the use of the MarsBar toolbox. To correct for multiple testing across brain voxels cluster extent threshold for the minimum cluster size needed for a family-wise error-corrected $p<0.05$ across the analysis mask volume was determined for the analysis with the SPM cluster size threshold tool available at (https://github.com/CyclotronResearchCentre/SPM_ClusterSizeThreshold). This yielded a cluster extent threshold of $k > 44$ voxels. In addition, we report results at a more liberal threshold of $p=0.001$, $k > 19$ contiguous voxels to allow for meta-analysis. Such a threshold inflates the risk of false positives, but it is more stringent than the arbitrary $k=10$ threshold used by many studies (Eklund, Nichols et al. 2016) and much more stringent than recommended by (Lieberman and Cunningham 2009).

We assessed correlations between average parameter estimates from all significant clusters and behavioural measures (HTAS subscales, BIS-11) using Pearson correlations in SPSS.

3. Results

Prior to the MRI scan, participants reported medium hunger levels (mean=60.7, ±SD=11.7).

3.1 Behavioural results

Linear Mixed Model analysis yielded significant main effects for package and taste, but no significant 2-way interactions between package*taste (healthiness $F(1,235)=1.06$, $p=0.30$; liking $F(1,235)=0.20$, $p=0.65$; attractiveness $F(1,235)=0.26$, $p=0.63$; sweetness F(1,235=0.02, $p=0.90$; creaminess $F(1,235)=0.02$, $p=0.90$; flavour intensity $F(1,235)=0.07$, $p=0.79$; fruitiness $F(1,235)=1.02$, $p=0.31$). This indicates that taste perception was not differently influenced by the different packages (or vice versa). Behavioural covariates (HTAS, BIS-11 subscales) did not significantly affect results, *e.g.,* healthiness perception did not co-vary with health or taste orientation from HTAS, nor with impulsivity measures from BIS-11 (all p-values>0.05). Sensory and hedonic behavioural results are shown in Figures 3.3 and 3.4. For package, healthier packages yielded slightly higher scores compared to the regular package versions for perceived healthiness ($F(1,235)=16.17$, $p<0.001$), fruitiness ($F(1,235)=14.31$, $p<0.001$) and sweetness (F(1,235)=5.31, p=0.02), but there was no significant main effect for perceived attractiveness (F(1,235)=5.52, p=0.02), liking (F(1,235)=1.03, p=0.31), creaminess (F(1,235)=2.59, p=0.11) or flavour intensity (F(1,235)=0.12, p=0.73). For taste, there were significant main effects for all attributes. Figures 3.3 and 3.4 show that the healthier taste yielded slightly higher scores compared to the regular taste for perceived healthiness (F(1,235)=12.83, p<0.001) as well as slightly lower scores for perceived attractiveness (F(1,235)=9.83, p<0.001) and lower scores for liking (F(1,235)=78.52, p<0.001). Healthier taste yielded lower scores on sweetness (F(1,235)=113.87, p<0.001), creaminess (F(1,235)=340.83, p<0.001), fruitiness (F(1,235)=50.78, p<0.001) and flavour intensity (F(1,235)=109.65, p<0.001).

When investigating relationships between HTAS subscales and BIS-11 subscales, Pearson correlations showed significant inverse correlation between HTAS General Health Interest and Craving Sweet subscales (r=-0.412, p=0.02) as well as HTAS Light Product Interest and Food As Reward subscales (r=-0.374, p=0.03).

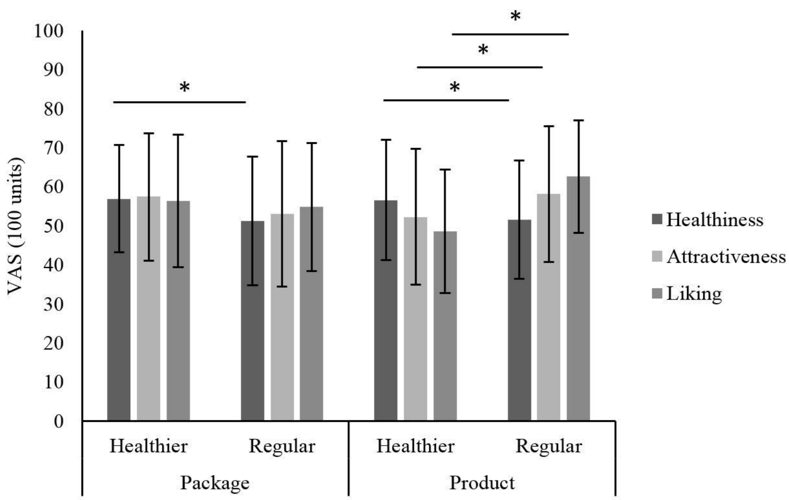

Figure 3.3 Mean (±SD) of perceived hedonic attributes per package or tasted product, * indicate significant differences between products or packages at p<0.05.

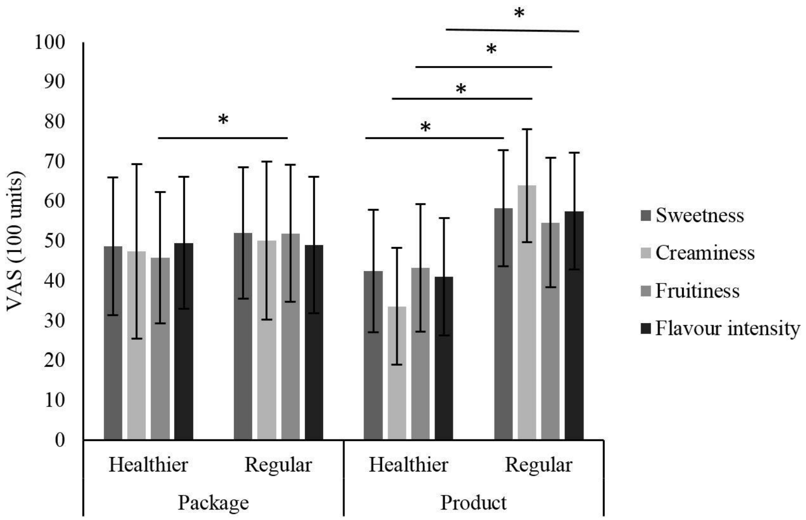

Figure 3.4 Mean (±SD) of perceived sensory attributes per package or tasted product, * indicate significant differences between products or packages at $p<0.05$.

3.2 Neuroimaging results

Table 3.1 gives an overview of ROI brain regions that were differentially activated by packages, tastes or package*taste interactions.

Table 3.1 ROI clusters with significant different activation when comparing packages, tastes and package-taste combinations using a flexible factorial fMRI analysis.

Effect	ROI	Side	Cluster size	X	Y	Z	Peak Z-score
Main package effect							
Regular package vs Healthier package	Inferior frontal gyrus (vlPFC)	R	40	51	26	-1	4.33
	Putamen (ventral striatum)	L	19	-15	5	-7	4.74
	Orbital inferior frontal gyrus (OFC)	L	37	-48	32	-13	3.73
Main product effect							
Healthier product vs Regular product	Caudate (dorsal striatum)*	R	56	18	-16	23	5.02
	Middle frontal gyrus (BA46) (dlPFC)*	L	204	-24	50	17	4.06
	Orbital inferior frontal gyrus (OFC)	L	25	-21	35	-10	4.56
	Pallidum (ventral striatum)	R	35	27	-7	-7	4.13
	Putamen (dorsal striatum)	R	30	24	11	5	3.92
	Putamen (dorsal striatum)	L	21	-24	14	2	3.8
	Superior frontal gyrus (dlPFC)	L	21	-15	26	50	3.87
Package * product interaction effect							
Healthier package + Healthier product & Regular package + Regular product vs Healthier package + Regular product & Regular package + Healthier product	Orbital inferior frontal gyrus (OFC)	L	19	-36	41	-10	3.75

MNI peak coordinates, significant at $p_{uncorrected} < 0.001$, voxel threshold: 19 voxels.

*Significant at $p_{FWE} < 0.05$ ($p_{uncorrected} < 0.001$, k > 44 voxels)

3.2.1 The effect of package type on brain activation

When comparing regular with healthier packages (irrespective of the tasted product), brain areas activated stronger when viewing the regular packages compared to the healthier packages included bilateral inferior frontal regions (including inferior frontal and orbitofrontal parts, *i.e.,* OFC) as well as left sided putamen (see Table 3.1 and Figure 3.5). Additionally, putamen activity when viewing regular packages was correlated positively with the General Health Interest (GHI) scores from HTAS (r=0.431, p=0.01) and negatively with BIS attention subscale scores (r=-0.461, p=0.01). Similarly, differences in putamen activity between regular and healthier packages correlated with BIS attention subscale scores (r=-0.349, p=0.04), which was driven mainly by greater putamen activation when viewing the regular package in less impulsive participants.

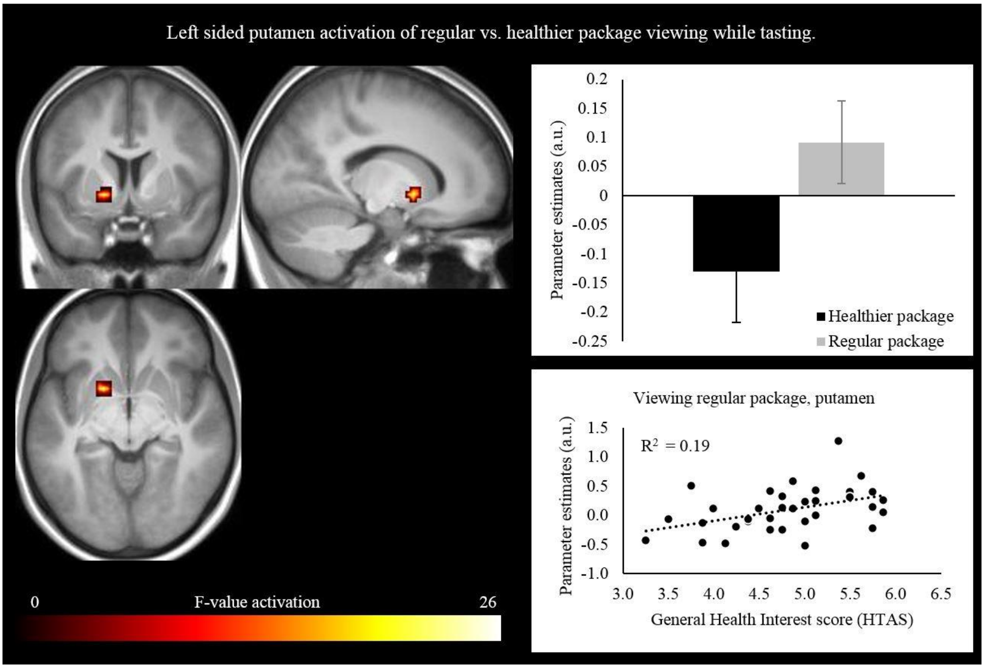

Figure 3.5 Difference between contrasts of viewing healthier packages and regular packages while tasting in the left sided putamen and mean (±SD) parameter estimates for this cluster. F-map overlaid on mean anatomical image, p<0.001, F>11.33. Flexible factorial analysis was performed comparing contrasts of healthier and regular package viewing while tasting. Bottom right: Average cluster parameter estimates of left sided putamen when viewing a regular package while tasting plotted against General Health Interest scores from HTAS, p<0.05.

3.2.2 The effect of tasted product on brain activation

When comparing tasting healthier taste with tasting regular taste (irrespective of the package), several brain regions responded significantly stronger to the taste of healthier taste compared to regular taste; left sided middle and inferior frontal region (Figure 3.6), bilateral putamen, right sided caudate nucleus, and pallidum (see Table 3.1). Next to this, we found a significant negative correlation between HTAS General Health Interest scores and superior frontal gyrus (dlPFC) activation when tasting the regular taste (r=-0.459, p=0.01).

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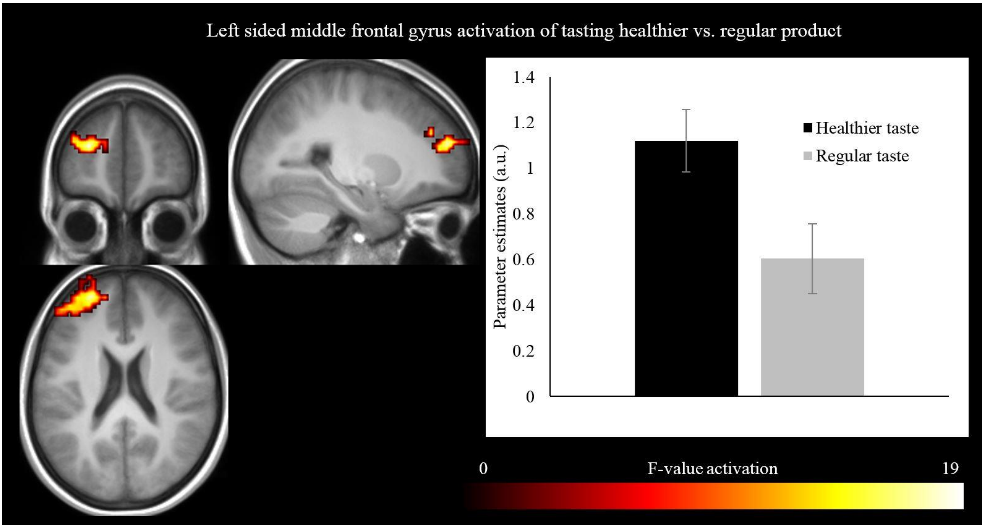

Figure 3.6 Difference between contrasts of tasting healthier product taste and regular product taste in the left middle frontal gyrus and mean (±SD) parameter estimates for this cluster. F-map overlaid on mean anatomical image, p<0.001, F>11.33. Flexible factorial analysis was performed comparing contrasts of healthier and regular product tasting versus rest, irrespective of presented packages.

3.2.3 The effect of package*taste interaction on brain activation

When looking at *package*taste* interactions, congruent combinations (*i.e.,* healthier package + healthier taste or regular package + regular taste) gave rise to more activation in the left lateral OFC (Figure 3.7) compared to incongruent combinations (*i.e.,* healthier package + regular taste or regular package + healthier taste) which resulted in deactivation in the left lateral OFC (see Table 3.1).

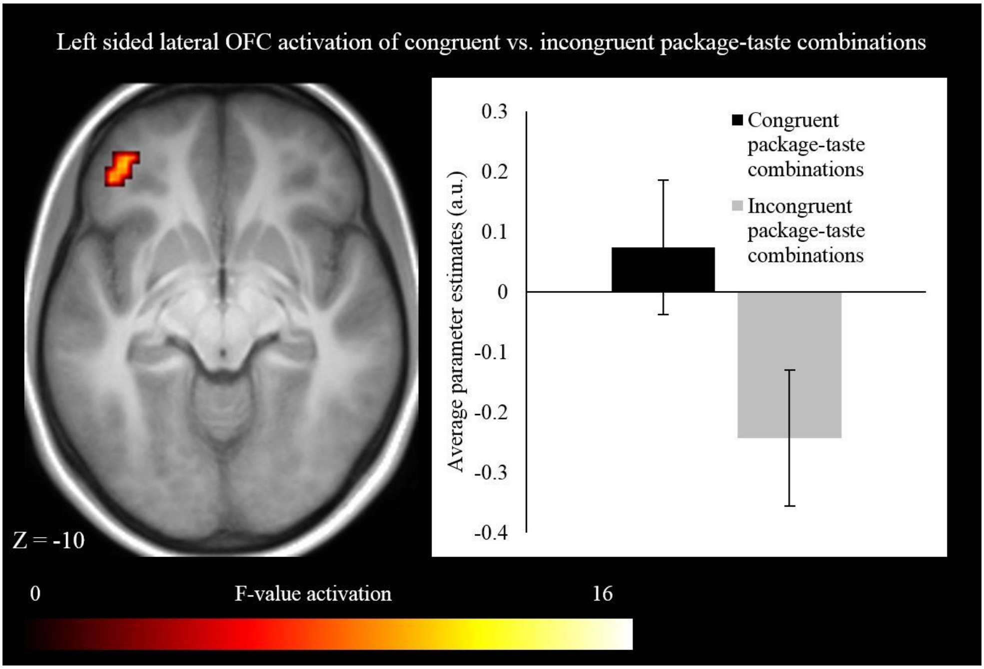

Figure 3.7 Difference between contrasts of congruent and incongruent package-taste combinations in the left lateral OFC and mean (±SD) parameter estimates for this cluster. F-map overlaid on mean anatomical image, $p<0.001$, $F>11.33$. Flexible factorial analysis was performed comparing contrasts of congruent- and incongruent package-taste combination versus rest, irrespective of presented packages.

4. Discussion

In this study the effects of taste and package colour cues on brain activity patterns in taste, reward and inhibitory control regions were explored to determine whether effects are mediated via bottom-up (sensory) or top-down (cognitive) pathways. Modulatory influences of personal characteristics (*i.e.,* impulsiveness, health and taste attitude) were also studied.

Effects of taste and package colour cues were seen on neural activation in regions related to reward and inhibitory control, but not in primary taste processing regions (insula). In line with expectations, neural activation in reward related (*i.e.,* striatum, OFC) regions was reduced when viewing healthier packages compared to regular packages while tasting. A higher health interest related to lower neural activation in the striatum (regular package). Viewing healthier packages also induced reduced neural activation in inhibitory control (IFG) regions compared to regular packages (while tasting), which was not what we hypothesized. The taste of the healthier product, regardless of package, enhanced activation in reward (*e.g.,* striatum) and in inhibitory control (*e.g.,* dlPFC) regions compared to the taste of the regular product. For consumers with a goal of healthy eating this may suggest a cognitively driven preference for the taste of the healthier product as opposed to a stimulus driven preference for the taste of the regular product. Lastly, incongruency (*e.g.,* healthier package + regular taste) gave rise to deactivation in a reward related region (lateral OFC) while congruency (*e.g.,* healthier package + healthier taste) of package-taste combinations resulted in activation in the lateral OFC.

These findings suggest that cognitive top-down processes modulate brain activity by package and taste properties, rather than bottom-up processes. Furthermore, they illustrate the importance of taking participant characteristics such as health attitude into account when investigating the effects of package and taste on neural activation.

Viewing a regular, more ‘indulgent’, package induced stronger activation in the putamen and OFC compared to the healthier package. Enhanced activation in these regions implies enhanced reward (anticipation) (Schultz, Tremblay et al. 2000, Tremblay and Schultz 2000, Tremblay and Schultz 2000, O'Doherty, Deichmann et al. 2002, Small, Jones-Gotman et al. 2003, Rolls 2015). Enhanced activation in reward related regions is in line with earlier research when using more hedonic, preferred cues (Grabenhorst et al., (2008); OFC, ventral striatum), a stronger brand cue (Kuhn et al., (2013); OFC) or a higer priced wine (Plassmann et al., (2008); ventral stiatum). Furthermore, HTAS General Health Interest scores correlated positively with putamen activation when viewing the regular packages. An explanation, though speculative, may be that participants with stronger health interest hold stronger implicit associations that healthier package colours (more bright, less saturated) are associated with healthiness and the regular package colours (less bright, more saturated) with attractiveness.

Viewing a regular, more ‘indulgent’ package also induced stronger activation in the IFG compared to the healthier package. Enhanced IFG activation may reflect an enhanced need for inhibitory control to suppress the ‘urge to indulge’ in our health-conscious consumers (Guerrieri, Nederkoorn et al. 2007, van der Laan, Barendse et al. 2016).

Regarding taste effects, the healthier product contained less calories and sugar. This product was perceived as less attractive, liked, sweet, creamy, fruity and flavour intense compared to the regular product. In contrast to our expectations, the healthier calorie-reduced product (compared to the regular product) resulted in greater activation in regions implicated in reward representation (OFC), reward anticipation and reward delivery (striatal regions). From an evolutionary point of view, more calories warrant greater reward value, since nutritional energy is needed for survival and therefore energy dense foods are rewarding in order to stimulate motivation behaviour for energy dense foods (Cabanac 1971). Also, the sensory property sweetness often signals sugars, a source of energy (Anderson 1995). The activation we observed in brain (*e.g.,* striatum) regions when tasting does not align with these standpoints. Involvement of other processes related to participants' (health) associations, attitudes and cognitions are also reflected in (*e.g.,*) the striatum and may interfere with neural activation (Berridge 1996, Balleine, Delgado et al. 2007, Delgado 2007). Therefor activation in (*e.g.,*) the striatum may not simply reflect a mere nutritional related reward. Enhanced reward-related activation for the healthier calorie-reduced product may reflect a cognitively driven preference which fits well with participants' healthy eating goal, as reflected in the relatively high HTAS scores of our population. This was also seen in van Rijn et al., (2017). Such a cognitive preference for the healthier calorie-reduced product may also explain the enhanced neural activation in dlPFC (middle and superior frontal gyrus), implicated in inhibitory control, compared to the regular product.

In addition, incongruent combinations of package and taste resulted in deactivation in the lateral OFC compared to congruent combinations. This resulted in activation, indicating lower reward value. Lack of predictability, and breaches of expectation, have been related to enhanced activation in regions related to attention (IFG) and reward (OFC). Attentional brain activation with respect to breaches of expectation however is often found in opposite direction to aid identification and learning (Berns, McClure et al. 2001, Veldhuizen, Douglas et al. 2011). As predictability or taste expectation may not have been obviously signalled through package colour (*i.e.,* no clear prediction error in striatum found in incongruent trials), we do not know if this was the case here but lack an alternative explanation. Deactivation in the lateral OFC for incongruent combinations may simply reflect less rewarding properties of incongruent package-taste combinations compared to congruent package-taste combinations.

No evidence for bottom-up effects of package colour properties on neural activity in taste processing regions such as the anterior insula was found. The lack of findings in the insula could be a result of interactions of bottom-up effects with other (top-down) processes in which the insula is also involved, such as salience and emotional processing (Critchley, Wiens et al. 2004, Kurth, Zilles et al. 2010). Specifically, simultaneous viewing while tasting may have also influenced attentional focus resulting in an apparent lack of taste related activation. Along a similar line, Grabenhorst et al., (2008) demonstrated that focussing on either affective value or physical properties of a stimulus activates different brain areas, with only insula activation when the focus was on taste intensity.

The diversity of experimental designs and stimuli used in other research makes it hard to generalise and interpret findings of taste, label and price effects across studies. Some studies have shown effects of taste, brand, label and price cues in reward, taste and inhibitory control coding brain regions (de Araujo, Rolls et al. 2005, Grabenhorst, Rolls et al. 2008, Plassmann, O'Doherty et al. 2008, Veldhuizen, Douglas et al. 2011, Grabenhorst, Schulte et al. 2013, Kuhn and Gallinat 2013). Others, however, reported no effects in reward related brain regions (Nitschke, Dixon et al. 2006, Woods, Lloyd et al. 2011, Veldhuizen, Nachtigal et al. 2013). Differences in population characteristics, such as gender (Wang, Volkow et al. 2009), BMI (Stoeckel, Weller et al. 2008), health attitude and impulsivity (van der Laan, Barendse et al. 2016, van Rijn, Wegman et al. 2017), provide potential explanations for discrepancies between earlier and current findings.

Furthermore, differences in experimental set-ups may have contributed to the diverse findings reported in literature: (1) different use of stimuli: others used taste solutions, soft drinks, wines or odours whereas in our study we used a rich flavoured and creamy dairy drink, (2) inclusion of ratings after each trial resulting in potential differences in terms of an active cue-stimulus evaluative component compared to our more passive cue-stimulus evaluation due to no compulsory rating after each stimulus presentation, (3) timing and nature of cues: prior studies used verbal cues, often preceding the tasted stimuli, to impose a certain focus on, for example, taste or hedonics, whereas in the present study subtle visual package colour cues were presented simultaneously to tasting (Grabenhorst and Rolls 2008).

There are several strengths and limitations of the present study worthwhile to discuss. A strength is the use of realistic subtle non-verbal package cues. Image colour is seen as a low level content feature, whereas verbal descriptors are seen as higher level content features (Liu, Zhang et al. 2007). Processing of lower level features is more automatic and subconscious, therefore more in line with the automatic, subconscious nature of expectancy driven modulations and food evaluations compared to more cognitively processed verbal descriptors. The novelty of our subtle cues extends prior findings of higher level cognitive influences (McClure, Li et al. 2004, de Araujo, Rolls et al. 2005, Nitschke, Dixon et al. 2006, Grabenhorst, Rolls et al. 2008, Plassmann, O'Doherty et al. 2008, Veldhuizen, Douglas et al. 2011, Woods, Lloyd et al. 2011, Grabenhorst, Schulte et al. 2013, Kuhn and Gallinat 2013, Veldhuizen, Nachtigal et al. 2013).

Related to reliability, the more stringent statistical threshold used compared to other related papers (*e.g.,* around 5 voxels vs. our primary threshold of k=44 voxels and secondary most liberal threshold of k=19 voxels at p=0.001 (McClure, Li et al. 2004, Veldhuizen, Douglas et al. 2011, Grabenhorst, Schulte et al. 2013, Veldhuizen, Nachtigal et al. 2013)) decreases the chance of false positives.

There are also several limitations and recommendations worth mentioning. In hindsight, placing the sensory evaluation of package-taste stimuli prior to the rather demanding fMRI task instead of following the fMRI task, may have given better comparability with our fMRI results, as well as with previous sensory findings (Tijssen, Zandstra et al. 2017). Sensory specific satiety, boredom and fatigue may have influenced behavioural results. Next to this, the results found here may be product (taste) or product category specific. Replicating this study using other product packages and tastes, such as savoury products (*e.g.,* soups), as well as in different or diverse populations (*e.g.,* in terms of health consciousness), would give a better idea about boundary conditions and generalisability. Lastly, investigating interactions with other package elements (*e.g.,* material, package shape, text) would be valuable. For example, credence characteristics, referring to (package) characteristics that influence the credibility of the seller in relation to the buyer have been shown to influence liking (Fernqvist and Ekelund 2014).

To conclude, our findings underscore the potential ability of package colour properties to influence perception and neural activation in reward and inhibition related brain activation via more cognitive (top-down) systems. Individual differences in health interest and impulsivity modify package and taste related brain responses which underscore the importance of taking participant characteristics into account in food research. This paper highlights some of the mechanisms and conditions under which these effects operate.

References

Anderson, G. H. (1995). "Sugars, sweetness, and food intake." The American Journal of Clinical Nutrition 62(1): 195S-201S.

Aron, A. R. (2007). "The neural basis of inhibition in cognitive control." Neuroscientist 13(3): 214-228.

Balleine, B. W., M. R. Delgado and O. Hikosaka (2007). "The role of the dorsal striatum in reward and decision-making." Journal of Neuroscience 27(31): 8161-8165.

Barratt, E. S. (1985). "Impulsiveness subtraits: Arousal and information processing." Spence JT, Itard CE, editors. Motviation, emotion and personality. Amsterdam: Elsevier: 137-146.

Berns, G. S., S. M. McClure, G. Pagnoni and P. R. Montague (2001). "Predictability modulates human brain response to reward." Journal of neuroscience 21(8): 2793-2798.

Berridge, K. C. (1996). "Food reward: Brain substrates of wanting and liking." Neuroscience & Biobehavioral Reviews 20(1): 1-25.

Cabanac, M. (1971). "Physiological Role of Pleasure." Science 173(4002): 1103-1107.

Clark, J. E. (1998). "Taste and flavour: their importance in food choice and acceptance." Proceedings of the Nutrition Society 57(4): 639-643.

Corbetta, M. and G. L. Shulman (2002). "Control of goal-directed and stimulus-driven attention in the brain." 3: 201.

Critchley, H. D., S. Wiens, P. Rotshtein, A. Öhman and R. J. Dolan (2004). "Neural systems supporting interoceptive awareness." Nature Neuroscience 7(2): 189-195.

Dagher, A. (2012). "Functional brain imaging of appetite." Trends in Endocrinology & Metabolism 23(5): 250-260.

de Araujo, I. E., E. T. Rolls, M. I. Velazco, C. Margot and I. Cayeux (2005). "Cognitive Modulation of Olfactory Processing." Neuron 46(4): 671-679.

Delgado, M. R. (2007). "Reward-related responses in the human striatum." Reward and Decision Making in Corticobasal Ganglia Networks 1104: 70-88.

Eklund, A., T. E. Nichols and H. Knutsson (2016). "Cluster failure: Why fMRI inferences for spatial extent have inflated false-positive rates." Proceedings of the National Academy of Sciences 113(28): 7900-7905.

Fernqvist, F. and L. Ekelund (2014). "Credence and the effect on consumer liking of food–A review." Food Quality and Preference 32: 340-353.

Grabenhorst, F. and E. T. Rolls (2008). "Selective attention to affective value alters how the brain processes taste stimuli." European Journal of Neuroscience 27(3): 723-729.

Grabenhorst, F., E. T. Rolls and A. Bilderbeck (2008). "How cognition modulates affective responses to taste and flavor: Top-down influences on the orbitofrontal and pregenual cingulate cortices." Cerebral Cortex 18(7): 1549-1559.

Grabenhorst, F., F. P. Schulte, S. Maderwald and M. Brand (2013). "Food labels promote healthy choices by a decision bias in the amygdala." Neuroimage 74: 152-163.

Guerrieri, R., C. Nederkoorn, K. Stankiewicz, H. Alberts, N. Geschwind, C. Martijn and A. Jansen (2007). "The influence of trait and induced state impulsivity on food intake in normal-weight healthy women." Appetite 49(1): 66-73.

Gutjar, S., C. de Graaf, A. Palascha and G. Jager (2014). "Food choice: The battle between package, taste and consumption situation." Appetite 80: 109-113.

Ishihara, S. (1951). Tests for colour-blindness. Tokyo?, Nippon Isho Shuppan Co.

Kuhn, S. and J. Gallinat (2013). "Does Taste Matter? How Anticipation of Cola Brands Influences Gustatory Processing in the Brain." Plos One 8(4).

Kurth, F., K. Zilles, P. T. Fox, A. R. Laird and S. B. Eickhoff (2010). "A link between the systems: functional differentiation and integration within the human insula revealed by meta-analysis." Brain Structure and Function 214(5): 519-534.

Lenartowicz, A., F. Verbruggen, G. D. Logan and R. A. Poldrack (2011). "Inhibition-related Activation in the Right Inferior Frontal Gyrus in the Absence of Inhibitory Cues." Journal of Cognitive Neuroscience 23(11): 3388-3399.

Lieberman, M. D. and W. A. Cunningham (2009). "Type I and Type II error concerns in fMRI research: re-balancing the scale." Social Cognitive and Affective Neuroscience 4(4): 423-428.

Liu, Y., D. Zhang, G. Lu and W.-Y. Ma (2007). "A survey of content-based image retrieval with high-level semantics." Pattern Recognition 40(1): 262-282.
Maldjian, J. A., P. J. Laurienti, R. A. Kraft and J. H. Burdette (2003). "An automated method for neuroanatomic and cytoarchitectonic atlas-based interrogation of fMRI data sets." NeuroImage 19(3): 1233-1239.
McClure, S. M., J. Li, D. Tomlin, K. S. Cypert, L. M. Montague and P. R. Montague (2004). "Neural correlates of behavioral preference for culturally familiar drinks." Neuron 44(2): 379-387.
Ng, M., C. Chaya and J. Hort (2013). "The influence of sensory and packaging cues on both liking and emotional, abstract and functional conceptualisations." Food Quality and Preference 29(2): 146-156.
Nitschke, J. B., G. E. Dixon, I. Sarinopoulos, S. J. Short, J. D. Cohen, E. E. Smith, S. M. Kosslyn, R. M. Rose and R. J. Davidson (2006). "Altering expectancy dampens neural response to aversive taste in primary taste cortex." Nature Neuroscience 9(3): 435-442.
O'Doherty, J. P., R. Deichmann, H. D. Critchley and R. J. Dolan (2002). "Neural responses during anticipation of a primary taste reward." Neuron 33(5): 815-826.
Okamoto, M. and I. Dan (2013). "Extrinsic information influences taste and flavor perception: A review from psychological and neuroimaging perspectives." Seminars in Cell & Developmental Biology 24(3): 247-255.
Patton, J. H. and M. S. Stanford (1995). "Factor structure of the Barratt impulsiveness scale." Journal of clinical psychology 51(6): 768-774.
Piqueras-Fiszman, B. and C. Spence (2015). "Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts." Food Quality and Preference 40: 165-179.
Plassmann, H., J. O'Doherty, B. Shiv and A. Rangel (2008). "Marketing actions can modulate neural representations of experienced pleasantness." Proceedings of the National Academy of Sciences of the United States of America 105(3): 1050-1054.
Roininen, K., L. Lahteenmaki and H. Tuorila (1999). "Quantification of consumer attitudes to health and hedonic characteristics of foods." Appetite 33(1): 71-88.
Roininen, K., H. Tuorila, E. H. Zandstra, C. de Graaf, K. Vehkalahti, K. Stubenitsky and D. J. Mela (2001). "Differences in health and taste attitudes and reported behaviour among Finnish, Dutch and British consumers: a cross-national validation of the Health and Taste Attitude Scales (HTAS)." Appetite 37(1): 33-45.
Rolls, E. T. (2011). "Taste, olfactory and food texture reward processing in the brain and obesity." International Journal of Obesity 35(4): 550-561.
Rolls, E. T. (2015). "Taste, olfactory, and food reward value processing in the brain." Progress in Neurobiology 127-128(Supplement C): 64-90.
Schifferstein, A. Fenko, P. M. Desmet, D. Labbe and N. Martin (2013). "Influence of package design on the dynamics of multisensory and emotional food experience." Food Quality and Preference 27(1): 18-25.
Schultz, W., L. Tremblay and J. R. Hollerman (2000). "Reward Processing in Primate Orbitofrontal Cortex and Basal Ganglia." Cerebral Cortex 10(3): 272-283.
Small, D. M., M. Jones-Gotman and A. Dagher (2003). "Feeding-induced dopamine release in dorsal striatum correlates with meal pleasantness ratings in healthy human volunteers." NeuroImage 19(4): 1709-1715.
Stanford, M. S., C. W. Mathias, D. M. Dougherty, S. L. Lake, N. E. Anderson and J. H. Patton (2009). "Fifty years of the Barratt Impulsiveness Scale: An update and review." Personality and Individual Differences 47(5): 385-395.
Stoeckel, L. E., R. E. Weller, E. W. Cook Iii, D. B. Twieg, R. C. Knowlton and J. E. Cox (2008). "Widespread reward-system activation in obese women in response to pictures of high-calorie foods." NeuroImage 41(2): 636-647.
Tijssen, I., E. H. Zandstra, C. de Graaf and G. Jager (2017). "Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar- and fat-reduced products." Food Quality and Preference 59: 46-58.
Tremblay, L. and W. Schultz (1999). "Relative reward preference in primate orbitofrontal cortex." 398: 704.
Tremblay, L. and W. Schultz (2000). "Modifications of reward expectation-related neuronal activity during learning in primate orbitofrontal cortex." Journal of Neurophysiology 83(4): 1877-1885.

Tremblay, L. and W. Schultz (2000). "Reward-related neuronal activity during go-nogo task performance in primate orbitofrontal cortex." Journal of Neurophysiology 83(4): 1864-1876.

Tzourio-Mazoyer, N., B. Landeau, D. Papathanassiou, F. Crivello, O. Etard, N. Delcroix, B. Mazoyer and M. Joliot (2002). "Automated Anatomical Labeling of Activations in SPM Using a Macroscopic Anatomical Parcellation of the MNI MRI Single-Subject Brain." NeuroImage 15(1): 273-289.

van der Laan, L. N., M. E. A. Barendse, M. A. Viergever and P. A. M. Smeets (2016). "Subtypes of trait impulsivity differentially correlate with neural responses to food choices." Behavioural Brain Research 296: 442-450.

van Rijn, I., J. Wegman, E. Aarts, C. de Graaf and P. A. Smeets (2017). "Health interest modulates brain reward responses to a perceived low-caloric beverage in females." Health Psychol 36(1): 65-72.

Veldhuizen, M. G., D. Douglas, K. Aschenbrenner, D. R. Gitelman and D. M. Small (2011). "The anterior insular cortex represents breaches of taste identity expectation." The Journal of neuroscience : the official journal of the Society for Neuroscience 31(41): 14735-14744.

Veldhuizen, M. G., D. J. Nachtigal, L. J. Flammer, I. E. de Araujo and D. M. Small (2013). "Verbal descriptors influence hypothalamic response to low-calorie drinks." Molecular Metabolism 2(3): 270-280.

Wang, G.-J., N. D. Volkow, F. Telang, M. Jayne, Y. Ma, K. Pradhan, W. Zhu, C. T. Wong, P. K. Thanos, A. Geliebter, A. Biegon and J. S. Fowler (2009). "Evidence of gender differences in the ability to inhibit brain activation elicited by food stimulation." Proceedings of the National Academy of Sciences 106(4): 1249-1254.

Woods, A. T., D. M. Lloyd, J. Kuenzel, E. Poliakoff, G. B. Dijksterhuis and A. Thomas (2011). "Expected taste intensity affects response to sweet drinks in primary taste cortex." Neuroreport 22(8): 365-369.

World Medical, A. (2013). "World medical association declaration of helsinki: Ethical principles for medical research involving human subjects." JAMA 310(20): 2191-2194.

Zandbelt, B. B. and M. Vink (2010). "On the Role of the Striatum in Response Inhibition." PLOS ONE 5(11): e13848.

Zandstra, E. H., C. de Graaf and W. A. Van Staveren (2001). "Influence of health and taste attitudes on consumption of low- and high-fat foods." Food Quality and Preference 12(1): 75-82.

Chapter 4

Colour shapes attitudes: Implicit associations of package colour and concepts of product healthiness and attractiveness

Irene O.J.M. Tijssen
Gerry Jager
Elizabeth H. Zandstra

in preparation

Abstract

What do package colours communicate in terms of healthiness and attractiveness? Research addressing this question has mainly used explicit methods (*i.e.* self-reporting) that rely on conscious awareness. Food evaluations and preferences, however, are to a large extent habitual, intuitive and subconscious. Using methodology congruent with the more habitual, intuitive and less conscious processing mode, such as the Implicit Association Test (IAT), is therefore important when examining subconscious attitudes and implicit associations with package colours.

This research investigated implicit associations between package colour (more/less vibrantly coloured packages and ‘cool’/’warm’ coloured packages) and the concepts of healthiness and attractiveness across eight IATs (n=302) covering different product categories (dairy drink, sausage, biscuits).

Results consistently showed that less vibrantly coloured packages and ‘cool’ coloured packages were implicitly more strongly associated with healthiness compared to vibrantly coloured packages and ‘warm’ coloured packages (p<0.05). Similarly, vibrantly coloured packages and ‘warm’ coloured packages were shown to be more strongly associated with attractiveness compared to less vibrantly coloured packages and ‘cool’ coloured packages (p<0.05).

These results indicate the importance of package colour properties when designing attractive and healthier food products. We recommend a combined approach of explicit and implicit methodologies to understand the meaning and messages conveyed through packages (*e.g.,* through colour) at both a conscious as well as a more subconscious level.

1. Introduction

"If something tastes good, it's probably unhealthy" and "if something is healthy, it probably tastes bad". These are common beliefs among consumers (Raghunathan et al., 2006), although these beliefs can vary between countries, cultures and consumer segments (*e.g.,* "the healthy = tasty French intuition", Jo and Lusk (2018); Werle, Trendel, and Ardito (2013)). At point of purchase, existing beliefs on healthiness and tastiness interact with extrinsic food properties such as packaging and labelling. This interaction gives rise to inferences about intrinsic food properties such as taste and flavour of the food, since these often cannot be evaluated at this stage (*e.g.,* Mai et al., (2016); Piqueras-Fiszman and Spence (2015)).

To date, these inferences and beliefs are often captured using measurements that rely on conscious awareness (*e.g.,* self-reporting). However these beliefs often operate on a more subconscious level. In order to accurately understand these subconscious influences, it is important to measure them using methodology that is congruent with the subconscious processing mode.

When it comes to inference formation regarding product expectations and taste evaluations in a choice and purchase setting, package colour is an important extrinsic property because it conveys meaning and message about health and taste (Singh, 2006). Recent research showed that blue coloured packages were perceived to be healthier than red coloured packages (Huang & Lu, 2015; Tijssen et al., 2017). Similarly, a green package colour was more healthy than a red package colour (van Rompay, Deterink, & Fenko, 2016). Green and blue were considered 'cool' colours whereas red, orange, pink were considered 'warm' colours. A light colour intensity (*i.e.,* low colour saturation) in packaging has also been associated with healthiness (Mai et al., 2016; Tijssen et al., 2017). In terms of food enjoyment, red or more vibrantly coloured packages (*i.e.,* high saturation) were more strongly associated with attractiveness and liking whereas blue, or less vibrantly coloured packages (*i.e.,* low saturation) were more strongly associated with unattractiveness (Tijssen et al., 2017).

In line with literature, personal observations of the Dutch market (consistent with other Western markets) show that in the supermarket healthier food products (*e.g.,* 'light' products) are often packaged in 'cool', less vibrantly coloured packages compared to their regular counterparts, which are often packaged in more vibrantly or 'warm' coloured packages.

The majority of the abovementioned findings rely on explicit methodologies (*i.e.,* self-reporting). These methods rely on conscious awareness and can be susceptible to demand characteristics, desirable responding or misattribution of emotional states (Fazio & Olson, 2003). In reality, food choice behaviour and related beliefs are to a large extent intuitive, unconscious, habitual and automatic, not driven by deliberation over consequences and rational comparison. We often rely on simple heuristics and use inferences and associations to determine food preferences and guide behaviour (Kahneman, 2012). Using methodology congruent with the more automatic, intuitive and less conscious processing mode, such as the Implicit Association Test (IAT), is therefore important when investigating subconscious attitudes (Greenwald et al., 1998; Greenwald et al., 2003). Next to this, conscious and subconscious preferences and beliefs do not always line up. For example, explicitly people state that eating healthily is important (Carrillo, Varela, Salvador, & Fiszman, 2011), and sometimes preferred, while implicitly they believe that "healthy is not tasty" (Raghunathan et al., 2006; Tijssen, Zandstra, & Jager, in prep.). Combining implicit measures such as the IAT with explicit self-reporting measures can shed light on the similarities and discrepancies between measures, and combined can potentially better explain (unexpected) behaviour.

Recently, we performed several experiments in which we combined explicit and implicit measures assessing the relationship between package colour cues and concepts of healthiness and attractiveness (Tijssen et al., 2017; Tijssen et al., in prep.). Here we wanted to determine the robustness and generalisability of the implicit associations across different types of package colours, product categories and target populations. Therefore we combined all implicit data from these experiments. Experiment 1 investigated implicit associations between more/less vibrantly coloured packages and the concepts of attractiveness (Experiment 1a) and healthiness (Experiment 1b). Experiment 2 examined implicit associations between 'cool'/ 'warm' coloured packages and again the concepts of attractiveness and healthiness.

With regard to healthiness we hypothesized that less vibrantly, and 'cool' coloured packages would be more strongly associated with healthiness than vibrantly and 'warm' coloured packages. In addition, we regarding attractiveness, we expected that more vibrantly coloured and 'warm' coloured packages would be more strongly associated with attractiveness than less vibrantly and 'cool' coloured packages.

2. Materials and Methods

Implicit associations between package colour cues and the concepts of healthiness and attractiveness were examined using the IAT, an established tool to demonstrate implicit associations (Greenwald et al., 1998; Greenwald et al., 2003). All IATs were presented on a computer using E-Prime 2.0 software (Psychology Software Tools, Inc.). Combining IAT data from two large experiments (data published elsewhere, see also section 2.4 on the procedures, Tijssen et al. (2017); Tijssen et al. (in prep.)) underscores the robustness and generalisability of implicit associations. Data were collected at Wageningen University (The Netherlands) and the experimental protocols were submitted and exempted from ethical approval by the Medical Ethical Committee of Wageningen University (The Netherlands).

2.1 Participants

Participants from both Experiment 1 and 2 were recruited from Wageningen and surroundings. All participants were healthy, normal-weight (BMI between 18.5-25 kg/m^2, self-reported) and of Dutch nationality, not colour blind (as tested with the Ishihara's colour blindness test Ishihara (1951)), and aged between 18-45 years old. In Experiment 1a, the participants (n=148) were divided among two product category conditions (dairy drink and sausage) to assess implicit associations of more/less vibrantly coloured packages towards attractiveness (IAT Attractiveness). In Experiment 1b, participants (n=59) were divided among two product category conditions (dairy drink and sausage) to assess implicit associations of more/less vibrantly coloured packages towards healthiness (IAT healthiness). In Experiment 2, participants (n=95) were randomly divided into two IATs to assess implicit associations of 'warm'/'cool' coloured packages representing multiple product categories towards either healthiness (IAT Healthiness) *or* attractiveness (IAT Attractiveness) (session 1). Later, in the same experiment, all participants that completed the experiment (*n* = 91) performed both IATs to assess implicit associations between 'warm'/'cool' coloured packages and the concepts healthiness (IAT Healthiness) *and* attractiveness (IAT attractiveness) (session 2). Table 4.1 shows an overview of participant characteristics per experiment, product category condition, session and IAT performed.

Table 4.1 Participant numbers per experiment, condition, session and IAT performed

Experiment	**Product Category Condition, Session**	**IAT**	**Participants (*n*)**
1a	Dairy drink	IAT Attractiveness	83 (18 male)
1a	Sausage	IAT Attractiveness	65 (14 male)
1b	Dairy drink	IAT Healthiness	30 (6 male)
1b	Sausage	IAT Healthiness	29 (6 male)
2	Multiple products, session 1	IAT Attractiveness	47 (10 male)
2	Multiple products, session 1	IAT Healthiness	48 (8 male)
2	Multiple products, session 2	IAT Attractiveness and IAT Healthiness	91 (17 male)

2.2 Implicit Association Test

The IAT is a classification task where attribute stimuli (IAT Attractiveness: *attractive* versus *unattractive* terms; IAT Healthiness: *healthy* versus *unhealthy* terms) and target stimuli (coloured images of product packages per product category) have to be sorted into the correct categories by using keyboard response keys that correspond to both an attribute as well as target category. Target images of product packages in Experiment 1a and 1b consisted of *vibrantly coloured packages* (*i.e.,* low brightness, high saturation) vs. *less vibrantly coloured packages* (*i.e.,* high brightness, low saturation) (see Figure 4.1). Target images of products in Experiment 2 consisted of *warm coloured packages* (*i.e.,* red, orange, pink, purple) vs. *cool coloured packages* (*i.e.,* green, blue) (see Figure 4.1). The IAT consisted of seven blocks. The fourth and seventh blocks were the two most critical blocks. During the fourth block, in Experiment 1a, *less vibrantly coloured package* target images and *unattractive* attribute terms shared a response key on the keyboard (see Figure 4.1 for the attribute terms used). Whenever a *vibrantly coloured package* target image or an *attractive* attribute term appeared, participants pressed another key. In Experiment 1b, compared to Experiment 1a, *attractive* attribute terms were replaced by *unhealthy* attribute terms, and *unattractive* attribute terms were replaced by *unhealthy* attribute terms. In Experiment 2, compared to Experiment 1a and 1b, *less vibrantly coloured package* target images were replaced by *cool coloured package* target images, and *vibrantly coloured package* target images were replaced by *warm coloured package* target images. Throughout the task, the target and attribute category terms/images stayed on the screen. The fourth block is seen as the congruent IAT block. During the seventh block the attribute categories (*i.e.,* terms) switched response keys, so that a *less vibrantly coloured package* (Experiment 1a, 1b) or a *cool coloured package* (Experiment 2) target image and an *attractive* (Experiment 1a, 2) or an *unhealthy* attribute (Experiment 1b, 2) term shared a response key. Whenever a *vibrantly coloured package* (Experiment 1a, 1b) or a *warm coloured package* (Experiment 2) target image or an *unattractive* (Experiment 1a, 2) or a *healthy* attribute (Experiment 1b, 2) word appeared, participants pressed another shared key. This is seen as the incongruent IAT block. Table 4.2 shows an overview of all blocks, trials and category combinations per experiment. Participant performance for strongly associated target and attribute categories (measured in reaction time) is expected to be enhanced (*i.e.,* shorter reaction time) compared to performance for weaker associated categories.

Table 4.2 Summary of IAT blocks presented in the experiments

			IAT Attractiveness* (Experiment 1a)		IAT Healthiness* (Experiment 1b)	
Block	**Number of trials**	**Function**	**Items assigned to the left-key response**	**Items assigned to the right-key response**	**Items assigned to the left-key response**	**Items assigned to the right-key response**
1	12	Practice	Vibrantly coloured package images	Less vibrantly coloured package images	Less vibrantly coloured package images	Vibrantly coloured package images
2	12	Practice	Attractive terms	Unattractive terms	Healthy terms	Unhealthy terms
3	24	Practice	Vibrantly coloured package images + Attractive terms	Less vibrantly coloured package images + Unattractive terms	Less vibrantly coloured package images + Healthy terms	Vibrantly coloured package images + Unhealthy terms
4	48	Critical test block	Vibrantly coloured package images + Attractive terms	Less vibrantly coloured package images + Unattractive terms	Less vibrantly coloured images + Healthy terms	Vibrantly coloured packages + Unhealthy terms
5	12	Practice	Unattractive terms	Attractive terms	Unhealthy terms	Healthy terms
6	24	Practice	Vibrantly coloured package images + Unattractive terms	Less vibrantly coloured package images + Attractive terms	Less vibrantly coloured package images + Unhealthy terms	Vibrantly coloured package images + Healthy terms
7	48	Critical test block	Vibrantly coloured package images + Unattractive terms	Less vibrantly coloured package images + Attractive terms	Less vibrantly coloured package images + Unhealthy terms	Vibrantly coloured package images + Healthy terms

* In Experiment 2, the vibrantly coloured package images and less vibrantly coloured package images were replaced by warm coloured package images and cool coloured package images respectively.

2.3 Stimuli IATs

The terms used in the IATs were selected based on literature and synonyms related to the concepts of healthiness and attractiveness (*e.g.,* Raghunathan et al. (2006)). Figure 4.1 shows the attribute terms used in Experiment 1a, 1b and 2. Package images in Experiments 1a and 1b were designed to differ on hue (*i.e.,* colour category, such as red and blue), brightness (*i.e.,* the amount of black/white added to the hue), and saturation (*i.e.,* the intensity of the hue) to create more/less vibrantly coloured packages (Tijssen et al., 2017). Images of packages were slightly blurred in Experiment 1 to emphasise package colour aspects compared to other package features (*e.g.,* brand, labels). Package images in Experiment 2 were a selection of packages designed by the Department of Packaging Design and Management of the University Twente (The Netherlands) in which the association between packaging and perceived (un)healthiness (Gelici-Zeko, Lutters, Klooster, & Weijzen, 2013) and (un)attractiveness (Van der Laan et al., 2012) was established in Dutch consumers. See Figure 4.1 for all package images used.

2.4 Procedure

In experiments 1a, 1b and 2 participants were invited to a central location at Wageningen University. The venues accommodated a maximum of 15 subjects at a time, and participants were seated at individual tables in front of a computer (23 inch, 1920×1080 screen resolution, 32 bit colour depth, 60 Hz screen refresh rate).

2.4.1 Experiment 1a and 1b

Participants performed an IAT (Experiment 1a; attractiveness, Experiment 1b; healthiness), afterwards they were asked to evaluate *expected* sensory and hedonic properties of either a low-calorie dairy drink or a fat-reduced sausage based on package images (Tijssen et al., 2017). Participants received €10,- monetary reimbursement after finishing the experiment.

2.4.2 Experiment 2

Initially, participants performed either an IAT healthiness *or* an IAT attractiveness. Afterwards they blindly evaluated chocolate-sesame biscuits (not reported here). After 6 Home Use Tests across 3 weeks, in which they evaluated the same cookie with different packages, participants returned to the central location for a last session to perform both the IAT attractiveness *and* IAT healthiness (Tijssen et al., in prep.). Participants received €25,- monetary reimbursement after finishing the experiment.

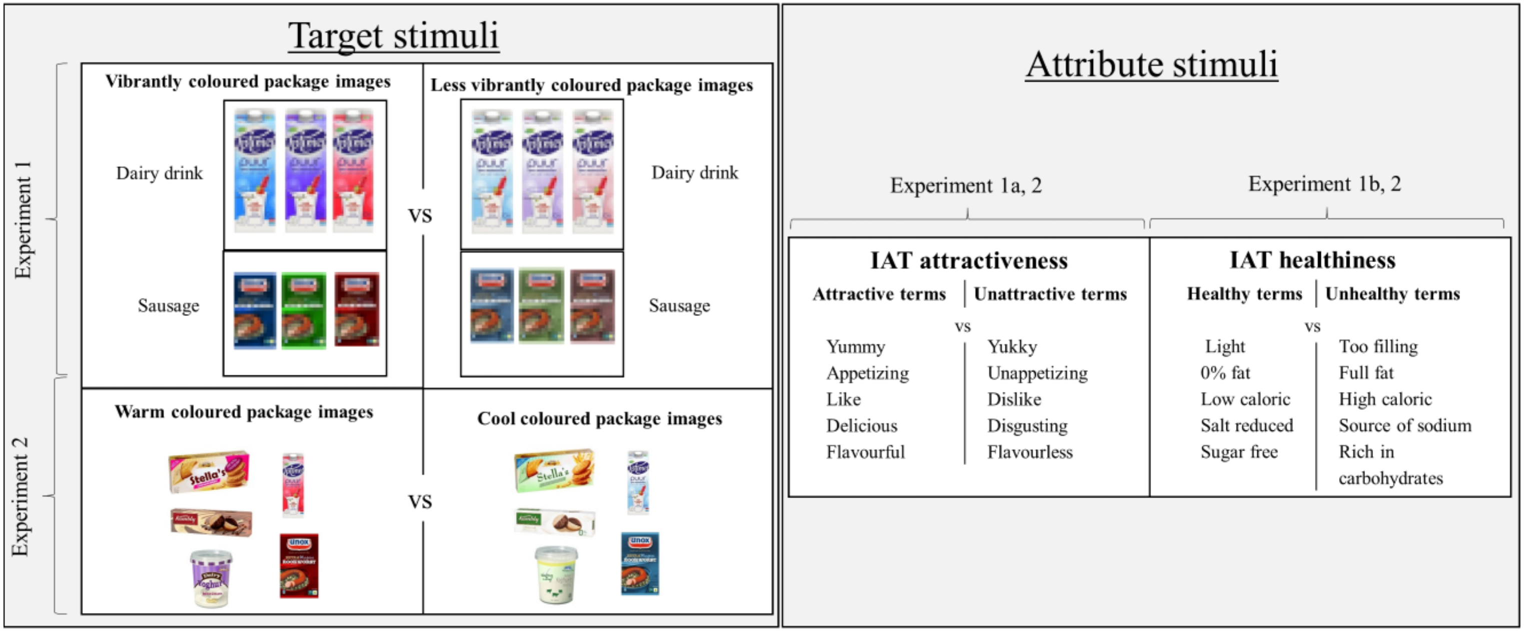

Figure 4.1 Overview of target images of products categories (*i.e.,* dairy drink, sausage, multiple products) per experiment, and attribute terms for IAT attractiveness and IAT healthiness per experiment.

2.5 Data analysis

Reaction times (RTs) and error rates were recorded. The difference in performance between congruent and incongruent test blocks is used as a measure of association strength. This measure is calculated according to the scoring algorithm suggested by Anthony G. Greenwald et al. (2003) resulting in effect size 'D' which can be interpreted similar to Cohen's *d* effect sizes. One sample T-tests were used to investigate if effect sizes (D) were significantly different from zero ($p<0.05$). Across experiments, two one-sample T-tests (*i.e.,* IAT attractiveness, IAT healthiness) were used to assess if overall effect sizes (D) were significantly different from zero ($p<0.05$).

3. Results

3.1 IAT Attractiveness

Response latencies for the IAT Attractiveness were shorter when *attractive* terms were combined with *vibrantly coloured package* images (Experiment 1a) or *warm coloured package* images (Experiment 2) compared to combinations of *unattractive* terms and *vibrantly coloured package* images (Experiment 1a) or *cool coloured package images* (Experiment 2). The effect sizes (D) were significantly different from zero in Experiment 1a and in session 1 of Experiment 2, but not in session 2 (session 1: $p<0.001$; session 2: $p=0.315$) (Table 4.3).

3.2 IAT Healthiness

Response latencies for the IAT Healthiness were shorter when *healthy* terms were combined with *less vibrantly coloured package* images (Experiment 1b) or *cool coloured package* images (Experiment 2) compared to combinations of *unhealthy* terms and *less vibrantly coloured package* images (Experiment 1b) or *cool coloured package images* (Experiment 2). In Experiment 1b, the effect sizes (D) were significantly different from zero for the dairy drink, but not for the sausage (dairy drink, $p<0.001$; sausage, $p=0.273$). In Experiment 2, the effect sizes (D) were significantly different from zero in both sessions ($p<0.001$) (Table 4.3).

3.3 Overall effects across experiments

Across experiments, response latencies for the IAT attractiveness were shorter when *attractive* terms were combined with *vibrantly coloured/warm coloured package* images compared to combinations of *unattractive* terms and *vibrantly coloured/warm coloured package* images. The overall effect sizes (D) were significantly different from zero ($p<0.001$) (Table 4.3). Response latencies for the IAT healthiness were faster when *healthy* terms were combined with *less vibrantly coloured/cool coloured package* images compared to combinations of *unhealthy* terms and *less vibrantly coloured/cool coloured package* images. The overall effect sizes (D) were significantly different from zero ($p<0.001$) (Table 4.3).

Table 4.3 Summary of IAT results of Experiments 1a, 1b, 2 and overall.

Experiment	Product images	Session	IAT	Target/Attribute combination IAT block 4	Response time ms (mean ± *SD*)	Target/Attribute combination IAT block 7	Response time ms (mean ± *SD*)	Effect size (*D*) (mean ± *SD*)	T-value	*p*-value	Number of participants
1a	Dairy drink	Session 1	IAT Attractiveness	Vibrantly coloured package images + Attractive terms & Less vibrantly coloured package images + Unattractive terms	773 (*175*)	Vibrantly coloured package images + Unattractive terms & Less vibrantly coloured package images + Attractive terms	907 (*241*)	0.59 (*0.78*)	6.8	$p<0.001$	83 (18 male)
1a	Sausage	Session 1	IAT Attractiveness	Vibrantly coloured package images + Attractive terms & Less vibrantly coloured package images + Unattractive terms	744 (*117*)	Vibrantly coloured package images + Unattractive terms & Less vibrantly coloured package images + Attractive terms	1021 (*184*)	1.24 (*0.78*)	12.79	$p<0.001$	65 (14 male)
1b	Dairy drink	Session 1	IAT Healthiness	Less vibrantly coloured package images + Healthy terms & Vibrantly coloured package images + Unhealthy terms	849 (*117*)	Less vibrantly coloured package images + Unhealthy terms & Vibrantly coloured package images + Healthy terms	1054 (*263*)	0.67 (*0.52*)	7.12	$p<0.001$	30 (6 male)
1b	Sausage	Session 1	IAT Healthiness	Less vibrantly coloured package images + Healthy terms & Vibrantly coloured package images + Unhealthy terms	947 (*251*)	Less vibrantly coloured package images + Unhealthy terms & Vibrantly coloured package images + Healthy terms	995 (*195*)	0.12 (*0.56*)	1.12	$p=0.27$	29 (6 male)
2	Cookies, dairy products, sausage	Session 1	IAT Attractiveness	Warm coloured package images + Attractive terms & Cool coloured package images + Unattractive terms	833 (*246*)	Warm coloured package images + Unattractive terms & Cool coloured package images + Attractive terms	858 (*118*)	0.32 (*0.57*)	3.89	$p<0.001$	47 (10 male)
2	Cookies, dairy products, sausage	Session 2	IAT Attractiveness	Warm coloured package images + Attractive terms & Cool coloured package images + Unattractive terms	743 (*200*)	Warm coloured package images + Unattractive terms & Cool coloured package images + Attractive terms	746 (*139*)	0.07 (*0.62*)	1.01	$p=0.32$	91 (17 male)
2	Cookies, dairy products, sausage	Session 1	IAT Healthiness	Cool coloured package images + Healthy terms & Warm coloured package images + Unhealthy terms	925 (*310*)	Cool coloured package images + Unhealthy terms & Warm coloured package images + Healthy terms	1140 (*345*)	0.44 (*0.48*)	6.44	$p<0.001$	48 (8 male)
2	Cookies, dairy products, sausage	Session 2	IAT Healthiness	Cool coloured package images + Healthy terms & Warm coloured package images + Unhealthy terms	722 (*193*)	Cool coloured package images + Unhealthy terms & Warm coloured package images + Healthy terms	889 (*246*)	0.51 (*0.43*)	11.34	$p<0.001$	91 (17 male)
Overall			IAT Attractiveness		766.79 (188.03)		873.50 (214.81)	0.53 (0.83)	10.78	$p<0.001$	286
Overall			IAT Healthiness		823.37 (251.15)		990.50 (288.04)	0.46 (0.50)	13.04	$p<0.001$	198

4. Discussion

This study investigated the robustness and generalisability of implicit associations between package colour properties and the concepts of healthiness and attractiveness. We robustly demonstrated implicit associations in eight IATs across two studies in Dutch consumers. Results consistently showed that *less vibrantly coloured packages* and *'cool' coloured packages* were implicitly more strongly associated with *healthiness* compared to *vibrantly coloured packages* and *'warm' coloured packages*. Similarly, *vibrantly coloured packages* and *'warm' coloured packages* were shown to be more strongly associated with *attractiveness* compared to *less vibrantly coloured packages* and *'cool' coloured packages*. These results indicate the importance of package colour properties when designing attractive and healthier food products.

We are the first to implicitly research to what extent package colour properties signal product attractiveness and healthiness. Earlier research using explicit methodologies showed that package colour mainly influenced product expectations and, to a lesser extent, product perception when products were tasted (*e.g.,* Tijssen et al. (2017); Zellner et al. (2018), for a review see Spence and Velasco (2018)). The results of related studies using explicit methods are in line with the results of our study demonstrating that blue and green ('cool') coloured packages as well as lighter, less vibrantly coloured packages were expected and perceived to be healthier and less attractive than red ('warm') and/or darker, more vibrantly coloured packages (Huang & Lu, 2015; Schuldt, 2013; Tijssen et al., 2017). Although explicit measurement has been efficient and convenient when it comes to food evaluation, they rely on the key assumption that people are aware and able to verbalize their behaviours. However, a substantial portion of food behaviour is shaped outside of conscious awareness and is largely driven by habits, *i.e.,* behavioural patterns acquired by frequent repetition that proceed in an automatic, subconscious way, with little or no conscious deliberation about competing alternatives (Bargh, 2002). Explicitly and consciously verbalizing such behaviours, can thus be difficult and incongruent with the implicit automatic processing mode (Fazio & Olson, 2003; Kahneman, 2012). Methods that implicitly measure the influences of package colour properties on healthiness and attractiveness, such as the IAT, provide quantifiable insights into the underlying, subconscious, automatic associations, thereby complementing the traditional explicit methods. We therefore recommend a combined approach of explicit and implicit methodologies, to tap into both conscious and unconscious attitudes, to better understand the meaning and messages conveyed through packages (*e.g.,* through colour).

The implicit knowledge can be used by the food industry to facilitate the development of new and reformulated food products during different stages of product and package design. At present, the majority of new products fail to be successful in the marketplace despite extensive consumer testing of both product and packaging. This may well be because of the explicit nature of consumer testing of new products, which rely on a consumer's verbalised consciously aware beliefs (for a review see Van Kleef, Van Trijp, and Luning (2005)). Next to this, insufficient understanding about the translation of conscious, explicit food evaluation to more unconscious, implicit determinants of food evaluation and choice behaviour may also hamper chances of market success.

There are also some limitations worthwhile to discuss. Implicit measures such as the IAT measure behavioural tendencies of relative constructs (*e.g.,* more/less associated with healthiness)which means that the absolute degree to which the construct is of importance in terms of food behaviour is not reflected by this implicit measure and should be established separately, *e.g.* by using focus groups or questionnaires. In line with this, how these relative tendencies correlate to subsequent food behaviour is underexamined, although Greenwald et al. (2009) state that, in general, the IAT has great potential to predict 'actual' food behaviour. Lastly, what happens in terms of product evaluation in real-life contexts in the presence of other contextual cues (*e.g.,* price, brand, visibility) is at present unknown.

To conclude, we robustly demonstrate the ability of the IAT to tap into unconscious attitudes of package colour properties and the concepts of healthiness and attractiveness. *Less vibrantly coloured* or *'cool' coloured packages* signal *healthiness* and less *attractiveness* compared to *vibrantly coloured* or *'warm' coloured packages*. Implicit measures such as the IAT are valuable additions to the test repertoire to assess consumer responses to foods and predict consumer food choice behaviour.

References

Bargh, J. A. (2002). Losing Consciousness: Automatic Influences on Consumer Judgment, Behavior, and Motivation. Journal of Consumer Research, 29(2), 280-285.

Carrillo, E., Varela, P., Salvador, A., & Fiszman, S. (2011). MAIN FACTORS UNDERLYING CONSUMERS'FOOD CHOICE: A FIRST STEP FOR THE UNDERSTANDING OF ATTITUDES TOWARD “HEALTHY EATING”. Journal of Sensory Studies, 26(2), 85-95.

Fazio, R. H., & Olson, M. A. (2003). Implicit Measures in Social Cognition Research: Their Meaning and Use. Annu Rev Psychol, 54(1), 297-327. doi: 10.1146/annurev.psych.54.101601.145225

Gelici-Zeko, M., Lutters, D., Klooster, R. t., & Weijzen, P. (2013). Studying the influence of packaging design on consumer perceptions (of dairy products) using categorizing and perceptual mapping. Packaging Technology and Science, 26(4), 215-228.

Greenwald, A. G., McGhee, D. E., & Schwartz, L. K. (1998). Measuring individual differences in implicit cognition: The implicit association task. Journal of Personality and Social Psychology, 74(6), 1464-1480.

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the Implicit Association Test: I. An improved scoring algorithm. Journal of Personality and Social Psychology, 85(2), 197-216. doi: 10.1037/0022-3514.85.2.197

Greenwald, A. G., Poehlman, T. A., Uhlmann, E. L., & Banaji, M. R. (2009). Understanding and using the Implicit Association Test: III. Meta-analysis of predictive validity. Journal of Personality and Social Psychology, 97(1), 17.

Huang, L., & Lu, J. (2015). The Impact of Package Color and the Nutrition Content Labels on the Perception of Food Healthiness and Purchase Intention. Journal of Food Products Marketing, 1-29. doi: 10.1080/10454446.2014.1000434

Ishihara, S. (1951). Tests for colour-blindness (10th completely rev. ed.). Tokyo?: Nippon Isho Shuppan Co.

Jo, J., & Lusk, J. L. (2018). If it’s healthy, it’s tasty and expensive: Effects of nutritional labels on price and taste expectations. Food Quality and Preference, 68, 332-341. doi: https://doi.org/10.1016/j.foodqual.2018.04.002

Kahneman, D. (2012). Thinking, fast and slow: Farrar, Straus and Giroux.

Mai, R., Symmank, C., & Seeberg-Elverfeldt, B. (2016). Light and Pale Colors in Food Packaging: When Does This Package Cue Signal Superior Healthiness or Inferior Tastiness? Journal of Retailing, 92(4), 426-444. doi: https://doi.org/10.1016/j.jretai.2016.08.002

Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. Food Quality and Preference, 40, 165-179. doi: 10.1016/j.foodqual.2014.09.013

Raghunathan, R., Walker Naylor, R., & Hoyer, W. D. (2006). The unhealthy is tasty intuition an its effect on taste inferences enjoyment and choice of food products. Journal of Marketing, 70, 170-184.

Schuldt, J. P. (2013). Does green mean healthy? Nutrition label color affects perceptions of healthfulness. Health Commun, 28(8), 814-821. doi: 10.1080/10410236.2012.725270

Singh, S. (2006). Impact of color on marketing. Management Decision, 44(6), 783-789. doi: 10.1108/00251740610673332

Spence, C., & Velasco, C. (2018). On the multiple effects of packaging colour on consumer behaviour and product experience in the ‘food and beverage’and ‘home and personal care’categories. Food Quality and Preference.

Tijssen, I., Zandstra, E. H., de Graaf, C., & Jager, G. (2017). Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar- and fat-reduced products. Food Quality and Preference, 59, 46-58. doi: 10.1016/j.foodqual.2017.01.019

Tijssen, I., Zandstra, E. H., & Jager, G. (in prep.). Taste matters most: effects of package design on the dynamics of implicit and explicit product evaluations over repeated in-home consumption.

Van der Laan, L. N., De Ridder, D. T., Viergever, M. A., & Smeets, P. A. (2012). Appearance matters: neural correlates of food choice and packaging aesthetics. PLoS One, 7(7), e41738. doi: 10.1371/journal.pone.0041738

Van Kleef, E., Van Trijp, H. C., & Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. Food Quality and Preference, 16(3), 181-201.

van Rompay, T. J. L., Deterink, F., & Fenko, A. (2016). Healthy package, healthy product? Effects of packaging design as a function of purchase setting. Food Quality and Preference, 53, 84-89. doi: 10.1016/j.foodqual.2016.06.001

Werle, C. O. C., Trendel, O., & Ardito, G. (2013). Unhealthy food is not tastier for everybody: The "healthy=tasty" French intuition. Food Quality and Preference, 28(1), 116-121. doi: 10.1016/j.foodqual.2012.07.007

Zellner, D., Greene, N., Jimenez, M., Calderon, A., Diaz, Y., & Sheraton, M. (2018). The effect of wrapper color on candy flavor expectations and perceptions. Food Quality and Preference, 68, 98-104.

Chapter 5

Taste matters most: Effects of package design on the dynamics of implicit and explicit product evaluations over repeated in-home consumption

Irene O.J.M. Tijssen
Elizabeth H. Zandstra
Annick den Boer
Gerry Jager

Submitted

Abstract

Package design influences consumers' expectations of a product's sensory properties and expected healthiness and/or tastiness, and potentially also changes actual product perception during consumption. The robustness of these effects is far from clear, however. This study investigated the influence of package cues signalling either hedonic or healthy product properties on expectations and subsequent product evaluation over repeated consumption.

In a between-subjects design, 92 participants evaluated product expectations and taste perceptions of a chocolate-sesame flavoured biscuit with a package emphasising either its healthy (n=44) or hedonic (n=48) aspects, both at a central location (CLT) and during six home use tests (HUT), using both explicit (questionnaires) and implicit (IAT) measures.

Package design significantly affected (p<0.05) consumers' expectations of the product. They expected the biscuit to be tastier, less attractive and less healthy in the hedonic package condition, and less tasty, more attractive and healthier in the healthy package condition. However, these effects did not transfer to actual product evaluations upon tasting, either blind or tasting in combination with viewing the package during the HUTs. Implicit attitudes did change as a result of repeated exposures, depending on the package consumers were provided with, indicating product-package interactions over time (p<0.05).

In conclusion, package design influences product expectations and associations with its healthiness and attractiveness, which is of relevance in product choice and purchase settings. However, at the stage of (repeated) consumption, intrinsic (sensory) properties become the dominant drivers of products' sensory and hedonic evaluations, and the impact of package cues seems less potent.

1. Introduction

The impact of a multitude of packaging cues, *e.g.,* colour and label, on consumers expectations concerning a product's sensory properties and conceptual appraisals, such as a product's attractiveness, has been well established over the years (for a review see Piqueras-Fiszman and Spence (2015)). Fewer studies, however, have investigated if these effects of packaging cues on consumers' expectations result in changes in actual product perception. And if they do, it is largely unknown whether these effects are long-lasting and robust over repeated exposure. Briefly, this is the focus of the present study where the effects of extrinsic package cues signalling either more healthy or more hedonic properties on product (a biscuit) expectations and subsequent evaluation over repeated consumption were investigated.

Several studies have examined effects of package based expectations on actual healthy/hedonic product evaluation (*e.g.,* colour; Tijssen, Zandstra, de Graaf, and Jager (2017), label; Tarancón, Sanz, Fiszman, and Tárrega (2014), impression; van Rompay, Deterink, and Fenko (2016), shape; Spence and Gallace (2011), communication message; Liem, Toraman Aydin, and Zandstra (2012); Yeomans, Chambers, Blumenthal, and Blake (2008)). In a previous study, we demonstrated that more vibrantly coloured packages (perceived as relatively more attractive and less healthy) gave rise to more intense sensory expectations which consequently also resulted in more intense sensory evaluations (*e.g.,* regarding sweetness) after consumption compared to the same product in combination with less vibrantly coloured packages (perceived as relatively healthier) (Tijssen et al., 2017). Relatedly, Yeomans et al. (2008) demonstrated that while expected pleasantness of a savoury mouse labelled "ice-cream" was higher compared to a "frozen savoury mouse" or a neutral control condition, the actual pleasantness evaluation resulted in the opposite, likely due to expectations of a sweet taste in the "ice-cream" condition resulting in a negative hedonic 'surprise' when subsequently exposed to the savoury taste.

A widely used theoretical model that has been put forward to explain the effects of expectations on sensory perception of food and drinks (for an detailed review and empirical evidence see Piqueras-Fiszman and Spence (2015)), is the assimilation/contrast model (Anderson, 1973; Cardello & Sawyer, 1992; Davidenko et al., 2015; Deliza & MacFie, 1996; Piqueras-Fiszman & Spence, 2015). Whenever we interact with food or drinks, our brain makes predictions about expectations based on inferences from all present and previously experienced information that may be available about the food or drinks (Clark, 2013). At the point of subsequent consumption, there can be a discrepancy between these prediction based expectations and actual evaluation. A strategy of the brain is to correct for this discrepancy (*i.e.,* prediction error) by altering the evaluation towards expectations (*i.e.,* assimilation) when the discrepancy (in the eyes of the consumer) is small enough *e.g.,* in the case of Tijssen et al. (2017). If the discrepancy is too large, evaluation is altered away from prediction (*i.e.,* contrast) *e.g.,* in the case of Yeomans et al. (2008).

Package based expectations depend on factors such as product type, contextual setting and consumer attitudes/beliefs related to this. For example, van Rompay et al. (2016) showed that package design (signalling healthiness/tastiness impressions) influenced taste evaluation in a discount supermarket, but not in a 'green supermarket' demonstrating influences of contextual setting on effects. Related to consumer attitudes, Huang and Lu (2015) demonstrated that package colour effects on sensory and healthiness expectations were moderated by consumers' level of external eating. Furthermore related to effects on actual consumption, Cavanagh and Forestell (2013) showed that restraint eaters consumed more of a cookie with a healthful brand compared to the same cookie with an unhealthful brand, but consumption did not differ among unrestraint eaters. Hence, what happens in terms of expectation formation, based on consumers' prior related knowledge, attitudes and beliefs, and subsequent consequences of these expectations on evaluation upon consumption is complex. And it becomes even more complex when we take into account the dynamics of expectation formation. Prediction based expectations are updated with every encounter with the product to decrease the likelihood of future "errors" in prediction (Clark, 2013). Hence, the boundaries as to when assimilation or contrast occur may change and as familiarity with the product increases, expectations and perceptions based on extrinsic product properties (*i.e.,* package cues) may become more certain and closer to intrinsic (sensory) product properties (Ludden, Schifferstein, & Hekkert, 2009). Still, most food research focussed on effects of single product exposure, often in a lab context, on effects of expectation on evaluation disregarding influences of familiarity dynamics. Research on the effects of expectation on experience over repeated exposure outside a lab context is very limited (*e.g.,* Willems, van Hout, Zijlstra, and Zandstra (2014)).

Finally, formation and constant updating of product expectations through experience, as well as sensory food evaluations is, in part, a habitual, implicit and subconscious process (Clark, 2013; Piqueras-Fiszman & Spence, 2015). Apart from explicit (self-report) methods, inclusion of implicit tests to access the less conscious processing mode, such as the implicit association test (IAT), is important when investigating effects on dynamic subconscious product evaluation (Greenwald, McGhee, & Schwartz, 1998; Greenwald, Nosek, & Banaji, 2003).

The aim of the present study was to investigate the effect of packaging design (with multiple package cues signalling healthy/hedonic properties) on product expectations, and actual product perception over repeated exposures, using both implicit and explicit measures. In addition, we evaluated if such packaging effects are moderated by relevant consumer beliefs and attitudes, *i.e.,* health and taste attitudes, eating style and impulsiveness.

In a between-subjects design participants evaluated the same biscuits packaged in one out of two packages that were especially designed for this study, and either signalled 'healthiness' or 'attractiveness'. Blind (product) evaluations, expectations (based on package) with regard to sensory, health and hedonic attributes, and informed evaluations (package + product) were assessed for three consecutive weeks over six exposures at home. Prior and post to the at home tests, products were evaluated in central location tests, both explicitly (questionnaires) and by measuring implicit attitudes towards package designs signalling relatively more 'healthiness' and 'attractiveness' using implicit association tests (IATs). Lastly, consumers' eating goals, eating style and trait impulsiveness were measured.

We hypothesized that multiple cues on packages that signal healthy/hedonic features would elicit their effect on product perception through assimilation, that is shifting sensory perception of the biscuits towards what was expected based on the package design. We further expected that during initial evaluations of the product, *i.e.,* when familiarity was low, the impact of extrinsic product properties (*i.e.,* package cues) on product expectations would be larger, whereas with increasing familiarity with intrinsic (sensory) product properties, the effect of packaging cues on expectations and actual product evaluation would decrease. We expected that implicit measurements, reflecting unconscious behavioural intentions ('automatic mind set'), would be more prone to assimilation/contrast over repeated exposure compared to explicit measurements, which capture more controlled behavioural intentions ('rational mind set'). Lastly, we expected that more health-conscious consumers have a more positive attitude towards healthy product packages compared to less health-conscious consumers.

2. Materials and methods

2.1 Participants

96 Dutch participants were recruited for the experiment from Wageningen and surroundings. During participant recruitment, prior to the start of the experiment, data with regard to inclusion criteria, as well as data on several other participant demographics (*e.g.,* household composition and education level) were collected. Inclusion criteria were: untrained in sensory evaluation, not colour blind (as tested by Ishihara's colour blindness test (Ishihara, 1951)), normal smell and taste abilities (self-reported), normal weight (BMI between 18.5-25 kg/m^2) and aged between 18 – 45 years old. Four participants dropped out during the experiment due to disliking of the product or untimely completing of the questionnaires. Therefore, explicit data from 92 subjects (M=21.7 kg/m^2, SD=2.0, M=22.5 years old, SD=6.4), were considered for the analysis. In total 91 participants completed both the implicit measures of the experiment, but technical problems resulted in some incomplete data logging. Therefore, implicit data from 88 participants were included for further analyses. The study was carried out according the ESOMAR ethical standards embodied in the ICC/ESOMAR International Code of marketing and Social Research Practice (www.esomar.org). Participants gave written consent and received a monetary reimbursement (€25,00) for their participation.

2.2 Product and packages

A commercially available chocolate-sesame biscuit with added minerals, vitamins and fibres (brand: Céréal, Nutrition & Santé, Vilvoorde, Belgium) was selected as test product because of its potential to be considered both as a hedonic (tasty) and utilitarian (healthy) snack. Each biscuit portion contained 3 biscuits and was packaged in a plastic silver opaque foil inside a cardboard box. Two experimental cardboard packages, signalling more/less healthy or hedonic properties, were designed and produced by a packaging company (Bepacked, Vichte, Belgium) (see Figure 5.1). For each package design multiple elements were modified, such as colour, font, and label. Adjustments of these elements were based on research findings showing how package elements affect people's perception of the packages (Hanson-Vaux, Crisinel, & Spence, 2013; Hodgkins et al., 2015; Lei Huang & Ji Lu, 2015; Jacquot, Berthaud, Sghaïr, Diep, & Brand, 2013; Karnal, Machiels, Orth, & Mai, 2016; Kauppinen-Räisänen, 2014; Mai, Symmank, & Seeberg-Elverfeldt, 2016; Spence, 2012; Spence & Gallace, 2011; van Rompay et al., 2016; Varela, Ares, Giménez, & Gámbaro, 2010; Westerman et al., 2013).

The healthy package design contained the following packaging cues: green and blue colours, text focussing on health, nutrition content claim (NCC) about health benefits, front of pack (FOP) nutrition information regarding calories, fat, sugar and salt content per portion, and the brand name pointing downward. For the hedonic package design, package cues consisted of: red and orange colour, text focussing on tastiness of the product, no NCC but a claim about good flavour, FOP nutrition information regarding calories and sugar content per portion, and the brand name pointing upward. The cardboard material used for the hedonic package was more luxurious with a gloss finish. Brand name (fictive) and factual information (*e.g.,* nutritional content and ingredient list) were kept identical and layout was kept similar. Table 5.1 gives an overview of textual details.

Both package versions were tested in a pilot study (*n*=20, data not reported here) where packages were evaluated on expected tastiness, attractiveness and healthiness of the product, using 100-unit Visual Analogue Scales (VAS) anchored “not at all” (left) and “extremely” (right). The results confirmed that indeed the healthy package was perceived as more healthy and less attractive than the hedonic, which was considered more attractive and less healthy.

Figure 5.5 Healthy package version (left) and hedonic package version (right).

2.3 Measurements

Online questionnaires (Logic8 EyeQuestion software, version 4.2.11) were employed to record the responses of each participant regarding each of the below mentioned questionnaires.

Table 5.1. Text as used on the packaging designs, translated from Dutch to English.

	Healthy package design	**Hedonic package design**
Colours	Green, blue	Red, orange
Font brand name	Thick, rounded	Thin, italic
Directionality brand name	Downward	Upward
Material	Cardboard	Cardboard, glossy finish
NCC	"Improves the immune system and decreases fatigue"	"With pieces of dark chocolate for a delicious taste"
FOP nutrition information	Calories fat, sugar and salt content per portion	Calories and sugar content per portion
Text below brand name	"For a vital life"	"Delicious sesame-chocolate biscuits"
Text above ingredients	"Biscuit with sesame seed and chocolate, with added vitamins"	"Biscuit with real sesame seed and pieces of dark chocolate"
Text above nutritional content	*"For years, Gullán has been selecting the best ingredients from nature for you.* <u>Source of vitamins</u> These Gullán sesame-chocolate biscuits contain pieces of dark chocolate and are a source of fibre, vitamin B and E, magnesium and calcium. Gullán biscuits are pure and natural. A tasty treat that is easy to take with you. It is important to have a well-balanced and varied diet, and to live healthy. Enjoy this sesame-chocolate biscuit. Gullán guarantees: The composition: • Folic acid contributes to normal functioning of the immune system • Magnesium contributes to decreasing fatigue • Rich in fibres About naturalness: • No artificial colorants Only natural aromas	*"For years, Gullán has been selecting the best ingredients from nature for you".* <u>Delicious taste</u> Gullán is inspired by our favourite family recipes. Baked according to traditional baking methods and with carefully selected ingredients, these biscuits are a nice treat and easy to take with you. The delicious chocolate and crispy sesame make it a moment of happiness. Enjoy this sesame-chocolate biscuit. Gullán guarantees: The composition: • Chocolate from the best cacao • Real pieces of sesame seed The perfect biscuit: • A good taste • A crispy bite

2.3.1 Participant characteristics

Three questionnaires regarding participant characteristics were employed. The Health & Taste Attitude Scale (HTAS), a 38 item questionnaire scored on a 7-point Likert format scale, to measure the importance of health and taste aspects of food in the choice and consumption process (Roininen, Lähteenmäki, & Tuorila, 1999). To measure trait impulsivity the Barratt Impulsiveness Scale-11 (BIS11), a 30 item, 4-point Likert format scale, was employed (Barratt, 1985; Patton & Stanford, 1995). Lastly the Dutch Eating Behaviour Questionnaire (DEBQ) was used to assess participants' eating style (Van Strien, 1986). DEBQ consists of 33 items with statements about eating behaviour scored on a 5-point Likert format scale.

2.3.2 Product and package evaluation

Questionnaires using 100-unit VAS scales (anchored "not at all" (left) and "extremely" (right)) were employed to collect data on blind product evaluation, package based expectations, and informed evaluation of product-package combinations. Questionnaires consisted of 4 blocks of questions, randomized within blocks. Blocks covered four questions regarding hunger status (block 1), three conceptual appraisal questions regarding healthiness, attractiveness and liking (block 2), seven sensory questions regarding the intensity of sweetness, crunchiness, chocolate flavour, sesame flavour, fattiness, dryness and aftertaste (block 3) and decoy questions regarding other product features (*e.g.,* appropriateness, convenience, portion size appropriateness) (block 4). The order of blocks 2 and 4 was randomized across participants to avoid order effects. Decoy questions were not considered for analyses.

2.3.3 Implicit attitudes

To investigate implicit associations between product package design and attractiveness or healthiness concepts, two Implicit Association Tests (IATs) were conducted (Greenwald et al., 1998; Greenwald et al., 2003). The IAT is a classification task where attribute stimuli (IAT attractiveness: attractive versus unattractive terms; IAT healthiness: healthy versus unhealthy terms) and target stimuli (Both IATs: images of products with a healthy package (*i.e.,* cool coloured design) and hedonic package design (*i.e.,* warm coloured design)) are sorted into the correct categories by using keyboard response keys that correspond to both an attribute as well as target category. Both attribute-target category response key combinations are used in separate blocks. Terms used to represent attribute categories (Table 5.2) were selected based on literature and synonyms related to category concepts (Chapman & Maclean, 1993; Chrysochou, Askegaard, Grunert, & Kristensen, 2010; Croll, Neumark-Sztainer, & Story, 2001; Povey, Conner, Sparks, James, & Shepherd, 1998; Raghunathan, Walker Naylor, & Hoyer, 2006). Package images representing target categories (Figure 5.2) were a combination of images used in a previous study (Tijssen et al., 2017), and images adopted from research that established the association between packaging and perceived (un)attractiveness (Van der Laan, De Ridder, Viergever, & Smeets, 2012), and research that established the association between packaging and perceived (un)healthiness in Dutch consumers (Gelici-Zeko, Lutters, Klooster, & Weijzen, 2013).

Participant performance for strongly associated target and attribute categories (measured in reaction time) was expected to be enhanced (shorter reaction time) compared to performance for weaker associated categories. The difference in performance is used as a measure of association strength and is calculated using a scoring algorithm by (Anthony G. Greenwald et al., 2003), resulting in effect sizes 'D' which can be interpreted similar to Cohen's *d* effect sizes.

Table 5.2 Stimuli terms used for IAT

IAT attractiveness		IAT healthiness	
Attractive	***Unattractive***	***Healthy***	***Unhealthy***
Yummy	Yukky	Light	Too filling
Appetizing	Unappetizing	0% fat	Full fat
Like	Dislike	Low caloric	High caloric
Delicious	Disgusting	Sugar free	Rich in carbohydrates
Flavourful	Flavourless	Salt reduced	Source of sodium

Figure 5.2 Target images used for IATs
Sources: Van der Laan et al. (2012), Tijssen et al. (2017)
Top row: hedonic 'warm' coloured package designs, bottom row: healthy 'cool' coloured package designs

2.4 Procedure

A schematic overview of all procedures is given in Figure 5.3 and explained in more detail below. Data were collected at a research location of Wageningen University (the Netherlands) and at participants homes. Participants were randomly divided into two groups: receiving the healthy package design (*i.e.,* "healthy condition") (*n*=44; 6 male) or receiving the hedonic package design (*i.e.,* "hedonic condition") (*n*=48; 12 male). Participants were unaware of the multiple conditions and were told the aim was to assess "what makes a product perfect". Each participant completed 8 sessions. At the start, a central location test (CLT) was conducted to assess blind product evaluation and implicit attitudes. This was followed by 6 home-use tests (HUT) across three weeks to assess package expectations, and informed product-package evaluations. At the end, a CLT was conducted again to assess implicit attitudes. Participants refrained from eating and drinking calorie-or caffeine containing products, and smoking up to two hours before each session.

2.4.1 Central location test

2.4.1.1 CLT (session 0)

Participants were positioned at separate tables and evaluated the product blindly using an online questionnaire presented on a PC. They received one portion (*i.e.,* three biscuits) of the product in a plastic silver opaque foil without cardboard package on a white plastic plate and a cup of water to rinse their mouths in between if required. Multiple bites were allowed to evaluate the product. Participants then performed an IAT, half (*n*=45) of the participants completed the IAT healthiness, the other half (*n*=43) completed the IAT attractiveness (randomly divided). Participants completed only one IAT (either IAT healthiness or attractiveness) during the session due to time limitations. Lastly, participants received 6 portions of the product in the assigned package (healthy or hedonic) to take home to evaluate during the HUT sessions.

2.4.1.2 CLT (session 7)

Participants were again positioned at separate tables behind a computer and completed two IATs in random order; IAT healthiness and IAT attractiveness. Afterwards they finished the experiment with a questionnaire to assess participants' aim awareness. Less than 5% of the participants uncovered the true aim of the experiment. Data were analysed both including and excluding these participants, no significant differences were seen. Therefore, no participants were excluded from the analyses as reported.

2.4.2 Home-use test (session 1-6)

On each Monday and Friday for three consecutive weeks, participants received an online questionnaire (accessible via a link on the day of the planned session only) to assess informed evaluation of product-package combinations. Participants were instructed to perform all test sessions at the same time of the day (*e.g.,* consistently at 11 a.m.). During the first HUT session they were instructed to evaluate product expectations based on the package, prior to taking the product out of the package, opening it and consuming the entire content (*i.e.,* three biscuits) while answering the questions regarding the product in combination with the package, *i.e.,* informed evaluation. During the 2^{nd}, 3^{rd} and 4^{th} session the informed product-package evaluation was followed by a questionnaire regarding participant characteristics (*i.e.,* HTAS, BIS-11, DEBQ respectively).

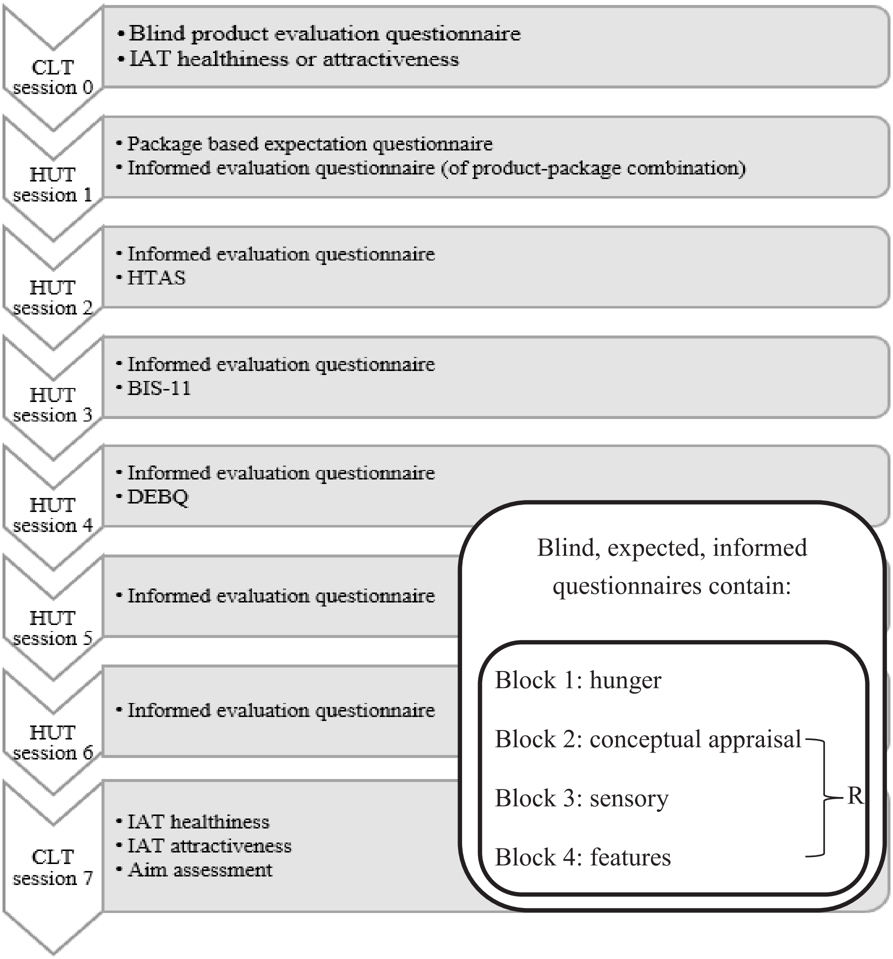

Figure 5.3. Overview of the study procedure. The R indicates a randomized order of blocks 2 and 4.

2.5 Data analysis

Statistical analyses were carried out using SPSS (version 23; SPSS Inc., Chicago, IL, USA). Differences in participant characteristic between conditions (age, BMI, household composition, education level, HTAS subscales, BIS-11 sum, DEBQ subscales) were tested using one-way analysis of variance (ANOVA) ($p<0.05$). For the explicit data, assumption of a normal distribution was checked with QQ plots and Kolmogorov-Smirnov tests, and equal variance was assessed using Levene's tests.

Full factorial General Linear Model (GLM) analyses were performed (within-subject factor: attribute scores per session (8 levels); between-subjects factor: package condition; covariates: age, BMI, household composition, education level, HTAS subscales, BIS-11 sum, DEBQ subscales), to test for effects of repeated exposure on product perception per attribute (healthiness, attractiveness, liking, sweetness, crunchiness, sesame flavour, chocolate flavour, fattiness, dryness, aftertaste). Bonferroni post hoc tests were used to test for differences between sessions per package condition, and differences between package conditions per session ($p<0.05$). If sphericity was violated in the GLM analyses, the Greenhouse-Geisser correction was used to interpret the data ($p<0.05$).

Regarding implicit data, measures of association strength (effect size D) for IATs were calculated per participant (using Greenwald et al., (2003) scoring algorithm). To investigate implicit associations between package images representing healthy/hedonic package designs and words representing healthiness (healthy versus unhealthy words) or attractiveness (attractive versus unattractive words) response latencies were calculated. T-tests were used to determine if measures of association strength (effect size D) was significantly different from zero. Paired sample t-tests were used to compare CLT sessions 0 and 7 ($p<0.05$).

3. Results

3.1 Participant characteristics

Table 5.3 shows the main characteristics of all participants per package condition. There were no significant differences in any measured participant characteristic between conditions.

Table 5.3. Average participant characteristics divided per packaging condition.

	Healthy condition		**Hedonic condition**		**Condition differences***	
Number of participants (*n*)	44 (6 male)		48 (12 male)			
	Mean	***SD***	***Mean***	***SD***	***F-value***	***p-value***
Age (y)	22.0	*5.7*	23.0	*7.0*	1.29	0.26
BMI (kg/m^2)	22.0	*2.2*	22.0	*1.9*	0.80	0.38
HTAS (range 1-7)						
General Health Interest (GHI)	5.0	*0.7*	4.8	*0.9*	1.08	0.31
Light Product Interest (LPI)	3.4	*1.4*	3.2	*1.1*	0.69	0.41
Natural Product Interest (NPI)	3.7	*1.2*	3.5	*1.1*	1.10	0.30
Food as Reward (FAR)	4.3	*0.8*	4.2	*0.8*	0.09	0.77
Craving Sweet foods (CS)	3.8	*1.0*	3.9	*0.9*	0.46	0.50
Pleasure (P)	4.6	*0.8*	4.7	*0.8*	0.36	0.55
BIS11 (range 30-120)						
Impulsivity	60.5	*7.2*	61.4	*8.7*	0.29	0.60
DEBQ (range 1-5)						
Emotional eating (EE)	2.6	*0.6*	2.6	*0.8*	0.14	0.71
Restraint eating (RE)	2.8	*0.7*	2.7	*0.7*	0.41	0.52
External eating (ExE)	3.2	*0.4*	3.1	*0.6*	0.57	0.45

* Differences between conditions were tested for significance by ANOVA ($p<0.05$).

3.2 Effects of package design on (expected) product perception over repeated exposure

Table 5.4 shows the blind product evaluations, package based expectations and informed product-package evaluations per package condition per session. Normality and equal variances could be assumed. Mauchly's test of sphericity was violated in all analyses ($p<0.05$), so Greenhouse-Geisser was used to interpret the output of the GLM analyses.

GLM analyses yielded significant effects between package condition and session indicating different attribute scores over time (session) or between package conditions for the following attributes: healthiness ($F(7,532)=10.47$, $p<0.001$), attractiveness ($F(7,532)=4.81$, $p=0.001$), sweetness ($F(7,532)=7.49$, $p<0.001$), chocolate flavour ($F(7,532)=20.51$, $p<0.001$), sesame flavour ($F(7,532)=4.19$, $p<0.001$), fattiness ($F(7,532)=3.62$, $p<0.01$) and dryness ($F(7,532)=2.65$, $p=0.02$). No significant differences between products across sessions were found for liking ($F(7,532)=0.60$, $p=0.68$), crunchiness ($F(7,532)=1.00$, $p=0.41$) and aftertaste ($F(7,532)=0.86$, $p=0.49$) (Table 5.4). No significant effects of covariates (*i.e.,* age, BMI, household composition, education level, HTAS subscales, BIS-11 sum, DEBQ subscales) were seen ($p>0.05$).

Regarding session effects, significant post hoc effects show that mainly expected evaluations when based on the package alone (HUT 1) were different from blind (CLT 0) and/or informed product evaluations (HUT 1-6). Depending on package condition, expectations were either significantly higher or lower than evaluations in the blind evaluation session and informed sessions. For example, expected chocolate flavour based on the package alone (HUT 1) was significantly higher than perceived chocolate flavour in the blind (CLT 0) and informed evaluations (HUT 1-6) in the hedonic package condition (respective scores of 62.2, 50.0, and *e.g.,* 49.0 (see Table 5.4)), whereas in the healthy package condition expected chocolate flavour scores (HUT 1) were significantly lower than to blind/informed evaluations (CLT 0 / HUT 1-6) (respective scores of 18.9, 50.5, *e.g.,* 51.7 (see Table 5.4)). Related effects were seen for healthiness, attractiveness, liking, sweetness, fattiness and dryness ($p<0.05$). In addition, post hoc results revealed a few significant differences between blind evaluation (CLT 0) and informed product-package evaluation across sessions (HUT 1-6), although no clear patterns could be detected. In the hedonic package condition, attractiveness scores during blind evaluation (CLT 0) were significantly higher than attractiveness scores in the informed evaluation (respective scores: blind: 64.5, HUT 3: 56.7, HUT 5: 55.2 (Table 5.4)) and fattiness scores during blind evaluation (CLT 0) were lower than fattiness scores in the informed evaluations (HUT 2-6). In the healthy package condition, fattiness scores during the blind evaluation (CLT 0) were lower compared to fattiness scores during informed evaluation (HUT 2-6) (Table 5.4).

Regarding package conditions, no post hoc differences were found in the blind evaluation (CLT 0). However differences were seen regarding product expectations (HUT 1), where biscuits packed in the healthy package were expected to be significantly healthier, more attractive, more sesame flavoured and dryer, but less sweet, chocolate flavoured and fatty compared to biscuits packed in the hedonic package ($p<0.05$). Very few significant differences between package conditions were seen in the informed product-package evaluations (HUT 2-6). Biscuits in the healthy package condition were perceived as sweeter (HUT 2), more attractive (HUT 5) and more healthy (HUT 2, 5, 6) compared to the hedonic package condition ($p<0.05$) (Table 5.4).

Table 5.4. Mean scores (±SD) per session for all conceptual appraisals and sensory attributes. Significant differences ($p<0.05$) between sessions are indicated per row with superscript letters. Significance ($p<0.05$) between products is indicated with an asterisk across columns.

	CLT Blind Blind Based on tasting	HUT Session 1 Expected Based on package alone	HUT Session 1 Informed	HUT Session 2 Informed	HUT Session 3 Informed	HUT Session 4 Informed	HUT Session 5 Informed	HUT Session 6 Informed
			Informed evaluation on the basis of packaging and tasting the product					
Healthiness product								
Healthy package	48.5 (20.4)^{a}	63.3 (20.4)^{b} *	45.8 (19.3)^{a}	51.5 (19.4)^{a} *	48.1 (19.2)^{a}	51.6 (19.2)^{a}	49.8 (17.7)^{a} *	49.4 (19.0)^{a} *
Hedonic package	47.9 (19.0)^{a}	44.5 (18.5)^{a}	49.5 (17.2)^{a}	41.9 (18.7)^{a}	44.7 (18.9)^{a}	43.1 (21.2)^{a}	40.7 (18.5)^{a}	40.0 (18.1)^{a}
Attractiveness product								
Healthy package	58.7 (17.2)^{a}	52.0 (18.4)^{a} *	56.0 (18.5)^{a}	60.9 (12.9)^{a}	59.8 (11.4)^{a}	59.2 (15.9)^{a}	62.2 (13.8)^{a} *	60.0 (15.8)^{a}
Hedonic package	64.5 (17.8)^{a}	46.5 (20.3)^{b}	56.7 (17.7)^{a,b,c}	59.5 (16.9)^{a,c}	56.7 (17.4)^{c}	57.0 (19.4)^{a,c}	55.2 (15.6)^{c}	57.9 (17.9)^{a,c}
Liking								
Healthy package	68.3 (14.2)^{a}	50.2 (17.7)^{b}	64.8 (14.8)^{a}	67.8 (13.3)^{a}	66.1 (11.5)^{a}	63.6 (14.2)^{a}	64.2 (14.0)^{a}	65.2 (14.1)^{a}
Hedonic package	66.9 (14.4)^{a}	50.0 (17.7)^{b}	61.1 (16.0)^{a}	62.1 (17.9)^{a}	62.0 (17.5)^{a}	63.1 (16.6)^{a}	62.0 (16.4)^{a}	60.7 (17.9)^{a}
Sweetness								
Healthy package	52.8 (16.1)^{a}	32.5 (18.6)^{b} *	55.0 (15.1)^{a}	59.8 (12.1)^{a} *	54.9 (12.7)^{a}	56.3 (13.4)^{a}	56.8 (13.2)^{a}	59.5 (14.0)^{a}
Hedonic package	51.7 (14.9)^{a}	50.2 (20.4)^{a}	46.5 (17.5)^{a}	51.0 (15.2)^{a}	55.5 (16.0)^{a}	52.0 (17.3)^{a}	57.7 (17.0)^{a}	53.0 (17.2)^{a}
Crunchiness								
Healthy package	69.6 (13.7)^{a}	62.2 (18.2)^{a}	66.1 (13.8)^{a}	67.6 (14.6)^{a}	66.0 (11.4)^{a}	63.4 (14.5)^{a}	64.7 (14.3)^{a}	66.4 (13.0)^{a}
Hedonic package	66.4 (15.9)^{a}	55.4 (22.4)^{a}	63.7 (13.3)^{a}	62.8 (13.0)^{a}	64.7 (13.0)^{a}	60.8 (14.3)^{a}	62.4 (14.6)^{a}	60.8 (12.8)^{a}
Chocolate flavour								
Healthy package	50.5 (17.7)^{a}	18.9 (12.9)^{b} *	51.7 (21.9)^{a}	52.6 (18.6)^{a}	55.5 (18.4)^{a}	51.2 (17.0)^{a}	52.2 (17.2)^{a}	55.5 (17.6)^{a}
Hedonic package	50.0 (18.6)^{a}	62.2 (15.8)^{b}	49.0 (21.7)^{a}	51.9 (18.5)^{a}	51.8 (19.0)^{a}	53.4 (19.5)^{a}	52.0 (19.4)^{a}	50.8 (18.9)^{a}
Sesame flavour								
Healthy package	59.4 (18.5)^{a}	71.1 (15.5)^{a} *	62.9 (18.7)^{a}	61.4 (18.3)^{a}	61.5 (18.4)^{a}	59.4 (19.9)^{a}	62.6 (18.3)^{a}	59.3 (23.0)^{a}
Hedonic package	57.5 (20.2)^{a}	49.1 (23.1)^{a}	63.3 (17.8)^{a}	56.2 (20.2)^{a}	59.6 (19.4)^{a}	58.3 (19.9)^{a}	58.6 (17.1)^{a}	58.3 (17.4)^{a}
Fattiness								
Healthy package	26.2 (18.1)^{a}	30.4 (23.1)^{a,b} *	35.6 (17.8)^{a,b}	36.7 (16.5)^{b}	39.8 (17.3)^{b}	38.3 (16.7)^{b}	38.7 (16.3)^{b}	38.9 (16.9)^{b}
Hedonic package	25.6 (19.1)^{a}	41.4 (21.7)^{b}	32.6 (19.2)^{a,b}	36.7 (16.7)^{b}	38.2 (16.9)^{b}	36.4 (18.8)^{b}	37.0 (19.6)^{b}	38.3 (17.5)^{b}
Dryness								
Healthy package	46.4 (19.9)^{a}	59.9 (19.1)^{b} *	44.8 (17.4)^{a}	48.9 (20.7)^{a,b}	44.1 (19.2)^{a}	45.7 (20.6)^{a}	48.0 (18.8)^{a}	44.0 (19.8)^{a}
Hedonic package	50.8 (20.3)^{a}	49.1 (19.1)^{a}	48.0 (21.0)^{a}	47.8 (17.3)^{a}	48.8 (18.2)^{a}	43.7 (17.8)^{a}	46.7 (17.6)^{a}	48.6 (17.7)^{a}
Aftertaste								
Healthy package	59.2 (17.2)^{a}	51.6 (17.0)^{a}	60.4 (17.0)^{a}	59.4 (17.2)^{a}	58.5 (19.5)^{a}	62.4 (17.1)^{a}	61.7 (19.0)^{a}	60.8 (19.7)^{a}
Hedonic package	51.4 (19.0)^{a,b}	43.9 (16.4)^{a}	59.9 (18.5)^{b}	53.3 (19.8)^{a,b}	56.1 (20.1)^{b}	55.1 (18.3)^{b}	53.4 (20.3)^{a,b}	54.1 (22.3)^{a,b}

3.3 Implicit associations

Figure 5.4 shows effect sizes of the implicit association tests. Positive effect sizes indicate stronger associations between healthy package designs and terms related to healthiness and unattractiveness, and between hedonic package design and terms related to unhealthiness and attractiveness.

3.3.1 IAT attractiveness effect size

Response latencies for the IAT in both CLTs (sessions 0 and 7) were faster when attractive terms were combined with images representing a hedonic package design (healthy condition CLT session 0 M=815, SD=178 ms; CLT session 7 M=693, SD=139 ms; hedonic condition CLT session 0 M=838, SD=297 ms; CLT session 7 M=747, SD=190 ms) compared to combinations of attractive terms and images representing a healthy package design (healthy condition CLT session 0 M=853, SD=163 ms; CLT session 7 M=711, SD=118 ms; hedonic condition CLT session 0 M=846, SD=181 ms; CLT session 7 M=757, SD=124 ms). The effect sizes (D) were significantly different from zero in CLT session 0 but not in CLT session 7 (healthy condition CLT session 0: t(18)=2.38, p=0.03; CLT session 7: t(23)=0.36, p=0.72; hedonic condition CLT session 0: t(23)=2.44, p=0.02; CLT session 7: t(23)=0.93, p=0.36).

3.3.2 IAT healthiness effect size

Response latencies for the IAT for the total group (CLT session 0,7) were faster when healthy terms were combined with images representing a healthy package design (healthy condition CLT session 0 M=819, SD=224 ms; CLT session 7 M=667, SD=137 ms; hedonic condition CLT session 0 M=1028, SD=348 ms; CLT session 7 M=760, SD=286 ms) compared to combinations of healthy terms and images representing a hedonic package design (healthy condition CLT session 0 M=1158, SD=332 ms; CLT session 7 M=832, SD=134 ms; hedonic condition CLT session 0 M=1115, SD=350 ms; CLT session 7 M=1002, SD=385 ms). The effect sizes (D) were significantly different from zero in CLT session 0 in the healthy condition (healthy condition: t(21)=9.91, p<0.001) but only trend significant in the hedonic condition (hedonic condition: t(22)=1.89, p=0.07). Effect sizes (D) in CLT session 7 were significantly different from zero for both conditions (healthy condition: t(21)=8.64, p<0.001; hedonic condition: t(22)=5.81, p<0.001).

3.3.3 IAT effect size changes

When comparing IAT attractiveness effect sizes over time per package condition, a significant decrease in effect sizes (0.35 and 0.06 respectively) was found within the healthy condition (t(18)=2.16, p=0.04) but no significant decrease in effect sizes (0.27 and 0.11 respectively) over time within the hedonic condition (t(23)=1.43, p=0.17). Thus, hedonic package designs were relatively more attractive, and healthy package designs more unattractive in both package conditions. This association significantly decreased over repeated exposures in the healthy condition.

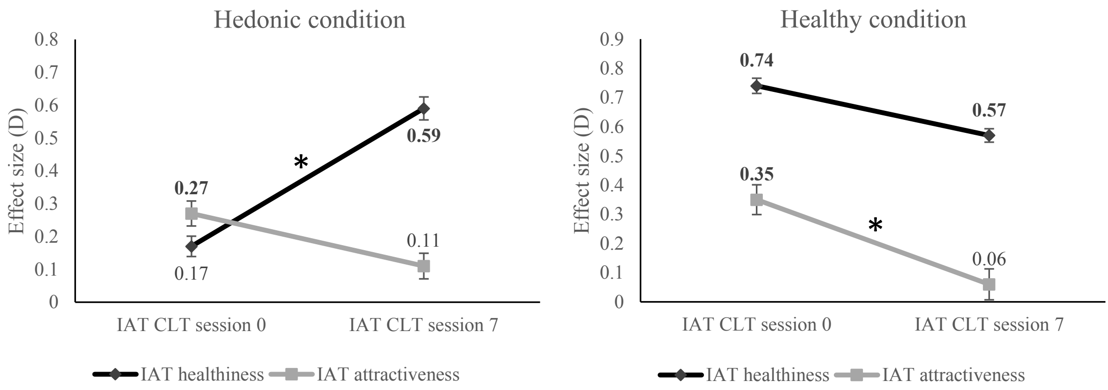

Figure 5.4 Overview of mean (±SE) IAT effect sizes (D) and effect size changes over time across CLT sessions per condition
BOLD effect sizes (D) indicate significant association effects compared to zero effect ($p<0.05$).
* significant differences in IAT effect sizes between sessions ($p<0.05$).

Looking at IAT healthiness effect sizes per condition over time, the effect sizes of the healthy package condition tended to decrease (respectively 0.74 and 0.57) over time ($t(21)=1.89$, $p=0.07$) whereas the effect sizes of the hedonic package condition significantly increased (respectively 0.17 and 0.59) over time ($t(22)=3.31$, $p=0.01$). Thus, healthy package designs were relatively more healthy, and hedonic package designs more unhealthy in both package conditions. In the healthy package condition, this association decreased over repeated exposures (trend), whereas in the hedonic package condition this significantly increased over repeated exposures (Figure 5.4).

4. Discussion

This study explored the effect of packaging cues on product evaluations over repeated in-home exposures, both explicitly and implicitly. Beforehand, we hypothesized that expectations with respect to package designs signalling healthy/hedonic features would transfer to product evaluation, thus assimilating towards package based expectations (*e.g.,* evaluating the biscuits as healthier when packed in a healthy package design). Despite clear effects of package design on consumers' expectations of the product, no evidence was found for the transfer of these effects to actual product evaluation upon tasting, either tasted blind or in combination with viewing the package. No assimilation or contrast effects towards or away from the package based expectations were seen when initially tasting the biscuits in the presence of the package (*i.e.,* informed evaluation), and these effects remained absent over repeated consumption occasions when familiarity with the product increased. The evaluations of the biscuits' sensory properties, healthiness, attractiveness and liking in the presence of the package were rather stable across repeated exposures. Implicit attitudes, however, did change as a result of repeated exposures. The change in implicit attitudes depended on the package consumers were provided with, indicating an effect of product-package interaction that will be described in more detail later on.

Not surprisingly, when consumers evaluated the biscuits without the package (*i.e.,* blind), no differences between package conditions were seen. However, package design did influence expectations of sensory properties and expected healthiness and attractiveness ratings of the biscuits. In line with other studies and hypotheses, results here showed that biscuits packed in the healthy package (*i.e.,* 'cool' colours, health communication) were expected to be healthier than the same biscuits packed in the hedonic package (*i.e.,* 'warm' colours, taste communication) (Lei Huang & Ji Lu, 2015; Jacquot et al., 2013; Tarancón et al., 2014; Tijssen et al., 2017; van Rompay et al., 2016). Interestingly, the biscuits packed in the healthy package were also expected to be more attractive than the biscuits packed in the hedonic package (similar to results found by Van der Laan et al. (2012)), although the latter were expected to be tastier, *e.g.,* the biscuits were expected to be sweeter, fattier, less dry and scored higher on chocolate flavour (as expected and also seen in Mai et al. (2016); Tijssen et al. (2017)). Similar to Zellner et al. (2018), but opposite to our earlier findings Tijssen et al. (2017), we found that package design mainly affected product expectations, but effects disappeared upon (repeated) consumption of the packed biscuits at home.

Repeated consumption of the packed biscuits at home (*i.e.,* informed) resulted in similar sensory, healthiness, attractiveness and liking ratings compared to the ratings when consuming the biscuits without the package at a central location (*i.e.,* blind). Although the healthiness ratings did differ between the package conditions on several occasions at home when tasting the biscuits in the presence of the package (*i.e.,* informed evaluation), we found no stable effects or patterns of assimilation/contrast towards the expected healthiness ratings based on the package alone. It seems, therefore, that package based effects (vision, touch) are overruled by a products' sensory (flavour, texture) properties upon tasting, resulting in a lack of effect of package cues over repeated exposures to the product (package and biscuits).

While others have previously demonstrated that repeated exposures are a better predictor of market success compared to initial (single exposure) ratings (Goldman, 1994; Kahneman & Snell, 1992; Köster, Kornelson, & Benz, 2001; Moskowitz, 2000), our current results do not support this notion. The initial evaluation (*i.e.,* first consumption moment at home in the presence of the package) of sensory properties, healthiness, attractiveness and liking of the biscuits resulted in a profile of scores that did not much change afterwards. So, in a sense, having repeated exposures at home did not add relevant information here. The effects of context (*i.e.,* consumption environment, package) and effects of repeated exposures may, however, be product or product category dependent (Boutrolle, Delarue, Arranz, Rogeaux, & Köster, 2007). We did see a change in implicit attitudes over time, depending on package condition, indicating an effect of product-package interaction. Initially, implicit associations were primarily based on prior experiences and existing memories, as participants were unaware of the experimental manipulations at this stage. In line with others, we found that the healthy package designs were associated relatively stronger with healthiness and unattractiveness, and the hedonic package designs with unhealthiness and attractiveness (Mai et al., 2016; Raghunathan et al., 2006; Tijssen et al., 2017). Over repeated exposures, however, in the healthy condition, the association strength of the healthy package designs with healthiness and unattractiveness decreased (*i.e.,* relatively less healthy, more attractive). In the hedonic condition, the association strength of the hedonic package designs and unhealthiness increased and association strength with attractiveness decreased (*i.e.,* relatively unhealthier, less attractive). Thus, a shift in association strength occurred depending on the package condition. This shift could be attributed to the used product, a sweet chocolate/sesame biscuit, generally considered as a relatively unhealthy and tasty snack. Had the product been inherently healthy/less tasty, an opposite shift may have occurred.

In contrast to what we hypothesized, participant characteristics such as health and taste attitudes, eating style and trait impulsivity did not influence the effects of the healthy/hedonic packages on sensory, healthiness, attractiveness and liking ratings of the biscuits. Others have shown that consumers' knowledge and behavioural disposition with regard to healthiness can influence the effects of label/colour on product expectations and consumption ratings. For example, less knowledgeable consumers with regard to 'health' scored labelled biscuits as healthier compared to more knowledgeable consumers (Tarancón et al., 2014). Furthermore Mai et al. (2016) demonstrated that light and pale package colours signalled either superior healthiness (in case of health conscious consumers) or inferior tastiness (in case of less health conscious consumers). Our consumer sample consisted of a homogenous group of rather health-conscious consumers. It is possible that due to this homogeneity (low variability) we were unable to demonstrate differential effects of healthy/hedonic package designs on expectation and evaluation upon consumption, depending on health and taste attitudes, eating style and trait impulsivity.

Regarding measurement types (*i.e.,* implicit reaction time task vs. explicit questionnaire), we found discrepancies between implicit attitudes and explicit evaluations with respect to attractiveness. Explicitly, the healthy package was expected to be more attractive than the hedonic package. Implicitly however, healthy packages were more strongly associated with unattractiveness than hedonic packages. Arguably, explicit measures (*i.e.,* ratings) capture more controlled and conscious behavioural intentions ('rational mind set'), whereas implicit measures (*i.e.,* implicit associations) complement these traditional explicit measurements by capturing faster, more unconscious, habitual behavioural intentions ('automatic mind set'). The latter is also thought to be more prone to effects of simple intuitive cues (*i.e.,* packaging cues) (Mai & Hoffmann, 2015; Sheeran, Gollwitzer, & Bargh, 2013).

There are several possible explanations for the lack of robust effects of package design on evaluation of the biscuits when tasting them in the presence of the package over repeated exposures. First, there is the differential role and/or importance of sensory modalities at different stages of choice, purchase and eating behaviour. Visuals are more important when it comes to expectations, whereas tasting is more important with regard to consumption. The importance of visual package-induced (extrinsic) effects may have been downgraded after consumption, as tasting (intrinsic cue) is no longer a missing attribute at this stage (Mai & Hoffmann, 2017; Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013). Secondly, the importance/reliability of extrinsic package cues may decrease with increasing product familiarity (through repeated exposure) (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987; Kauppinen-Räisänen, 2014; Li, Jervis, & Drake, 2015; Piqueras-Fiszman & Spence, 2015; Pliner, 1982; Stein, Nagai, Nakagawa, & Beauchamp, 2003). The biscuits used in this study belonged to a segment of snack products usually found in health food stores or in the health-food division of certain supermarket chains. Hence, they were not readily available in most Dutch stores, so most of our consumers never encountered this specific biscuit before. However, familiarity with similar products from the same category (*e.g.,* chocolate-chip cookie) is likely. Existing associations and previous experiences with these similar products during product evaluation may have resulted in little attention to, and use of, extrinsic (package) cues when evaluating the product here. Unfortunately, familiarity with similar product categories was not measured, nor did we include a dynamic measure of familiarity with the biscuits (*i.e.,* measuring familiarity of the biscuits after each evaluation). Along a similar line, measuring changes in package based expectations over repeated encounters would have been interesting. Lastly, the realistic research setting (*i.e.,* at home) was a clear strength when it comes to ecological validity, but carries the potential downside of less strict compliance with the instructions.

To summarize, most literature describes the effects of individual packaging cues (*e.g.,* label, brand, shape) on product evaluation using only explicit measures in a controlled setting in a sensory laboratory, often using virtual instead of physical packages (Grażyna, Małgorzata, & Klaus, 2015; Lei Huang & Ji Lu, 2015; Karnal et al., 2016; Visschers & Siegrist, 2009). This study aimed to demonstrate the effect of a multitude of package cues (*i.e.,* 'package design') in a real-life situation using a realistic product. The study provides a new, more holistic, combined investigative approach (using both implicit and explicit measures) to the assimilation-contrast paradigm. Taking into account the implicit associations between package design and healthiness and attractiveness concepts, and the changes in these associations over repeated consumptions seems important on the basis of our results. Food choices are often made automatic, outside conscious awareness. Adding an implicit measure that accounts for the habitual, automatic mode of processing may therefore improve our understanding of the effects of package design on product evaluation and associations. To better predict food choice and evaluation behaviour in real life situations, we recommend further investigation of the relations between implicit and explicit measurements, to better grasp their inter-relations, as well as their influences on product perception.

In conclusion, package design influenced consumers' expectations of the biscuit (*i.e.,* on sensory properties, expected healthiness and attractiveness and liking), as well as implicit associations consumers have with the product's healthiness and/or attractiveness. However, as soon as the biscuits were consumed, the effects of packaging extinguished, and sensory properties of the biscuit itself seemed to drive product evaluations. This implicates that package design may be effective to influence product expectations and implicit associations in a choice or purchase setting. However, the use of package design to influence intrinsic product properties such as taste, healthiness and attractiveness at the point of (repeated) consumption seems to be less potent.

References

Anderson, R. E. (1973). Consumer Dissatisfaction: The Effect of Disconfirmed Expectancy on Perceived Product Performance. Journal of Marketing Research, 10(1), 38-44. doi: 10.2307/3149407

Barratt, E. S. (1985). Impulsiveness subtraits: Arousal and information processing. Spence JT, Itard CE, editors. Motviation, emotion and personality. Amsterdam: Elsevier, 137-146.

Birch, L. L., McPhee, L., Shoba, B. C., Pirok, E., & Steinberg, L. (1987). What kind of exposure reduces children's food neophobia?: Looking vs. tasting. Appetite, 9(3), 171-178. doi: https://doi.org/10.1016/S0195-6663(87)80011-9

Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M., & Köster, E. P. (2007). Central location test vs. home use test: Contrasting results depending on product type. Food Quality and Preference, 18(3), 490-499. doi: https://doi.org/10.1016/j.foodqual.2006.06.003

Cardello, A. V., & Sawyer, F. M. (1992). Effects of disconfirmed consumer expectations on food acceptibility. Journal of Sensory Studies, 7(4), 253-277. doi: 10.1111/j.1745-459X.1992.tb00194.x

Cavanagh, K. V., & Forestell, C. A. (2013). The effect of brand names on flavor perception and consumption in restrained and unrestrained eaters. Food Quality and Preference, 28(2), 505-509.

Chapman, G., & Maclean, H. (1993). “Junk food” and “healthy food”: meanings of food in adolescent women's culture. Journal of Nutrition Education, 25(3), 108-113. doi: 10.1016/s0022-3182(12)80566-8

Chrysochou, P., Askegaard, S., Grunert, K. G., & Kristensen, D. B. (2010). Social discourses of healthy eating. A market segmentation approach. Appetite, 55(2), 288-297. doi: 10.1016/j.appet.2010.06.015

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. Behavioral and Brain Sciences, 36(3), 181-204. doi: Doi: 10.1017/s0140525x12000477

Croll, J. K., Neumark-Sztainer, D., & Story, M. (2001). Healthy Eating: What Does It Mean to Adolescents? Journal of Nutrition Education, 33(4), 193-198. doi: 10.1016/s1499-4046(06)60031-6

Davidenko, O., Delarue, J., Marsset-Baglieri, A., Fromentin, G., Tome, D., Nadkarni, N., & Darcel, N. (2015). Assimilation and Contrast are on the same scale of food anticipated-experienced pleasure divergence. Appetite, 90, 160-167. doi: 10.1016/j.appet.2015.03.006

Deliza, R., & MacFie, H. J. H. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: a review. Journal of Sensory Studies, 11(2), 103-128. doi: 10.1111/j.1745-459X.1996.tb00036.x

Gelici-Zeko, M., Lutters, D., Klooster, R. t., & Weijzen, P. (2013). Studying the influence of packaging design on consumer perceptions (of dairy products) using categorizing and perceptual mapping. Packaging Technology and Science, 26(4), 215-228.

Goldman, A. (1994). Predicting product performance in the marketplace by immediate- and extended-use sensory testing. Food Technology, October, 103-106.

Grażyna, W., Małgorzata, S.-K., & Klaus, G. G. (2015). The meaning of colours in nutrition labelling in the context of expert and consumer criteria of evaluating food product healthfulness. Journal of health psychology, 20(6), 907-920. doi: 10.1177/1359105315580251

Greenwald, A. G., McGhee, D. E., & Schwartz, L. K. (1998). Measuring individual differences in implicit cognition: The implicit association task. Journal of Personality and Social Psychology, 74(6), 1464-1480.

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the Implicit Association Test: I. An improved scoring algorithm. Journal of Personality and Social Psychology, 85(2), 197-216. doi: 10.1037/0022-3514.85.2.197

Hanson-Vaux, G., Crisinel, A.-S., & Spence, C. (2013). Smelling Shapes: Crossmodal Correspondences Between Odors and Shapes. Chem Senses, 38(2), 161-166.

Hodgkins, C. E., Raats, M. M., Fife-Schaw, C., Peacock, M., Gröppel-Klein, A., Koenigstorfer, J., . . . Grunert, K. G. (2015). Guiding healthier food choice: systematic comparison of four front-of-pack labelling systems and their effect on judgements of product healthiness. British Journal of Nutrition, 113(10), 1652-1663. doi: Doi: 10.1017/s0007114515000264

Huang, L., & Lu, J. (2015). Eat with your eyes: Package color influences the expectation of food taste and healthiness moderated by external eating. Marketing Management, 25(2), 71-87.

Huang, L., & Lu, J. (2015). The Impact of Package Color and the Nutrition Content Labels on the Perception of Food Healthiness and Purchase Intention. Journal of Food Products Marketing, 1-29. doi: 10.1080/10454446.2014.1000434

Ishihara, S. (1951). Tests for colour-blindness (10th completely rev. ed.). Tokyo?: Nippon Isho Shuppan Co.

Jacquot, L., Berthaud, L., Sghaïr, A., Diep, C., & Brand, G. (2013). The Influence of "Tastiness" and "Healthiness" Labels in Cheese Flavor Perception. Chemosensory Perception, 6(2), 53-59. doi: 10.1007/s12078-013-9146-z

Kahneman, D., & Snell, J. (1992). Predicting a changing taste: Do people know what they will like? Journal of Behavioral Decision Making, 5(3), 187-200. doi: 10.1002/bdm.3960050304

Karnal, N., Machiels, C. J. A., Orth, U. R., & Mai, R. (2016). Healthy by design, but only when in focus: Communicating non-verbal health cues through symbolic meaning in packaging. Food Quality and Preference, 52, 106-119. doi: https://doi.org/10.1016/j.foodqual.2016.04.004

Kauppinen-Räisänen, H. (2014). Strategic use of colour in brand packaging. Packaging Technology and Science, 27(8), 663-676.

Köster, E. P., Kornelson, C., & K.H. Benz, K. H. (2001). Stability and change in food liking: food preferences in the two Germany's after reunification. M. Rothe (Ed.), Flavour 2000: Perception, release, evaluation, formation, acceptance, nutrition and health. Rhothe, Bergholz-Rehbrücke, Germany.

Li, X. E., Jervis, S. M., & Drake, M. A. (2015). Examining Extrinsic Factors that Influence Product Acceptance: A Review. J Food Sci, 80(5), R901-R909. doi: 10.1111/1750-3841.12852

Liem, D. G., Toraman Aydin, N., & Zandstra, E. H. (2012). Effects of health labels on expected and actual taste perception of soup. Food Quality and Preference, 25(2), 192-197. doi: 10.1016/j.foodqual.2012.02.015

Ludden, G. D., Schifferstein, H. N., & Hekkert, P. (2009). Visual–tactual incongruities in products as sources of surprise. Empirical Studies of the Arts, 27(1), 61-87.

Mai, R., & Hoffmann, S. (2015). How to combat the Unhealthy = tasty intuition: the influencing role of health consciousness. Journal of Public Policy & Marketing, 34(1), 63-68.

Mai, R., & Hoffmann, S. (2017). Indirect ways to foster healthier food consumption patterns: Health-supportive side effects of health-unrelated motives. Food Quality and Preference, 57, 54-68. doi: https://doi.org/10.1016/j.foodqual.2016.11.009

Mai, R., Symmank, C., & Seeberg-Elverfeldt, B. (2016). Light and Pale Colors in Food Packaging: When Does This Package Cue Signal Superior Healthiness or Inferior Tastiness? Journal of Retailing, 92(4), 426-444. doi: https://doi.org/10.1016/j.jretai.2016.08.002

Moskowitz, H. R. (2000). Engineering out food boredom: a product development approach that combines home use tests and time-preference analysis. Food Quality and Preference, 11(6), 445-456. doi: https://doi.org/10.1016/S0950-3293(00)00016-1

Patton, J. H., & Stanford, M. S. (1995). Factor structure of the Barratt impulsiveness scale. Journal of Clinical Psychology, 51(6), 768-774.

Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. Food Quality and Preference, 40, 165-179. doi: 10.1016/j.foodqual.2014.09.013

Pliner, P. (1982). The effects of mere exposure on liking for edible substances. Appetite, 3(3), 283-290. doi: 10.1016/s0195-6663(82)80026-3

Povey, R., Conner, M., Sparks, P., James, R., & Shepherd, R. (1998). Interpretations of healthy and unhealthy eating, and implications for dietary change. Health Educ Res, 13(2), 171-183.

Raghunathan, R., Walker Naylor, R., & Hoyer, W. D. (2006). The unhealthy is tasty intuition an its effect on taste inferences enjoyment and choice of food products. Journal of Marketing, 70, 170-184.

Roininen, K., Lähteenmäki, L., & Tuorila, H. (1999). Quantification of consumer attitudes to health and hedonic characteristics of foods. Appetite, 33(1), 71-88.

Schifferstein, Fenko, A., Desmet, P. M., Labbe, D., & Martin, N. (2013). Influence of package design on the dynamics of multisensory and emotional food experience. Food Quality and Preference, 27(1), 18-25. doi: 10.1016/j.foodqual.2012.06.003

Sheeran, P., Gollwitzer, P. M., & Bargh, J. A. (2013). Nonconscious processes and health. Health Psychology, 32(5), 460-473. doi: 10.1037/a0029203

Spence, C. (2012). Managing sensory expectations concerning products and brands: Capitalizing on the potential of sound and shape symbolism. Journal of Consumer Psychology, 22(1), 37-54. doi: https://doi.org/10.1016/j.jcps.2011.09.004

Spence, C., & Gallace, A. (2011). Tasting shapes and words. Food Quality and Preference, 22(3), 290-295. doi: 10.1016/j.foodqual.2010.11.005

Stein, L. J., Nagai, H., Nakagawa, M., & Beauchamp, G. K. (2003). Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. Appetite, 40(2), 119-129. doi: https://doi.org/10.1016/S0195-6663(02)00173-3

Tarancón, P., Sanz, T., Fiszman, S., & Tárrega, A. (2014). Consumers' hedonic expectations and perception of the healthiness of biscuits made with olive oil or sunflower oil. Food Research International, 55, 197-206.

Tijssen, I., Zandstra, E. H., de Graaf, C., & Jager, G. (2017). Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar- and fat-reduced products. Food Quality and Preference, 59, 46-58. doi: 10.1016/j.foodqual.2017.01.019

Van der Laan, L. N., De Ridder, D. T., Viergever, M. A., & Smeets, P. A. (2012). Appearance matters: neural correlates of food choice and packaging aesthetics. PLoS One, 7(7), e41738. doi: 10.1371/journal.pone.0041738

van Rompay, T. J. L., Deterink, F., & Fenko, A. (2016). Healthy package, healthy product? Effects of packaging design as a function of purchase setting. Food Quality and Preference, 53, 84-89. doi: https://doi.org/10.1016/j.foodqual.2016.06.001

Van Strien, T. (1986). The DEBQ for assesment of restrained, emotional and external eating behaviour. International Journal of Eating Disorders, 5(2), 295-315.

Varela, P., Ares, G., Giménez, A., & Gámbaro, A. (2010). Influence of brand information on consumers' expectations and liking of powdered drinks in central location tests. Food Quality and Preference, 21(7), 873-880. doi: https://doi.org/10.1016/j.foodqual.2010.05.012

Visschers, V. H. M., & Siegrist, M. (2009). Applying the evaluability principle to nutrition table information. How reference information changes people's perception of food products. Appetite, 52(2), 505-512. doi: https://doi.org/10.1016/j.appet.2009.01.004

Westerman, S. J., Sutherland, E. J., Gardner, P. H., Baig, N., Critchley, C., Hickey, C., . . . Zervos, Z. (2013). The design of consumer packaging: Effects of manipulations of shape, orientation, and alignment of graphical forms on consumers' assessments. Food Quality and Preference, 27(1), 8-17. doi: 10.1016/j.foodqual.2012.05.007

Willems, A. A., van Hout, D. H. A., Zijlstra, N., & Zandstra, E. H. (2014). Effects of salt labelling and repeated in-home consumption on long-term liking of reduced-salt soups. Public Health Nutr, 17(5), 1130-1137. doi: Doi: 10.1017/s1368980013001055

Yeomans, M. R., Chambers, L., Blumenthal, H., & Blake, A. (2008). The role of expectancy in sensory and hedonic evaluation: The case of smoked salmon ice-cream. Food Quality and Preference, 19(6), 565-573. doi: https://doi.org/10.1016/j.foodqual.2008.02.009

Zellner, D., Greene, N., Jimenez, M., Calderon, A., Diaz, Y., & Sheraton, M. (2018). The effect of wrapper color on candy flavor expectations and perceptions. Food Quality and Preference, 68, 98-104.

Chapter 6

General Discussion

The research described in this thesis explored the effectiveness of extrinsic cues, here package design and colour aspects, to make healthier food products more attractive, thereby making a *healthy* choice an *easy* choice. The general discussion will elaborate on the main findings of the research described in this thesis. Following the main findings, the methodological considerations are discussed. Then the main findings of the research are interpreted and discussed. Next, implications and future recommendations with regard to the research findings are elucidated. The general discussion ends with an overall conclusion.

Main findings

Package design and colour aspects have the ability to influence conceptual (*i.e.,* healthiness), hedonic (*i.e.,* attractiveness, liking) and sensory product expectations and, to a lesser extent, product evaluation upon tasting. Next to this, package colour properties evoke certain associations with regard to healthiness and attractiveness.

Less vibrantly coloured packages (*e.g.,* high brightness, low saturation), 'cool' coloured packages (*e.g.,* green/blue hue) and package designs emphasising health aspects (*e.g.,* green hue, information focussing on healthiness) represent healthier products. Vibrantly coloured packages (*e.g.,* low brightness, high saturation), 'warm' coloured packages (*e.g.,* red/orange) and package designs emphasising attractiveness (*e.g.,* red hue, information focussing on tastiness) represent regular/less healthy products.

Implicitly, packages that represent healthier products were more strongly associated with healthiness and unattractiveness compared to packages that represent regular/less healthy products (Chapter 2, 4, 5). Explicitly, packages representing healthier products were expected to be healthier and less tasty than regular/less healthy products (Chapter 2, 5). Sensory evaluation upon tasting assimilated towards package based expectations in the lab (Chapter 2), while no long lasting assimilation or contrast effects were found at home (Chapter 5). In most cases, taste and flavour properties seemed to be the most prominent drivers of product evaluation at the point of consumption (Chapter 5). Implicit associations did change over time as a result of repeated exposures. Association strength of package design and colour aspects decreased or increased over time, likely as a result of product-package interactions (Chapter 5). The effects of package design and colour aspects on product perception were driven by higher-order cognitive systems, predominantly in neural regions coding for reward and inhibitory control as opposed to lower-order sensory systems (*e.g.,* neural regions coding for taste and flavour) (Chapter 3).

Package design and colour aspects thus have the ability to influence expectations and implicit associations, important in a choice and purchase setting (Chapter 2, 4, 5). Furthermore they have the potential to subsequently influence product evaluation at the point of consumption (Chapter 2). The results indicate the importance of package design and colour aspects when designing attractive and healthier food products.

Methodological considerations

Some methodological aspects have to be taken into consideration before interpreting the findings of the research described in this thesis.

Participants

With regard to external validity, including a representative sample of the population of interest is important (Lawless and Heymann 2010). It has been shown that behavioural dispositions with respect to health and eating behaviour can influence the interpretation of communication conveyed through package aspects (Tarancón, Sanz et al. 2014, Huang and Lu 2015, Mai, Symmank et al. 2016). The findings described in this thesis apply mainly to a Western population of healthy non-obese individuals. Implications should thus first and foremost be seen in light of this population. Unintentionally, the consumer samples used in the studies reported here were skewed with respect to their behavioural disposition towards health; generally speaking they were rather health-minded. The recruitment pool mainly consisted of inhabitants of Wageningen and surroundings. Recruitment of a study population that covers all consumer segments, including the less health-minded, deemed difficult in 'food valley' Wageningen. Although not all segments of behavioural dispositions towards healthiness were represented, we do believe implications translate to a broader consumer population, especially to the less health-minded consumer. We argue that less health-minded consumers may be even more easily 'seduced' by package design and colour aspects to reinforce product attractiveness. Less health-minded consumers may evaluate a product more mindlessly and intuitively, thereby relying less on explicit sources of information (*e.g.,* nutritional content) and more on package aesthetics such as package design and colour aspects to evaluate the product compared to health-minded consumers. In contrast, health-minded consumers may emphasise the importance of health in product evaluation (Granzin, Olsen et al. 1998, Roininen, Tuorila et al. 2001, Sijtsema, Backus et al. 2009). These consumers often rely on conscious, explicit information sources such as nutritional content and ingredient information to evaluate the product (Sijtsema, Backus et al. 2009, Tarancón, Sanz et al. 2014) and may therefore rely less on intuitive information cues (*e.g.,* package design) when evaluating a product.

Research approach and measurements

The research described in this thesis aimed to investigate the potential effects of package design and colour aspects to make healthier food products more attractive. For this we used explicit (questionnaire, rating) as well as implicit measurement tools such as the Implicit Association Test (IAT) and functional Magnetic Resonance Imaging (fMRI) to capture both conscious as well as subconscious aspects of perception.

The research described in this thesis demonstrates the ability of package design and colour aspects to influence product expectations and implicit associations rather robustly, across measurements and methods. Methods and insights from multiple scientific disciplines were taken into consideration. Specific controlled research methods and measurements are indispensable to answer certain specific questions (*e.g.,* relative effects of one package colour cue compared to another, implicit associations with healthiness and attractiveness). However, the collaborative and holistic methodological approach used in the research described in this thesis places the research findings in a broader perspective, potentially grasping the reality of the situation better and enhancing the predictive validity.

Although the research described in this thesis does not fully grasp the reality of the situation, this research tackles some of the 'hurdles' when it comes to combining specific scientific insights to provide a more holistic view of food preferences and behaviour in real life. A broad and interdisciplinary research approach was used, covering fields of sensory and consumer science, psychology and neuroscience when investigating the effects of package design and colour on product evaluation. Multiple types of methodologies (*i.e.,* implicit and explicit), investigatory settings (*i.e.,* at home and in the lab), timeframes (*i.e.,* single and repeated exposures) and consumer characteristics (*i.e.,* eating goal, eating style, impulsiveness) were used. Therefore, I believe that within the research scope, internal and external validity were well balanced.

It is important to determine the magnitude of effects of one package design and colour aspect to another. Controlling for extraneous and confounding variables is key in order to grasp the potential of package design and colour aspects to enhance the attractiveness of healthier products. Controlled lab settings enable precise measurements of the effects and were therefore used to establish cause and effect relationships (Chapter 2, 3, 5). Although it is well known that results found in lab settings do not always illustrate what happens in real life situations, they can be useful to uncover and understand small but potentially important influences (Lawless and Heymann 2010). Lab settings often rely on explicit measurement tools such as rating scales (Lawless and Heymann 2010) and provide direct comparison and quantification of effects. Extrinsic measurements dominate the consumer research field (Van Kleef, Van Trijp et al. 2005) and are known for good internal validity, reliability and accuracy of responses when applied in a sensory lab context (Lawless and Heymann 2010). For reasons of reliability, accuracy and comparability between package design and colour effects, products, studies, and with literature, the research described in this thesis included measurement tools (*i.e.,* rating scales) in lab settings (Chapter 2, 3).

Explicit measurement tools rely on conscious awareness of the consumer; they capture controlled and conscious behaviour. However, it can be argued that only a fraction of mental operations is reflected by conscious expression, the rest being unavailable to introspection (Nisbett and Wilson 1977, Bargh 2002, Dijksterhuis, Smith et al. 2005, Kahneman 2012). Food related behaviour is particularly susceptible to less conscious mental operations, as these behaviours come about rather automatically and habitually. Consumers are thus not always aware, nor able to verbalise, the underlying, unconscious drivers of their behaviour. Although explicit measures are robust and valid to lay the ground work, it is important with respect to external validity to also incorporate indirect, implicit measurements that capture the more subconscious influences that food related behaviours are prone to. Researchers in the field have suggested that in the future, explicit sensory lab tests will no longer be the norm, and stress the importance of the development of new methodological approaches to understand the heuristics that influence food choice (Jaeger, Hort et al. 2017). The unconscious aspect of food related behaviours has been neglected in food research and taking this into account is necessary to better understand the drivers of food related behaviours in everyday situations. I agree with this notion, therefore the studies reported in this thesis incorporated implicit measurments.

Implicit behavioural measures such as the IAT used in Chapters 2, 4, 5 and fMRI used in Chapter 3 can circumvent some of the measurement restraints of explicit measures. The IAT has been used to measure implicit aspects of attitudes (Greenwald, McGhee et al. 1998, Greenwald, Nosek et al. 2003, Nosek, Greenwald et al. 2005, Lane, Banaji et al. 2007, Greenwald, Poehlman et al. 2009). Much like explicit ratings, the IAT typically displays good internal consistency (Greenwald, Poehlman et al. 2009), and has a relatively good test-retest variability (Lane, Banaji et al. 2007). Furthermore, moderate correlation coefficients between IAT- and explicit measures (r=0.32) were reported in a meta-analysis when it came to consumer preferences (Greenwald, Poehlman et al. 2009). This potentially underscores the added benefit of combining explicit and implicit measurements, thus capturing both conscious as well as more unconscious aspects of product perception and food related behaviour to better grasp reality. This notion has been stressed by others as well (Jaeger, Hort et al. 2017).

Although ratings and IATs can answer the '*how much*' and ' *when*' questions, they still do not explain the mechanism underlying these effects, thus the '*how*' question. Determining '*how'*, is important to further our knowledge on the opportunities and limitations of (here) package design and colour aspects on product perception. Therefore, we substantiated these findings using brain imaging technique (fMRI). Blood-oxygen level-dependent (BOLD) fMRI is the most widely used technique. Although an indirect measure, relying on correlations rather than causality, BOLD fMRI is nowadays seen as the preferred technique in cognitive neuroscience when determining relations between neural 'input' and 'output', thereby answering the '*how'* question (Poldrack 2008). Future directions for sensory and consumer science could benefit from engaging with other specialists, such as neuroscientists, to better understand the mechanisms behind (in this case, package design and colour) effects.

Another important future scientific direction that has been stressed by sensory researchers in the field is the transition from lab settings to more real life situations (Meiselman 2013, Jaeger, Hort et al. 2017). Often influences (*e.g.,* of package design and colour aspects) on product perception have been studied individually, which may be relevant if they do not interact with other contextual factors. However, these influences are often not independent and compete for attention, potentially overruling effects, or affecting the magnitude thereof. It is therefore necessary to make the transition and translation to more realistic contexts (*e.g.,* at-home) to progress the field of sensory and consumer science (Jaeger, Hort et al. 2017). In Chapter 5 we used a more realistic at-home setting to validate and better predict behaviour in real life situations. This was done to translate the effects found in lab setting to a more natural habitat, that includes distracting cues. The results, or lack thereof, and incongruency with lab findings underscores the importance of this transition.

Supplementary to measurement tools and research environment, another aspect to take into consideration is the habitual and dynamic nature of food choice and eating behaviour. Food behaviours are often repeated and initial evaluations are not always predictive of repeated evaluations (Kahneman and Snell 1992, Goldman 1994, Moskowitz 2000, Köster, Kornelson et al. 2001, Lawless and Heymann 2010). It is important not only to investigate effects of package design and colour aspects at a single exposure, but also over longer periods. Although in our case repeated exposures did not add any relevant information compared to initial exposures (Chapter 5), in many cases it provides an added dimension about the dynamic robustness and boundaries of effects, potentially shedding light on the likelihood of repeated purchase and consumption.

Lastly, we want to affirm that this research did not include any choice or intake measure. It has been shown that intentions and preferences do not always correlate with actual choice and intake behaviour (Randall and Sanjur 1981, Drewnowski 1997, Köster 2009, Vabø and Hansen 2014, McCrickerd and Forde 2016). Thus, the addition of choice or intake measurements would enhance understanding of effects of package design and colour aspects, not only with respect to perception but also regarding choice and intake, and thereby the relation between perception, choice and intake. Methodological restrains made it impossible to incorporate a choice or intake measure that would not be prone to influences from other aspects of the study. Perhaps future research could make use of new methodologies such as eye tracking (and virtual reality) to determine influences of package design and colour elements on attentional demand and choice, combined with expected product perception followed by ad libitum intake.

All in all, several key directions for the future of sensory and consumer science have been highlighted by researchers in the field, *interdisciplinary research* – engaging with other specialists such as neuroscientists, *ecological validity* - moving beyond the lab, and *decision making* – inclusion and development of methods that capture conscious as well as subconscious drivers of food behaviour (Jaeger, Hort et al. 2017). The research described in this thesis covers these important future directions. This methodological approach is thought to provide a holistic view the way package design and colour aspects influence product expectations, associations and evaluation upon consumption.

Discussion and interpretation

The goal of the research described in this thesis was to investigate the potential of package design and colour aspects to make healthier products more attractive. The findings described in this thesis provide insights into the effects of package design and colour aspects on product expectations, perception and dynamic implicit associations (Chapters 2, 4, 5) as well as the brain mechanisms underlying these effects (Chapter 3).

Expectation

Packaging plays an important role in capturing a consumer's attention and setting product related expectations. Relative to other packaging cues, colour triggers a fast response and is thus often used strategically to capture a consumers attention in a choice and purchase setting where visual information dominates perception (*e.g.,* Swientek (2001), Schifferstein, Fenko et al. (2013), Kauppinen-Räisänen (2014)). The use of package design and colour aspects to make healthier food products more attractive seems to be predominantly effective with regard to product expectations. Packaging products in more 'warm' coloured and vibrantly coloured packages deemed them more attractive, tastier and less healthy than products in 'cool' coloured and less vibrantly coloured packages. This effect was demonstrated at a conscious level in terms of consumers' explicit reflections (Chapter 2, 5), as well as on a more subconscious level with respect to implicit attitudes consumers have (Chapter 2, 4, 5) and it seems to be driven by top-down higher level cognitive systems rather than bottom-up, lower level sensory systems in the brain (Chapter 3). The results are in line with accumulating scientific evidence that acknowledges the influence of extrinsic aspects on product expectations, perception, choice and consumption behaviour (*e.g.,* McClure, Li et al. (2004), Rolls, Roe et al. (2004), Raghunathan, Walker Naylor et al. (2006), Grabenhorst, Rolls et al. (2008), Ülger (2008), Ares and Deliza (2010), Becker, van Rompay et al. (2011), Woods, Lloyd et al. (2011), Jacquot, Berthaud et al. (2013), Kuhn and Gallinat (2013), Ng, Chaya et al. (2013), Okamoto and Dan (2013), Huang and Lu (2015), Li, Jervis et al. (2015), Piqueras-Fiszman and Spence (2015), Wąsowicz, Styśko-Kunkowska et al. (2015), van Rompay, Deterink et al. (2016), Spence and Velasco (2018), Zellner, Greene et al. (2018)).

Package design and colour aspects can convey certain messages about a product within a product category. For example, in the Dutch marketplace, a red package colour in the milk category signals buttermilk, whereas it signals dark chocolate in the chocolate category. The communication of specific products within a product category is often culture or country specific. In the UK marketspace, a red colour on a milk carton would signal 'full fat' regular milk, whereas it is signalled through vibrant blue package colours in the Dutch marketspace. Next to this, the effectiveness and interpretation of package design and colour aspects to signal certain properties within a product range can also be context dependent, *e.g.,* in terms of purchase setting. For example, van Rompay, Deterink et al. (2016) showed that package design emphasising healthiness only elicited an effect on health evaluation in a discount supermarket, as opposed to a green supermarket. This shows the delicacy with which packages should be designed with respect to trends within the product category as well as the importance of consumer testing them in the appropriate culture and contextual setting.

Thus packaging is a powerful communication tool, but the challenge many companies are facing is to determine how to use package design to convey the right impression and message, and elicit appropriate expectations at various stages of product interaction. Ensuring that the consumers correctly interpret the message and meaning conveyed through package design and colour aspects is thus an intriguing challenge and may be dependent on many factors *e.g.,* context, product category, culture, purchase setting, product aspects, and a consumers' goal of eating.

Next to culture and contextual influences described above, there is accumulating evidence that suggests that a consumer's goal of eating may influence the interpretation of package design and colour aspects. Health-minded consumers inherently have a more positive attitude towards healthy products and often have a goal of eating healthy (Roininen, Tuorila et al. 2001, Sijtsema, Backus et al. 2009). Less health-minded consumers may be less positive towards healthy products as they do not have the explicit goal to eat healthily, and thereby often have an intuition that "healthy is not tasty" (Raghunathan, Walker Naylor et al. 2006). Emphasising the healthiness of a food might impede rather than facilitate eating healthy foods by means of unintended adverse effects. For example, signalling healthiness through package design may be interpreted with regard to healthiness for health-conscious consumers, however it may also be interpreted as less tasty in less health-conscious consumers (Raghunathan, Walker Naylor et al. 2006, Mai, Symmank et al. 2016) for a review see Chandon (2012)). Although our findings have not been able to demonstrate the impact of behavioural intentions such as health-mindedness, impulsivity, or eating style on product expectations and evaluations (Chapter 2, 3, 4, 5), the abovementioned examples illustrate the importance of understanding the behavioural intentions of the targeted consumer group when designing packaging and products. As suggested in the "Participant section, page 118", the used consumer samples were potentially not diverse enough in terms of behavioural dispositions to find robust influences.

Next to an interaction between package and consumer, when it comes to healthiness and attractiveness expectations, the product itself may also be part of the equation. The interpretation and inferred expectations based on package information are thus likely the result of an interaction between the package, product, and the health-mindedness of consumers. For example, health-minded consumers may feel a need to 'justify' eating less healthy foods. In that sense, packaging an inherently less healthy food (*e.g.,* a biscuit in Chapter 5) in a package design that signals healthiness may justify choosing or consuming this product, thereby enhancing the attractiveness compared to the biscuit in a package signalling hedonic features. With respect to healthier products (*e.g.,* dairy drink in Chapter 2), there may not be a need for choice or consumption 'justification'. Therefore, packaging the product in a package signalling hedonic features enhances hedonics compared to a package signalling healthiness. Less health-minded consumers may not have a need to justify eating less healthy products. For them, package cues signalling attractiveness may universally enhance product expectations regarding attractiveness. The effect of package design and colour may thus be less dependent on the inherent healthiness of the product at hand. It would be interesting to test this hypothesis *e.g.,* in a 2 × 2 × 2 research design, comparing packages, products and consumer groups differing in healthiness and heath-mindedness.

Package design and colour aspects also elicit expectations regarding sensory product aspects, *e.g.,* in terms of flavour, texture and aroma, also suggested by others (*e.g.,* Piqueras-Fiszman and Spence (2015), Spence and Velasco (2018), Zellner, Greene et al. (2018)). The effect package design and colour aspects can have on sensory expectations may depend on congruency of the package elements with the products sensory properties *e.g.,* in terms of flavour. I will elaborate on this using a specific example. In a sweet 'red berry fruits' flavoured dairy drink (Chapter 2), the influence of a red hue, congruent with the flavour, may be more impactful with respect to intensity of overall flavour expectations, compared to a red package design or colour in a sausage (Chapter 2) and biscuit product (Chapter 5), where the colour is less directly related to the product's flavour. Next to this, the impact of the *e.g.,* red hue may be more profound in terms of sweetness expectations compared to expectations regarding creaminess (dairy drink), fattiness (sausage) or crunchiness (biscuit). In nature, red often signals sweet, ripe fruits whereas there is no clear relation between creaminess, fattiness or crunchiness and red hue. Similarly, Huang and Lu (2015) showed that participants expected a product to be sweeter when packaged in a red package colour. Furthermore, Ares and Deliza (2010) demonstrated that a desert packaged in a yellow package was expected to be vanilla tasting and sweet whereas the desert packaged in a black package was expected to be bitter and dark chocolate flavoured.

At point of purchase, choice and expectation formation, it is therefore important to consider the communicative function of the package design while keeping in mind the culture, context and consumer's behavioural disposition. Is the function of package design to signal certain products within a shelf or category (*e.g.,* grab attention, or signal full fat vs. low fat versions), or to signal product properties (*e.g.,* healthiness, attractiveness) or does it signal flavour properties (*e.g.,* sweetness, intensity)? Not to mention other environmental cues and influences that may compete for attentional resources and interact with communication through package design and colour aspects (*e.g.,* Clement (2007), Hurley, Galvarino et al. (2013), Rebollar, Lidón et al. (2015)).

Although package colour and design aspects are potent cues to communicate messages, one of the questions not addressed in this thesis is what happens in light of other package elements (*e.g.,* label, brand, claims, package material, shape) or contextual influences (*e.g.,* shelf position, price, credence). Research has shown that a broad range of elements compete for a consumers visual attention at point of purchase (Clement 2007, Hurley, Galvarino et al. 2013, Rebollar, Lidón et al. 2015, Oliveira, Machín et al. 2016, Duerrschmid, Danner et al. 2018). Influences besides package elements have been left out of the research scope and should thus be included and considered in future research. After all, just because effects have been obtained in one situation, does not mean they always will. Next to this, behaviour is complex, and a magnitude of cues influence our behaviour. Package design and colour aspects do not solely determine the attractiveness of a product. Although package elements are only one part of the battery of elements that influence product perception, evaluation, and choice behaviour, studying their potential to enhance attractiveness provides understanding into their effect. The use of new methodologies and research approaches such as eye tracking and virtual reality have made it possible to start untangling the relative effects and influences of one package or contextual cue to another more realistically, and determine their interactions.

Evaluation

It is rather clear that package design and colour aspects can indeed help set a consumer's product related expectations. However, whether such expectations carry over to influence the consumer's product experience upon consumption, when intrinsic product aspects may be more important in terms of evaluation, is another aspect that needs to be addressed. Some studies have shown that package elements can influence taste perception upon consumption (*e.g.,* Nitschke, Dixon et al. (2006), Becker, van Rompay et al. (2011), Woods, Lloyd et al. (2011)) whereas others have not been able to demonstrate this (*e.g.,* Zellner, Greene et al. (2018)). In light of the research described in this thesis, the effects of package design and colour aspects on product evaluation upon consumption (Chapter 2, 5) were less profound than their effects on product expectations. At point of consumption, visual information is no longer the dominant modality in terms of perception, taste becomes the most important modality (Schifferstein, Fenko et al. 2013). Thus evaluation upon consumption is predominantly driven by intrinsic product properties, such as the taste and flavour of the product (Chapter 5). These results emphasise the importance of determining the key factor(s) accounting for when exactly package design and colour influences the product perception upon consumption. It seems that product design and colour aspects are more likely to affect product evaluation if the package aspects carry diagnostic meaning. This diagnostic meaning is often the result of learned associations between the package aspect and related product or environmental aspects (*e.g.,* red package colour signalling a 'red berry' flavoured drink). Next to this, the effectiveness of package design and colour aspects to influence product evaluation at point of consumption may depend on the level of interaction at the point of evaluation. The effect of package design and colour aspects on product evaluation may be more profound if there is a close interaction with the package upon the evaluation moment, *e.g.,* if the product is consumed directly out of the package, or is consumed in close proximity to the package. For example, in a lab context in Chapter 2 participants were closely interacting with the package at point of evaluation and consumption as they were instructed to pay attention to the package upon evaluation. Thus attention was directed to the package and differences in sensory aspects were seen in terms of expectation as well as evaluation upon consumption. At home, in Chapter 5, the evaluation instructions and context were less controlled, and other attentional contextual influences may have resulted in a lower level of interaction. This, combined with importance of intrinsic cues at the moment of evaluation upon consumption, may have resulted in a lack of package influences on product evaluation upon consumption.

Long term

Another important question to address is the stability of package based effects on perception over repeated evaluations. When familiarity is low, expectations are predominantly based on extrinsic information, *e.g.,* from the package. However, as familiarity with the product increases, expectations are likely updated as a result of repeated interaction, thereby including previous experiences with the intrinsic product aspects, *e.g.,* from the flavour. The more familiar one is with a given product, the more certain expectations are likely to be (Ludden, Schifferstein et al. 2009). Thus over time, the power of package based expectations to influence perception upon evaluation may decrease. The research described in this thesis was unable to explicitly demonstrate the dynamics of expectation, as well as the potential decreased power to influence perception when familiarity increases (Chapter 5).

Changes in implicit associations over time, as a result of repeated package-product interaction (Chapter 5), were demonstrated. Associations are often learned, and thus dynamic over time. Although market trends make use of certain colours to communicate a specific message (*e.g.,* 'cool', less vibrantly coloured packages and package information focussing on health to communicate healthiness of the product) the learned association can change as a result of repeated encounters with a product. In this case, association strength of package design and colour aspects with healthiness and attractiveness either increased or decreased over time depending on the package-product relationship (Chapter 5).

The fact that these implicit associations changed over repeated evaluations as a result of package-product interaction demonstrates the added benefits of implicit measurements. These dynamics of implicit associations demonstrated here also pose an interesting question. Are these associations between colour aspects and healthiness (or attractiveness) the result of package-product learning, or are they rather more basic, more broadly coming from learned associations in our everyday life? To illustrate this with an example; does the association of 'cool' green package colour with a products healthiness result from learned associations due to frequently used package-product combinations, or does it more broadly come from a learned associations that green colour relates to *e.g.,* nature/vegetables, thereby signalling healthiness? In case of the latter, the use of package design and colour aspects to emphasise attractiveness of a product may be rather robust. In case of the former, however, one can imagine that the associations between colour and healthiness/attractiveness over time will decrease and may become ineffective or even counter effective over time.

Irrespective of the origin of the associations, the demonstrated changes of implicit associations over time, as opposed to the lack of explicit findings over repeated exposure, illustrate the importance of measuring food related behaviours not only on an conscious explicit level, but also on a more unconscious automatic level.

Implications and future directions

From the perspective of increased numbers of health problems caused by an unhealthy diet it is important to understand the determinants involved in food choice, preference and evaluation. Understanding what impact extrinsic aspects may have on product choice, preference and evaluation may help to promote healthier food behaviours. The ability of package design and colour influences to make healthier foods more attractive, thereby making a healthier choice an easier choice, was studied in the research described in this thesis.

Across several Chapters (2, 3, 4, 5) the ability and mechanism of package design and colour aspects to influence sensory, healthiness and attractiveness expectations, associations and evaluation upon consumption are discussed. Designing packaging to signal attractiveness seemed to have a powerful effect on product expectations and associations, and in some cases also in terms of evaluation. These findings have relevance in several ways.

The identified links between extrinsic aspects and different product elements *e.g.,* healthiness, attractiveness and sensory aspects, can be used to create messages tailored to the product, purchase setting or targeted consumers. Simple cues in the food environment are powerful in terms of related expectations and associations and in turn potentially shape behaviour and perception. Food designers, marketers and package designers should be able to use these insights to optimize the appearance and message communicated about the product through the package. Next to this, although the research used package as vehicle, one can imagine that design and colour aspects can play an important role when applied to other vehicles (*e.g.,* plates, supermarket shelves, online shopping environments) and can therefore also be very relevant for restaurants and supermarkets.

This research also emphasises the fact that product developers need to look beyond mere intrinsic product properties when it comes to satisfying consumer wishes. Intrinsic product properties are mainly important at the stage of (repeated) consumption. However, equally important is the stage prior to consumption, *i.e.,* choice and purchase. This stage is crucial in terms of expectations and associations that can influence evaluation and consequently repeated purchase and consumption. Currently these two stages are often researched and optimised separately, and consumer wishes in a choice and purchase setting are satisfied irrespective of consumer wishes with respect to product intrinsic properties. The research in this thesis emphasises the opportunities of a more collaborative approach with respect to product development, combining research looking into intrinsic and extrinsic factors. This combined approach should be employed at all stages of product interaction, including product choice and purchase, as well as preparation and consumption stages. In food industry, departments of research and development should align with departments of marketing and consumers insights from the very beginning of a (new) product concept in order to establish and optimise the chances of a products market success. They should collaboratively determine important intrinsic and extrinsic aspects and should align these aspects to signal a congruent message from the start. Aligning 'must-haves' of the product from both an intrinsic and extrinsic perspective should be done from the very start of product (concept) development, and should be checked at several stages of development to confirm the alignment. This could enhance the likelihood of product choice and purchase, as well as the likelihood of repeated purchase as the message conveyed from the package is congruent with the intrinsic sensory properties, therefore less likely to cause disappointment.

This research also emphasises that a "one size fits all" approach can be detrimental in terms of communication. Although certain package design and colour aspects give rise to rather robust initial associations and expectations, the (magnitude of) influence upon consumption and the influence over repeated consumption heavily depend on the relation of the package with the product, context and consumer at hand. It seems wise to tailor the research towards the specific situations regarding product category, product context and consumers and culture. To ensure a good fit, several aspects may be important to determine. First of all, the function of the message, *e.g.,* to grab attention, to signal health, to signal flavour? Cultural associations between colour or design aspects and product or flavour are also important to determine. Next to this, trends and associations may not only be culture, but also product category or product dependent. Next to this the target population should be described in terms of their wishes, demands and eating goals. Lastly, the shopping and/or consumption environment should be described. Perhaps consumer interviews, focus groups and the use of laddering techniques or KANO methods, and the use of more implicit methods such as IATs, or observational research could help describe and cluster certain situations and consumer segments, thereby understanding the drivers of choice, purchase and consumption in specific relevant cases.

The research described in this thesis demonstrated the influences of certain package design and colour aspects on product perception at multiple stages from multiple perspectives, however also left aspects untouched upon. An important question that remains is what interactions there are with other competing sources of information *e.g.,* in the environment, on the package, in the mind of a consumer. In order to answer these questions food research needs to be approached in a more realistic and holistic way. Investigating effects of separate elements (*e.g.,* package colour and design) on perception, evaluation and behaviour is important to fundamentally understand the nature and mechanisms of such influences, however, these effects should not be treated as mutually exclusive and should be seen in light of other elements and influences (*e.g.,* other package elements, product (category), environmental context, culture). Each of them may help explain some proportion of the reality of the situation. In order to investigate influences and interrelations of a multitude of elements that may influence perception, evaluation and behaviour, methods need to be developed that capture all facets of influences. The development of new measurement tools and methods that paint a more holistic picture (such as the combining of methods that capture conscious and subconscious influences used here) and the development of new technologies such as eye tracking and virtual/augmented reality may aid to this holistic research approach and enable to take research beyond the lab, into the real world including supermarkets, restaurants, and at-home.

Main conclusion

This research obtained knowledge about the effectiveness of package design and colour aspects to influence product expectations, associations and evaluation, thereby making healthier products more attractive products. Although package design and colour aspects are influential when it comes to expectations and associations, their (long-term) effects on evaluation upon consumption are less profound. Packaging healthier products in package designs that emphasise attractiveness rather than healthiness, and using 'warm' or more vibrant package colours, can be a strategy to enhance attractiveness of the product. However, one needs to keep in mind the message that is conveyed through these package design and colour aspects. And in doing so, also take into account dependency and boundaries of these effects relative to other package elements and influences of the product (*i.e.,* product category, context, environment and consumer). Next to this, the research described in this thesis shows that incorporating measures that capture both conscious (*e.g.,* using rating scales) and unconscious aspects (*e.g.,* using IAT, fMRI) of food related behaviours provides an added dimension to the results. Therefore this combined approach is advised in order to better grasp the reality of the situation.

References

Ares, G. and R. Deliza (2010). "Studying the influence of package shape and colour on consumer expectations of milk desserts using word association and conjoint analysis." Food Quality and Preference 21(8): 930-937.

Bargh, J. A. (2002). "Losing Consciousness: Automatic Influences on Consumer Judgment, Behavior, and Motivation." Journal of Consumer Research 29(2): 280-285.

Becker, L., T. J. L. van Rompay, H. N. J. Schifferstein and M. Galetzka (2011). "Tough package, strong taste The influence of packaging design on taste impressions and product evaluations." Food Quality and Preference 22(1): 17-23.

Becker, L., T. J. L. van Rompay, H. N. J. Schifferstein and M. Galetzka (2011). "Tough package, strong taste: The influence of packaging design on taste impressions and product evaluations." Food Quality and Preference 22(1): 17-23.

Chandon, P. (2012). "How Package Design and Packaged-based Marketing Claims Lead to Overeating." Applied Economic Perspectives and Policy 35(1): 7-31.

Clement, J. (2007). "Visual influence on in-store buying decisions: an eye-track experiment on the visual influence of packaging design." Journal of Marketing Management 23(9-10): 917-928.

Dijksterhuis, A., P. K. Smith, R. B. van Baaren and D. H. J. Wigboldus (2005). "The Unconscious Consumer: Effects of Environment on Consumer Behavior." Journal of Consumer Psychology 15(3): 193-202.

Drewnowski, A. (1997). "TASTE PREFERENCES AND FOOD INTAKE." Annual Review of Nutrition 17(1): 237-253.

Duerrschmid, K., L. Danner and P. Varela (2018). Chapter 12 - Eye Tracking in Consumer Research A2 - Ares, Gastón. Methods in Consumer Research, Volume 2, Woodhead Publishing: 279-318.

Goldman, A. (1994). "Predicting product performance in the marketplace by immediate- and extended-use sensory testing." Food Technology October: 103-106.

Grabenhorst, F., E. T. Rolls and A. Bilderbeck (2008). "How cognition modulates affective responses to taste and flavor: Top-down influences on the orbitofrontal and pregenual cingulate cortices." Cerebral Cortex 18(7): 1549-1559.

Granzin, K. L., J. E. Olsen and J. J. Painter (1998). "Marketing to consumer segments using health-promoting lifestyles." Journal of Retailing and Consumer Services 5(3): 131-141.

Greenwald, A. G., D. E. McGhee and L. K. Schwartz (1998). "Measuring individual differences in implicit cognition: The implicit association task." Journal of Personality and Social Psychology 74(6): 1464-1480.

Greenwald, A. G., B. A. Nosek and M. R. Banaji (2003). "Understanding and using the Implicit Association Test: I. An improved scoring algorithm." Journal of Personality and Social Psychology 85(2): 197-216.

Greenwald, A. G., T. A. Poehlman, E. L. Uhlmann and M. R. Banaji (2009). "Understanding and using the Implicit Association Test: III. Meta-analysis of predictive validity." Journal of personality and social psychology 97(1): 17.

Huang, L. and J. Lu (2015). "Eat with your eyes: Package color influences the expectation of food taste and healthiness moderated by external eating." Marketing Management 25(2): 71-87.

Huang, L. and J. Lu (2015). "The Impact of Package Color and the Nutrition Content Labels on the Perception of Food Healthiness and Purchase Intention." Journal of Food Products Marketing: 1-29.

Hurley, R. A., J. Galvarino, E. Thackston, A. Ouzts and A. Pham (2013). "The effect of modifying structure to display product versus graphical representation on packaging." Packaging Technology and Science 26(8): 453-460.

Jacquot, L., L. Berthaud, A. Sghaïr, C. Diep and G. Brand (2013). "The Influence of “Tastiness” and “Healthiness” Labels in Cheese Flavor Perception." Chemosensory Perception 6(2): 53-59.

Jaeger, S. R., J. Hort, C. Porcherot, G. Ares, S. Pecore and H. J. H. MacFie (2017). "Future directions in sensory and consumer science: Four perspectives and audience voting." Food Quality and Preference 56: 301-309.

Kahneman, D. (2012). Thinking, fast and slow, Farrar, Straus and Giroux.

Kahneman, D. and J. Snell (1992). "Predicting a changing taste: Do people know what they will like?" Journal of Behavioral Decision Making 5(3): 187-200.

Kauppinen-Räisänen, H. (2014). "Strategic use of colour in brand packaging." Packaging Technology and Science 27(8): 663-676.

Köster, E. P. (2009). "Diversity in the determinants of food choice: A psychological perspective." Food Quality and Preference 20(2): 70-82.
Köster, E. P., C. Kornelson and K. H. K.H. Benz (2001). "Stability and change in food liking: food preferences in the two Germany's after reunification." M. Rothe (Ed.), Flavour 2000: Perception, release, evaluation, formation, acceptance, nutrition and health. Rhothe, Bergholz-Rehbrücke, Germany.
Kuhn, S. and J. Gallinat (2013). "Does Taste Matter? How Anticipation of Cola Brands Influences Gustatory Processing in the Brain." Plos One 8(4).
Lane, K. A., M. R. Banaji, B. A. Nosek and A. G. Greenwald (2007). "Understanding and using the implicit association test: IV." Implicit measures of attitudes: 59-102.
Lawless, H. T. and H. Heymann (2010). Sensory Evaluation of Food: Principles and Practices, Springer New York.
Li, X. E., S. M. Jervis and M. A. Drake (2015). "Examining Extrinsic Factors that Influence Product Acceptance: A Review." Journal of Food Science 80(5): R901-R909.
Ludden, G. D., H. N. Schifferstein and P. Hekkert (2009). "Visual–tactual incongruities in products as sources of surprise." Empirical Studies of the Arts 27(1): 61-87.
Mai, R., C. Symmank and B. Seeberg-Elverfeldt (2016). "Light and Pale Colors in Food Packaging: When Does This Package Cue Signal Superior Healthiness or Inferior Tastiness?" Journal of Retailing 92(4): 426-444.
McClure, S. M., J. Li, D. Tomlin, K. S. Cypert, L. M. Montague and P. R. Montague (2004). "Neural correlates of behavioral preference for culturally familiar drinks." Neuron 44(2): 379-387.
McCrickerd, K. and C. Forde (2016). "Sensory influences on food intake control: moving beyond palatability." obesity reviews 17(1): 18-29.
Meiselman, H. L. (2013). "The future in sensory/consumer research: ………....evolving to a better science." Food Quality and Preference 27(2): 208-214.
Moskowitz, H. R. (2000). "Engineering out food boredom: a product development approach that combines home use tests and time-preference analysis." Food Quality and Preference 11(6): 445-456.
Ng, M., C. Chaya and J. Hort (2013). "The influence of sensory and packaging cues on both liking and emotional, abstract and functional conceptualisations." Food Quality and Preference 29(2): 146-156.
Nisbett, R. E. and T. D. Wilson (1977). "Telling more than we can know: Verbal reports on mental processes." Psychological Review 84(3): 231-259.
Nitschke, J. B., G. E. Dixon, I. Sarinopoulos, S. J. Short, J. D. Cohen, E. E. Smith, S. M. Kosslyn, R. M. Rose and R. J. Davidson (2006). "Altering expectancy dampens neural response to aversive taste in primary taste cortex." Nature Neuroscience 9(3): 435-442.
Nosek, B. A., A. G. Greenwald and M. R. Banaji (2005). "Understanding and using the Implicit Association Test: II. Method variables and construct validity." Pers Soc Psychol Bull 31(2): 166-180.
Okamoto, M. and I. Dan (2013). "Extrinsic information influences taste and flavor perception: a review from psychological and neuroimaging perspectives." Semin Cell Dev Biol 24(3): 247-255.
Oliveira, D., L. Machín, R. Deliza, A. Rosenthal, E. H. Walter, A. Giménez and G. Ares (2016). "Consumers' attention to functional food labels: Insights from eye-tracking and change detection in a case study with probiotic milk." LWT - Food Science and Technology 68: 160-167.
Piqueras-Fiszman, B. and C. Spence (2015). "Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts." Food Quality and Preference 40: 165-179.
Poldrack, R. A. (2008). "The role of fMRI in cognitive neuroscience: where do we stand?" Current opinion in neurobiology 18(2): 223-227.
Raghunathan, R., R. Walker Naylor and W. D. Hoyer (2006). "The unhealthy is tasty intuition an its effect on taste inferences enjoyment and choice of food products." Journal of Marketing 70: 170-184.
Randall, E. and D. Sanjur (1981). "Food preferences—their conceptualization and relationship to consumption." Ecology of Food and Nutrition 11(3): 151-161.
Rebollar, R., I. Lidón, J. Martín and M. Puebla (2015). "The identification of viewing patterns of chocolate snack packages using eye-tracking techniques." Food Quality and Preference 39: 251-258.
Roininen, K., H. Tuorila, E. Zandstra, C. De Graaf, K. Vehkalahti, K. Stubenitsky and D. Mela (2001). "Differences in health and taste attitudes and reported behaviour among Finnish, Dutch and British

consumers: a cross-national validation of the Health and Taste Attitude Scales (HTAS)." Appetite 37(1): 33-45.
Rolls, B. J., L. S. Roe, T. V. Kral, J. S. Meengs and D. E. Wall (2004). "Increasing the portion size of a packaged snack increases energy intake in men and women." Appetite 42(1): 63-69.
Schifferstein, A. Fenko, P. M. Desmet, D. Labbe and N. Martin (2013). "Influence of package design on the dynamics of multisensory and emotional food experience." Food Quality and Preference 27(1): 18-25.
Sijtsema, S., G. Backus, A. Linnemann and W. Jongen (2009). "Linking perception of health-promoting food attributes to tangible product characteristics." British Food Journal 111(3): 207-222.
Spence, C. and C. Velasco (2018). "On the multiple effects of packaging colour on consumer behaviour and product experience in the 'food and beverage'and 'home and personal care'categories." Food Quality and Preference.
Swientek, B. (2001). "Uncanny developments." Beverage Industry 92(12): 38-39.
Tarancón, P., T. Sanz, S. Fiszman and A. Tárrega (2014). "Consumers' hedonic expectations and perception of the healthiness of biscuits made with olive oil or sunflower oil." Food research international 55: 197-206.
Ülger, B. (2008). "Packages with cartoon trade characters versus advertising: an empirical examination of preschoolers' food preferences." Journal of Food Products Marketing 15(1): 104-117.
Vabø, M. and H. Hansen (2014). "The relationship between food preferences and food choice: a theoretical discussion." International Journal of Business and Social Science 5(7).
Van Kleef, E., H. C. Van Trijp and P. Luning (2005). "Consumer research in the early stages of new product development: a critical review of methods and techniques." Food quality and preference 16(3): 181-201.
van Rompay, T. J. L., F. Deterink and A. Fenko (2016). "Healthy package, healthy product? Effects of packaging design as a function of purchase setting." Food Quality and Preference 53: 84-89.
Wąsowicz, G., M. Styśko-Kunkowska and K. G. Grunert (2015). "The meaning of colours in nutrition labelling in the context of expert and consumer criteria of evaluating food product healthfulness." Journal of health psychology 20(6): 907-920.
Woods, A. T., D. M. Lloyd, J. Kuenzel, E. Poliakoff, G. B. Dijksterhuis and A. Thomas (2011). "Expected taste intensity affects response to sweet drinks in primary taste cortex." Neuroreport 22(8): 365-369.
Zellner, D., N. Greene, M. Jimenez, A. Calderon, Y. Diaz and M. Sheraton (2018). "The effect of wrapper color on candy flavor expectations and perceptions." Food Quality and Preference 68: 98-104.

Summary

Dankwoord

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List of publications

Overview of completed training activities

Summary

A product's attractiveness is an important driver in food preferences, choices and consumption behaviour. Inherently, healthier food products (*i.e.,* 'light', sugar- or fat-reduced) are often perceived as less attractive, mainly in terms of liking, macronutrients, and sensory properties. Thus, healthier products are at a 'sensory disadvantage' and may be seen as less rewarding compared to their regular counterparts. Making healthier products more attractive could bridge this gap to help overcome the perceived or inferred shortcomings of healthier products. Extrinsic information such as package colour can influence our product expectations and perception, and could be an effective way to enhance the attractiveness of healthier products.

The research described in this thesis explored the effectiveness of package design and package colour aspects to make healthier food products more attractive. The influence of package design and colour aspects on product expectations, associations and evaluation upon tasting, both initially as over repeated encounters, were studied using questionnaires, sensory tests and implicit association tests (IATs). The underlying brain mechanisms and cognitive processes underlying these effects were investigated using functional Magnetic Resonance Imaging (fMRI).

Chapter 2 investigated the effects of several package colour aspects (hue, brightness and saturation) on perceived healthiness, attractiveness of food products, and sensory expectations based on the package alone, as well as product evaluation upon tasting in presence of the package. Implicit Association Tests (IATs) were used to measure the strength of associations between package colour aspects and perceived attractiveness and healthiness of the products. The results showed that the effects of package colour aspects were stronger for product expectations than for evaluations upon tasting. Packaging healthier products in warmer, saturated and less bright coloured packages (more similar to regular products) explicitly enhanced sensory expectations and evaluations, and implicitly improved attractiveness.

In **Chapter 3** the neural (brain activity patterns) and cognitive mechanisms, and the extent to which package colour aspects influence product perception were further investigated using fMRI. Packages with colour aspects representing healthier product packages (*i.e.,* high brightness, low saturation) and regular product packages (*i.e.,* low brightness, high saturation) were used as stimuli and brain responses where measured while viewing the packages, with and without simultaneously tasting two products (healthier and regular dairy drink). Results showed that package colour and taste properties modulate neural correlates. The influence of package colour aspects was predominantly elicited via top-down systems in brain regions related to reward representation and inhibitory control.

Across several experiments (Chapter 2, 5), implicit association tests (IATs) were employed to investigate subconscious attitudes with respect to healthiness and attractiveness. In **Chapter 4** results from all IATs were consolidated to determine the robustness of implicit associations between package colour aspects and concepts of healthiness and attractiveness. Results consistently showed that less vibrantly coloured packages and 'cool' coloured packages were implicitly more strongly associated with healthiness compared to vibrantly coloured packages and 'warm' coloured packages. Similarly, vibrantly coloured packages and 'warm' coloured

packages were shown to be more strongly associated with attractiveness compared to less vibrantly coloured packages and ‘cool’ coloured packages.

In **Chapter 5**, an experiment is described with two biscuit packages signalling either healthiness or tastiness of the biscuits. These packages were exclusively designed and produced for this study. The aim was to determine the influence of a multitude of package cues, including package colour, on product expectations as well as repeated (long-term) evaluation in a more realistic at-home setting. Implicit (IATs) as well as explicit (questionnaires) measurement tools were used and results showed that package designs mainly influenced product expectations. Product perception upon tasting was predominantly shaped by the intrinsic (flavour) properties of the biscuit itself. Implicitly, changes in associations between package design and perceived healthiness and attractiveness over time were seen. The direction of change depended on the package design thereby indicating a product-package interaction.

Lastly, in **Chapter 6**, the general discussion, the main findings and conclusions of this PhD thesis were described. Results showed that package design and colour aspects predominantly influence product expectations, and to a lesser extent product evaluation upon consumption. These influences are assumed to be the result of top-down processing in brain regions involved in reward and inhibitory control. On an implicit level, ‘warm’ and vibrantly coloured packages were clearly more associated with attractiveness (and unhealthiness) than ‘cool’ and less vibrantly coloured packages, and these associations were dynamic over time, where the directionality depended on the interaction between product and package.

Overall, we demonstrated the ability of package design and colour aspects to influence a product’s attractiveness, thereby potentially making healthier products more attractive to the consumer. The longevity and generalisability of these influences is however less clear and needs further investigation. Combining methods that capture conscious as well as less conscious aspects of food related behaviours, is recommended to better predict food related behaviour in real-life situations.

Dankwoord

Het zit er op, it's done, det er gjort, c'est fini, es ist fertig! Wat een bijzondere reis waren de afgelopen 4 jaren, en wát jammer dat het er op zit. Maar tegelijkertijd ben ik ook heel tevreden met, en trots op, het eindresultaat – DIT PROEFSCHRIFT!

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En nu... op naar een volgend avontuur!

About the author

Irene Odilia Jelly Marcelle Tijssen was born on November 9th 1987 in Eindhoven, The Netherlands. After completing secondary school at Plein College Bisschop Bekkers in Eindhoven, she moved to Wageningen to start her Bachelor's (Bsc) programme in Nutrition and Health at Wageningen University & Research. During her Bachelor's she took a year of studying to be a full-time financial manager of student association W.S.V. Ceres. She also completed a minor in Education and taught Biology classes in a local secondary school. After finishing her Bachelor's she enrolled in the Master's (MSc) specialization Sensory Science, a collaborative MSc programme of Wageningen University & Research and Copenhagen University. As part of this MSc programme she studied in Copenhagen for six months to attend several courses. After her MSc thesis on Temporal Dominance of Sensations and Emotions she completed her internship at PepsiCo International in Leicester, UK where she looked into the use of implicit facial expression software when evaluating food products. In 2014, after completing her MSc, she was appointed as a PhD candidate at Wageningen University & Research in the chair group of Sensory Science and Eating Behaviour. Her PhD research focussed on the abilities of package aspects, such as colour, to emphasise a product's attractiveness, thereby making healthier foods more attractive and an easier choice. Irene's research was part of the NUDGIS project. The NUDGIS project examined the effectiveness of nudges, defined as subtle rearrangements of the choice context, to gently suggest healthier food choices. The program aimed to formulate rules to design effective intervention strategies to help make healthy food choices easy and preferred food choices. During her PhD project, Irene joined the educational programme of Graduate School VLAG. She was also an MRI technician involved in neuromarketing research. Next to this she attended several (inter)national conferences and courses and was involved in teaching activities. She supervised BSc and MSc students in their thesis projects. Furthermore Irene was a member of the organising committee of the PhD study tour to the East Coast of the USA in 2015. She won an award (by NWO) for the best Research Pitch in 2015 as well as a travel award for the Pangborn Sensory Science symposium in 2017. In 2018, she was selected for the 24th Essentials programme of the European Nutritional Leadership Platform (ENLP).

List of publications

Publications in peer-reviewed journals

de Vries, R., Jager, G., **Tijssen, I**., & Zandstra, E. H. (2018). Shopping for products in a virtual world: Why haptics and visuals are equally important in shaping consumer perceptions and attitudes. *Food Quality and Preference*, *66*, 64-75.

Tijssen, I., Zandstra, E. H., de Graaf, C., & Jager, G. (2017). Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar-and fat-reduced products. *Food quality and preference*, *59*, 46-58.

Jager, G., Schlich, P., **Tijssen, I**., Yao, J., Visalli, M., De Graaf, C., & Stieger, M. (2014). Temporal dominance of emotions: Measuring dynamics of food-related emotions during consumption. *Food Quality and Preference*, *37*, 87-99.

Submitted publications

Tijssen, I.O.J.M., Smeets, P.A.M., Goedegebure, R.P.G., Zandstra, E.H., de Graaf, C., Jager, G. Colouring perception: package colour cues affect neural responses to sweet dairy drinks in reward and inhibition related regions. *Submitted.*

Tijssen, I.O.J.M., Zandstra, E.H., den Boer, A., Jager, G. Taste matters most: effects of package design on the dynamics of implicit and explicit product evaluations over repeated in-home consumption. *Submitted.*

Tijssen, I.O.J.M., Jager, G., Zandstra, E.H. Colouring attitude: implicit associations or package colour and concepts of product healthiness and attractiveness. *In preparation.*

Abstracts and presentations

Tijssen, I.O.J.M., Aucella, C., Schlich, P., Stieger, M., Jager, G (2014). Temporal dominance of emotions: a comparison between tasting (one-bite) and eating (ad libitum). Eurosense, Copenhagen, DK. (oral presentation)

Tijssen, I.O.J.M., Impric, I., Zandstra, E.H., Jager, G (2015). Explicitly healthy, implicitly pleasant: Implicit associations of healthy products with positive emotions. British Feeding and Drinking Group, Wageningen, NL. (oral presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2015). Colouring perception: how to make the healthy choice the easy choice? Pangborn Sensory Science Symposium, Goteborg, SW. (poster presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2016). Colouring perception: how to make a healthy product a tasty product? Society for the Study of Ingestive Behaviour, Porto, P. (poster presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2016). Colouring perception: how to make a healthy product an attractive product? Eurosense, Dijon, FR. (oral presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2017). Investigating healthiness and tastiness constructs with respect to package aesthetics and consumer attitudes. British Feeding and Drinking Group, Reading, UK. (poster presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2017). Investigating healthiness and tastiness constructs with respect to package aesthetics and consumer attitudes. Pangborn Sensory Science Symposium, Providence, USA. (poster presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2017). Colouring perception: Nudging attractiveness of healthier foods through package colour. Nudging Healthy Food Choice Symposium, Utrecht, NL. (oral presentation)

Tijssen, I.O.J.M., Zandstra, E.H., de Graaf, C., Jager, G (2018). Colouring perception: evidence from sensory, associative and neuroscientific research on nudging attractiveness of healthier foods through package colour. Eurosense, Verona, IT. (oral presentation)

Overview of completed training activities

Discipline specific courses and activities		
NUDGIS consortium meetings	Utrecht, Wageningen, NL	2014-2018
Eurosense Conference 2014	Copenhagen, DK	2014
PhD Sensory Science course	Copenhagen, DK	2014
Brain and Emotion pre-conference	Amsterdam, NL	2014
Pangborn Conference 2015	Göteborg, SW	2015
British Feeding and Drinking Group (BFDG)	Wageningen, NL	2015
Society for the Study of Ingestive Behaviour (SSIB)	Porto, P	2015
Masterclass Priming	Wageningen, NL	2015
Masterclass Habits	Wageningen, NL	2015
Summer school "Matters of Taste"	Tübingen, DE	2015
Temporal Dominance of Sensations course INRA	Göteborg, SW	2015
Eurosense Conference 2016	Dijon, FR	2016
Pangborn Conference 2017	Providence, USA	2017
British Feeding and Drinking Group (BFDG)	Reading, UK	2017
KNAW symposium “Freud en de neurowetenschap”	Amsterdam, NL	2017
NUDGE symposium	Utrecht, NL	2017
Eurosense Conference 2018	Verona, IT	2018
NUDGIS symposium	Utrecht, NL	2018
General courses and activities		
VLAG PhD week	Baarlo, NL	2014
Project and time management	Wageningen, NL	2014
Scientific Writing	Wageningen, NL	2014
Teaching and Supervising thesis students	Wageningen, NL	2015
Coaching	Wageningen, NL	2015
Career Perspectives	Wageningen, NL	2017
European Nutrition Leadership Platform – Essentials seminar	Luxembourg, LU	2018
Optional courses and activities		
Staff seminars & chair group meetings	Wageningen, NL	2014-2018
Preparation of PhD research proposal	Wageningen, NL	2014
Organising and participating in PhD study tour to the East Coast USA	USA	2015
Nutritional Neuroscience	Wageningen, NL	2015

Colophon

The research described in this thesis was conducted as part of the NUDGIS project. The NUDGIS project (Novel Understanding of Designs for Good Intervention Strategies in the food environment) involves four partners, Utrecht University, Wageningen University & Research, Unilever R&D Vlaardingen, and FrieslandCampina, Amersfoort and is financially supported by a grant from the Netherlands Organisation for Scientific Research (NWO), FrieslandCampina, Amersfoort, The Netherlands and Unilever R&D, Vlaardingen, The Netherlands (FCBG 057-13-001). The NUDGIS project examines the effectiveness of nudges, defined as subtle rearrangements of the choice context, to gently suggest healthier food choices. The program aims to formulate rules to design effective intervention strategies to help make healthy food choices easy and preferred food choices.

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