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The impact of food processing labels on consumer willingness to buy in an online supermarket

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Abstract

Ultra-processed foods increasingly dominate global diets and are linked to negative health outcomes. Although consumers often try to avoid ultra-processed foods, identifying them is challenging due to a lack of clarity on food packaging. This thesis investigated how displaying processing level indicators influences willingness to buy in a virtual online supermarket, comparing warning versus colour-coded labels and examining the role of textual explanations. A cross-sectional online experiment (N = 257) used a 2 (label type: warning vs. colour-coded) x 2 (processing level: high vs. low) x 2 (explanation: yes vs. no) between-subjects design. Participants evaluated products within a simulated supermarket interface. The results demonstrate that high processing levels significantly reduced willingness to buy. This effect was driven by a dual mediation through increased health risk perception and decreased naturalness perception. However, multiple regression revealed that only health risk perception directly predicted willingness to buy, suggesting that consumers prioritize health safety over naturalness in this specific context.

Notably, the visual format of the label (warning vs. colour-coded) did not significantly influence behaviour, indicating that the informational content is more impactful than the visual design. Furthermore, providing a textual explanation significantly improved both objective and subjective understanding, which amplified the impact of processing information on product perceptions. These findings suggest that online retailers can successfully nudge consumers away from ultra-processed foods by making processing levels salient. Practical implementation should consider combining processing labels with "tooltips" to provide context, thereby bridging the gap between consumer intentions and actual purchasing behaviour.

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1. Introduction

Ultra-processed foods are becoming a larger part of the global diet, with sales continuously increasing in all regions (Baker et al., 2020). According to the NOVA classification, these foods are defined as formulations of ingredients resulting from a series of industrial processes (Monteiro et al., 2019). This global trend is also happening in the Netherlands. According to market research by Foodwatch (2017), 70% of all products in Dutch supermarkets are ultra-processed. Furthermore, these foods have a high contribution in Dutch dietary patterns, with around 61% of total daily energy intake coming from these products (Vellinga et al., 2022).

The increasing consumption of ultra-processed foods is a cause of concern because of its negative impact on health. A systematic review of ten cross-sectional studies found that adults with high consumption levels had an increased risk of large waist circumference, obesity, reduced HDL-cholesterol levels and metabolic syndrome (Pagliai et al., 2021). A cohort study also found that high consumption of ultra-processed foods was associated with a higher likelihood of multimorbidity involving cancer and cardiometabolic diseases (Cordova et al., 2023). Other studies confirm these harmful effects. Hall et al. (2019) demonstrated that people consumed approximately 500 kcal more each day on an ultra-processed diet compared to an unprocessed diet, which led to a weight gain on the ultra-processed diet and a weight loss on the unprocessed diet. Similarly, Fardet (2016) found that increased food processing correlates with a higher glycaemic response (blood sugar spike) and lower satiety potential. Mental health outcomes are also affected; participants consuming nine or more ultra-processed servings per day had a 50% higher risk of developing depression compared to those eating the least (four or fewer servings) (Samuthpongtorn et al., 2023).

A systematic review of 45 meta-analyses involving almost 10 million participants confirmed these findings; Lane et al. (2024) systematically collected and re-analyzed existing meta-analyses to evaluate the strength and quality of evidence on the association between ultra-processed food consumption and health outcomes. According to this review of reviews, higher consumption of ultra-processed foods was linked to an increased risk of 32 negative health outcomes. These include cardiovascular mortality, obesity, type 2 diabetes, sleep problems, and depression. Specifically, the risk of cardiovascular mortality and the risk of anxiety and other common mental disorders each increased by approximately 50%, while the risk of depression increased by 22%.

These harmful effects can be explained by poor food quality such as high amounts of fat or added sugar, high energy density and low fibre levels. Packaging chemicals and harmful compounds formed during processing could also contribute to these negative effects (Pagliai et al., 2021). Finally, artificial sweeteners, emulsifiers, preservatives, and other food additives in large quantities can disturb the natural balance of gut bacteria. This disturbance can reduce the variety of "good" microbes, create conditions that trigger inflammation, make the gut lining more permeable, and ultimately contribute to an unhealthy gut environment (Rondinella et al., 2025).

Research conducted by Radar (2025) highlights that 85% of participants desired to avoid ultra-processed foods, but only 16% manage to do so. This struggle is mainly due to a lack of clarity regarding which products are ultra-processed. Consequently, 88% of consumers believe that ultra-processed foods should be easier to identify on packaging. This evidence highlights the importance of better informing consumers.

The online environment offers unique opportunities to provide this clarity more effectively than a physical store. Due to the digital space and technology available, online interfaces can provide the detailed explanations needed to help consumers recognize and interpret processing levels. Investigating these digital opportunities is relevant as online grocery shopping is becoming more common in the Netherlands. The number of consumers who occasionally shop for groceries online has increased from 10% to 22% (Deloitte Nederland, 2024). Consumers who do both online and physical grocery shopping buy 47% of their groceries online. In 2022, 7% of all supermarket revenue in the Netherlands came from online orders, and this is expected to increase to 9% by 2027 (CBRE, 2023).

While much research has already examined the health effects of ultra-processed foods, focusing mainly on the consumption of ultra-processed foods and the associated risks of chronic diseases, little research has explored how consumers are informed about the degree of food processing, particularly in an online shopping environment. In the EU, product information is only required to contain nutritional values such as calories, fat, sugar and salt. The level of food processing is seldom clearly communicated to the consumers, which can cause them to underestimate the negative impact of ultra-processed food consumption on their health.

Therefore, the aim of this thesis is to investigate the effect of displaying the degree of processing on the consumers' purchasing behaviour in an online supermarket. This information is needed to raise awareness or nudge consumers away from ultra-processed foods. To address this gap, the following research question has been formulated:

How does displaying the degree of food processing influence consumers' purchasing behaviour in an online supermarket?

2. Theoretical framework

2.1 How consumers process front-of-pack labels

Because ultra-processed food labels are a specific example of front-of-pack labelling, it is useful to first look at labels in general. Consumers are generally aware of nutrition labels and often recognise them on products. For example, French consumers said they knew the Nutri-Score logo and liked it, although observations showed that they did not use it as a main reason for purchase, with price and habits being more important (Cerf et al., 2024). Consumers prefer labels that are visible and easy to understand (Carlsson et al., 2022). Similarly, surveys in Europe and North America found that consumers were interested in receiving nutrition information on packaging. Preferences for formats varied, but there was support for simplified front-of-pack information (Wills et al., 2009). Any front-of-package label increased consumers' ability to understand nutritional quality of food products compared to no label (Gorski Findling et al., 2018; Hodgkins et al., 2015). Additionally, food labelling can be very effective in nudging consumers to choose healthier food products (Cecchini & Warin, 2016).

When consumers shop online, they often rely on visual cues like product images and logos rather than detailed product information (Benn et al., 2015). People stated that selecting products was more difficult when no pictures were shown. This suggests that in online supermarkets, textual elements such as labels or explanations are less noticeable, unless they are made salient and easy to interpret.

The Elaboration Likelihood Model may provide an explanation for why this happens. According to the model, attitudes are formed through two routes: the central route and the peripheral route (Petty & Cacioppo, 1986). The central route occurs when people are motivated and able to think carefully, whereas via the peripheral route, people rely on simple cues due to lower motivation. Online grocery shopping often involves quick, low-effort decisions based on limited information. Consequently, it is likely that consumers process information through the peripheral route and rely on simple cues like images and logos rather than more complex textual information. In such a low-elaboration setting, a short and clear explanation attached to the label can support the understanding; it helps consumers to correctly interpret label's meaning rather than misinterpreting it or relying only on other peripheral cues, such as the product image.

Overall, this suggests that front-of-pack labels need to be simple, visible and easy to process to influence choice, especially in online environments. The next section therefore turns to the types of front-of-pack labels that are used to communicate health-related information and, in particular, to types that communicate negative health cues or warnings.

2.2 Negative health information and warning-type labels

Multiple front-of-package labels exist for food products. Examples are "check" labels, numerical labels, colour coded labels and warning labels. These labels will further be discussed.

"Check" labels are simple quality labels indicating that a product meets certain standards (an example of such a label is shown in figure 1). Studies show that these logos attract relatively little visual attention compared to more detailed formats (Bialkova et al., 2014; Bialkova & van Trijp, 2010), and their credibility can be weakened when the underlying authority is unclear (Vyth et al., 2009) . Similar check-style symbols have shown limited effects for carbon-type labels as well (Edenbrandt et al., 2025). Because they attract little attention and trigger limited awareness, check labels are unlikely to communicate the degree of processing effectively and are therefore not considered further in this thesis.

Another type of front-of-package label is a numerical label. Numerical labels present information in a quantitative format, such as grams of nutrients, calories or percentage of daily value (an example is illustrated in figure 2). While simple numerical "Digit" labels can help consumers identify single attributes like carbon footprint (Edenbrandt et al., 2025), communicating nutritional quality or degree of processing requires integrating multiple pieces of information. This makes numerical schemes difficult to interpret. European consumers report that Guideline Daily Amount labels feel complex, information-heavy and require considerable cognitive effort, which also reduces their attentional capture (Deliza et al., 2020; Ducrot et al., 2015; van Kleef et al., 2008). Numerical labels therefore do not seem suitable for communicating processing level and are not considered further.

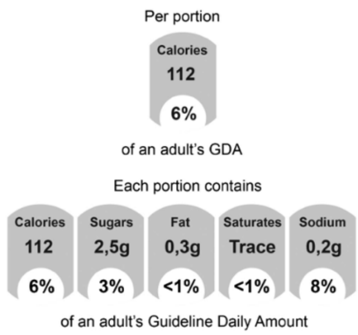
Figure 2

Overview of the different design groups

(Hoogendoorn & van den Berg, 2016)

Figure 1

A guideline daily amount scheme

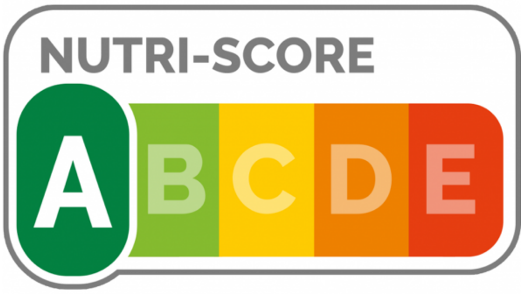


(Carter et al., 2011)

Colour-coded labels use colours to indicate the relative healthfulness of a product. There are different types of colour coded labels. Traffic-light system indicates the amount of each target nutrient and uses green, yellow, and red for low, medium, and high nutrient levels. The Nutri-Score summarizes the overall nutritional quality of the product and indicates the healthiness of this ratio with a colour which ranges from dark green (A) to red (E). The Nutri-score is illustrated in figure 3 and an example of a traffic-light system can be seen in figure 4.

Figure 4

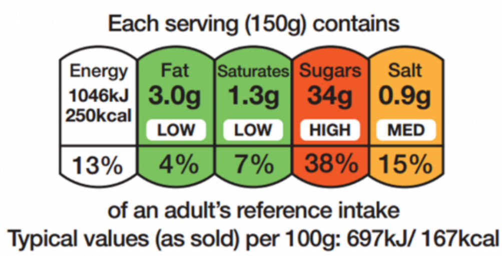
Nutri-Score



(Cerf et al., 2024)

Figure 3

A traffic-light system



(Song et al., 2021)

Research shows that simplified, colour-coded formats improve understanding: an Australian study found that the traffic light system labels helped consumers identify healthier products more easily than numerical formats, such as the Percentage Daily Intake system (Kelly et al., 2009). A large review of 156 studies confirmed that the traffic-light system was more suitable for complex understanding tasks such as classifying saturated fat and sugar. However, consumers sometimes reported confusion because too much information was presented. The Nutri-Score was perceived as more salient and easier to understand than the traffic light (Song et al., 2021), it required the least amount time and was not perceived as complex (Ducrot et al., 2015). The Nutri-Score had even higher objective understanding than the Multiple Traffic Lights label (Egnell et al., 2018).

Colour-coded systems have the same effect on climate labels; better understanding than other label formats. Dreist et al. (2024) found that while the climate-neutral label was perceived to be the most understandable and beneficial, the objective knowledge showed that traffic light labels were best understood. This could be because such labels are self-explanatory, it makes it easier for consumers to judge the label. Adding a traffic light ranking to a carbon footprint label might have a positive influence on consumers' environmental concern (Thøgersen & Nielsen, 2016).

Evidence on whether colour improves salience is mixed. When monochrome labels (black-white colours) were compared to colour-coded versions, the monochrome labels were identified faster than the colour-coded version (Bialkova & van Trijp, 2010; Deliza et al., 2020). This contradicts another study (Pettigrew et al., 2024) which suggested that that black-white labels caused their low salience: fewer than half of the participants noticed the label. These contradictory findings could be explained by differing background colours, which may influence attentional capture (Cabrera et al., 2017).

Balcombe et al. (2010) studied the UK traffic light system and found that consumers showed a strong preference to avoid baskets of products containing any red traffic light. People were willing to pay extra to swap out those red-labelled products for healthier options. This proves that colour-coded labels with red lights shift people away from unhealthy choices.
Egnell et al. (2021) examined the impact of the Nutri-Score label on food purchasing intentions across three randomized controlled trials in an online supermarket, using the NOVA classification to distinguish the four groups. Compared to a no-label and a Reference Intakes condition, the presence of the Nutri-Score led to fewer pre-packed processed and ultra-processed products, and a higher proportion of unpacked, minimally processed foods in the

shopping cart. These findings suggest that colour-coded labels can shift purchases intentions away from ultra-processed products and towards less processed alternatives, even though Nutri-Score itself is not explicitly based on processing level.

Another potential label for ultra-processed food products is a warning label. Warning labels highlight when a product contains high levels of nutrients lined to health risks. The focus of warning labels is to try to discourage consumers from purchasing something. They are effective if they catch consumers' attention and effectively communicate their key message (Laughery et al., 1993, as cited in Cabrera et al., 2017). Nutrient and health warnings drew more attention than control conditions and helped consumers understand the nutrition information, resulting in healthier purchases (Song et al., 2021). Their effect also depends on visibility; warning labels placed in the upper-left corner had the highest attentional capture (Cabrera et al., 2017). This could be explained by people's way of reading (from left to right).
Beyond attention, nutrient warnings are perceived as easy to understand, noticeable and credible, as they do not require deep thinking to understand the information (Taillie et al., 2020). They also improve consumers' ability to interpret nutritional information (Ares et al., 2021).
In terms of perception, warnings are more associated with "danger" due to cautionary texts, black and white colours and "stop" symbols. These design features elicit negative emotions and perceptions towards unhealthy products, reminding consumers to eat less unhealthy foods (Song et al., 2021). Shape also matters: a summary of studies found that the octagonal warnings were more closely associated with unhealthfulness than triangular shapes (Cabrera et al., 2017). This is probably linked to people's association with the octagonal STOP traffic sign. An example of an octagon warning label is illustrated in figure 5.

Figure 5

An example of an octagon warning label

(PAHO, n.d.)

Warning labels also influenced perceived healthfulness; products high in fat, sugar and energy were rated less healthy when they had a warning label compared to Guideline Daily Amounts and traffic-light system (Arrúa et al., 2017). Furthermore, warning labels not only influence perception but also behaviour. They can capture consumers' attention while they are purchasing a product, with approximately 60% of the consumers to change their decision (Ares et al., 2021). Warning labels trigger substitution-effects, which means that they try to help people into substituting their usual products by healthier alternatives. This effect is in line with the findings of Song et al. (2021), who found that warnings are generally more effective at discouraging unhealthful purchasing behaviour. A systematic review of studies conducted in a laboratory or online setting found that health warning labels on a food packaging could reduce the selection of such products (Clarke et al., 2021). Similarly, health warning labels reduced the hypothetical choice of energy-dense snacks in an online setting. These were more effective than only calorie information. (Clarke et al., 2020).

In conclusion, colour-coded and warning labels are potentially most suitable formats for communicating the degree of food processing. While colour-coded labels are easy to interpret, warning labels are particularly effective in discouraging unhealthy choices. Having considered different front-of-pack labels and their effects on attention, understanding, and behaviour, the next section examines the underlying construct that these labels communicate: the degree of food processing as defined by the NOVA classification.

2.3 Communicating ultra-processing through labels

The NOVA classification is currently the most widely used system for categorizing foods according to the extent of their processing, shifting the focus away from a nutrient-based perspective. The classification was developed for several reasons. One of the reasons is that the traditional food classifications based on nutrients were outdated because they overlooked the impact of food processing. This relates to the growing evidence of a relationship between food processing and health outcomes. At the same time, food systems and supplies around the world were shifting towards supermarkets and fast-food chains, often driven by powerful transnational corporations with lots of resources (Monteiro et al., 2018). NOVA classifies all foods and food products into four groups. An overview of these groups can be found in table 1.

Table 1

Overview of the different NOVA classification groups

Group	Degree of processing	Explanation	Examples
1	Unprocessed or minimally processed foods	Unprocessed foods are edible parts of animals or plants after they have been extracted from nature. While minimally processed foods are processed with the aim of preserving natural foods, make them suitable for storage, and making them safe or easier to eat.	Eggs, milk, seeds, fruits and water.
2	Processed culinary ingredients	These are substances that are extracted from foods in Group 1 or from nature by processes. These ingredients are not consumed on their own but used in kitchens to prepare, cook and season Group 1 foods.	Oils, butter, lard, sugar and salt.
3	Processed foods	Processed foods are made by adding ingredients from Group 2 to Group 1 foods. They contain only a few ingredients and are still recognizable as Group 1 foods, only modified. The goal of this processing is to increase the shelf-life of Group 1 foods or to enhance their flavour and texture while still being recognizable.	Tinned fish, fruits in syrup, cheese and canned vegetables.

4	Ultra-processed foods	These are industrial formulations made from extracted ingredients with several additives such as flavourings, colourings, sweeteners and emulsifiers. Almost nothing from the original food looks alike. Multiple sequences of processes is used to create the final product, hence 'ultra-processed'. The reason why the ultra-processing takes place is to make convenient, long-lasting, low-cost, and attractive food products.	Candy, chocolate, carbonated drinks, energy bars and instant noodles.

According to Monteiro et al. (2019), if an ingredient list contains one or more ingredient never or rarely used in kitchens, or additives making the product more appealing, the food product is likely ultra-processed.

The NOVA classification makes it easier to categorize products based on their level of processing. However, there are many exceptions of products that can belong to different groups For example, fresh milk falls into Group 1, while condensed milk would be classified as Group 3. Similarly, traditional cheese fits in Group 3 but cheese slices with stabilisers and sweeteners is a Group 4 product. Therefore, it is important to remember that many borderline cases exist. And these borderline cases show exactly that the degree of processing is not always intuitive for consumers. For these types of products, an explicit processing label can help consumers understand.

Although researchers can classify food products into NOVA groups quite strictly, it remains difficult for consumers to recognize these distinctions. Their decisions are eventually influenced by how they perceive and interpret the products. Therefore, it is important to understand how consumers process labeling information about the degree of processing.

Recent experimental studies show that explicitly mentioning ultra-processing on the front of the package helps consumers recognise when a product is ultra-processed, while effects on perceived healthfulness and purchase intentions are more limited and context dependent. In Brazil, adding a clear "WARNING: ULTRA-PROCESSED" label to products which already contain nutrient warnings led more participants to correctly classify all products as ultra-processed, but it did not further reduce purchase intentions or perceived healthfulness beyond the nutrient warnings that were already present (D'Angelo Campos, Ng, Duran, et al., 2024). A similar idea was tested in France with a modified Nutri-Score that combined the standard A–E nutrient scale with a black ultra-processed food banner. In this study, Nutri-Score 2.0 improved consumers' ability to understand both nutrient quality and processing level, and it shifted purchasing intentions toward less processed products (Srour et al., 2023). Similarly, in the US, an octagonal "ultra-processed" label on yoghurt increased how much people thought about the risks of eating the product and discouraged them more from wanting to buy it compared to a control label (D'Angelo Campos, Ng, McNeel, et al., 2024).

Taken together, these studies suggest that UPF labels mainly increase awareness and recognition of ultra-processing and can influence perceptions and choices when they provide new information or are combined with other warning cues. However, adding the term "ultra-processed" is not always sufficient to change purchase intentions, especially when strong nutrient warnings are already present.

Based on findings in previous literature, the following hypotheses are formulated:

H1a: A product with a higher processing level compared to a lower processing level leads to a lower willingness to buy.

Besides the information itself, the visual format of the label likely plays a key role in the consumer's decision. The specific label type is therefore expected to influence how strongly processing levels affect their willingness to buy:

H1b: The effect of processing level on willingness to buy is greater with a warning label than with a colour coded label.

The previous findings highlight the importance of understanding not only whether consumers recognise processing level, but also how information about processing and label type shape the perceptions that influence their decisions. The next section therefore considers how processing level and label type are expected to influence key perceptions such as naturalness and health risk.

2.4 Effects of processing level and label type on perceptions

The level of processing in food products influences perceived food naturalness. Rozin et al. (2012) define food naturalness as the absence of "negative" components, such as additives or pollutants. Even small amounts of additives in food products, such as fruit powder, can therefore have a large impact on perceived naturalness (Evans et al., 2010). After a certain level of additives, however, this decrease in perceived naturalness stabilises. The presentation of these additives also matters: products labelled with E-numbers are perceived as less natural than when the same preservatives are described by their common names (Evans et al., 2010). The type of processing also plays an important role in consumer naturalness perception (Rozin, 2005). Firstly, people often judge the naturalness of food more by how it was processed than by what they contain. Secondly, chemical manipulation, such as starch extracted from plants, caused a lower perceived naturalness compared to physical manipulations like chopping or drying.

A lack of perceived naturalness is often based on the perceived degree of processing (Hartmann et al., 2022). This was shown among Singaporean adults in two online survey studies in which participants rated pictures of foods from several categories that systematically varied in their level of processing, from low processed to high processed products. For each product, they evaluated how processed and how natural they perceived it to be. Across all categories, higher perceived levels of processing were associated with lower perceived naturalness, supporting the idea that more processed foods are viewed as less natural (Cheon et al., 2024). Similar findings were observed in South America (Aguirre et al., 2019) where young consumers characterised ultra-processed foods as unnatural. Dutch consumers showed the same perceptions. In a mixed-methods study among Dutch adults (Bolhuis et al., 2024), a questionnaire and follow-up interviews were used to explore attitudes and associations with industrial food processing. Respondents often linked processed foods to "artificial" and "not fresh", and interviewees explained that processed products no longer resembled their natural origins and therefore felt less natural.

Ultra-processed foods were also evaluated as unhealthy in European countries (Bolhuis et al., 2022, 2024; Hässig et al., 2023). Respondents associated consuming ultra-processed foods with weight gain. They even worried about the health risks of ultra-processing with concerns about the chemicals and the nutritional value of these products (EIT Food Consumer Observatory, 2024). The healthiness perception of ultra-processed foods is influenced by salient features such as nutrient claims, logos and branding (Machín et al., 2020). Consumers' awareness and understanding of nutritional components, symbols, and other intrinsic or extrinsic cues like smell, taste and health claims can lead to healthy or unhealthy food choices (Pinto et al., 2021). This is confirmed by Plasek et al. (2020) who showed that consumers judge the healthiness of a food based on multiple cues at once, not just the nutrient profile. According to them, perceived healthiness is shaped by communicated information (nutrition info, health claims, FoP labels, pictures), packaging cues, ingredients or nutrient levels, product category, organic or bio-origin, and sensory expectations. Organic labels and "healthier" compositions (e.g. reduced fat/sugar/salt) generally increase perceived healthiness. However, taste often dominates in actual choice: if a product is expected to taste bad, positive health cues are usually not enough to persuade consumers.

Previous literature indicates that a higher degree of food processing is associated with higher perceived health risks and lower perceived naturalness. Therefore, the following hypotheses are formulated:

H2: A product with a higher processing level compared to a lower processing level is associated with a lower perceived naturalness.

H3a: A product with a higher processing level compared to a lower processing level is associated with a higher perceived health risk.

Warning and colour-coded labels differ in how they communicate information. Warning labels draw attention to potential health risks, often using visual signals like colour contrasts or octagonal "stop" shapes. These features evoke negative emotions, leading consumers to perceive the product as unhealthy. Colour-coded labels on the other hand, are more informative and help consumers with comparing products, this makes them to evoke weaker emotional responses. Therefore, it is expected that warning labels are more effective in increasing health risk perceptions than colour-coded labels:

H3b: The effect of processing level on perceived health risk will be stronger when the product carries a warning label than when it carries a colour-coded label.

These hypotheses imply that processing level and label format first shape how consumers see the product. The next section therefore discusses how the naturalness perception and health risk perception influence consumers' behaviour towards food purchases.

2.5 Mediating role of perceived naturalness and health risk

The effect of processing level and label type on willingness to buy is expected to operate through perceived naturalness and perceived health risk. Earlier sections described how higher levels of processing and labels can decrease perceived naturalness and increase perceived health risk. This section explains how these perceptions are expected to influence purchase intentions.

A large systematic review concluded that naturalness in food products is important for consumers (Román et al., 2017; Rozin et al., 2004) . In general, products that are perceived as more natural lead to a higher levels attractiveness, credibility, quality, and purchase intention (Binninger, 2017). The perceived naturalness of food products depends on the type and extent of processing: more processing leads to lower perceived naturalness (Evans et al., 2010). Traditional and familiar food processes are associated with higher perceived naturalness (Etale

& Siegrist, 2021), whereas new or recently developed food processes are perceived as less natural. Consumers also perceive large-scale, industrial processing as more unnatural. Taken together, these findings suggest that labels which make the degree of processing salient, especially when they highlight that a product is ultra-processed, are likely to lower perceived naturalness. When a product is perceived as less natural, it becomes less attractive and less desirable to buy.

Based on this reasoning, the following hypothesis is formulated:

H4: A product with a lower perceived naturalness compared to a higher perceived naturalness leads to a lower willingness to buy.

Perceptions of the healthfulness of a food product show a similar effect on purchase intention. Several studies show that beliefs about the healthiness of a food product influence how much people want to consume it. When a snack is perceived as healthy, individuals consume substantially more of it than when the same snack is perceived as unhealthy (Provencher et al., 2009). Beliefs about the healthiness of a food product can make it feel more appropriate to eat in larger amounts. Front-of-pack nutrition claims that increase perceived healthfulness also tend to raise willingness to buy (Marsola et al., 2025).

Perceived risk works in the opposite direction: higher risk perception leads to lower purchase intention (Yeung & Morris, 2001). When a product is perceived as risky, consumers tend to either stop buying, reduce the consumption, shift to a similar product with less perceived risk, or accept the risk and continue to purchase (Roselius, 1971). This has also been observed in food contexts: food safety risk perception has a negative effect on consumers' willingness to buy (Machado Nardi et al., 2020). When consumers had a high health risk perception, they had a negative attitude towards the product leading to a lower purchase intention. Conversely, a lower health risk perception also led to a higher purchase intention (Ma & Zhang, 2023). A meta-analysis by Sheeran et al. (2014) showed that increasing the health risk perception changed purchase intention and behaviour. These effects increase when people believe they can effectively take action to reduce the risk.

In the context of ultra-processed foods, processing labels and warning-type labels are designed to highlight potential health risks of products that are classified as ultra-processed. When such labels increase perceived health risk, they are expected to reduce willingness to buy, particularly if consumers feel that choosing less processed alternatives is a way to lower this risk. Therefore, the following hypothesis is formulated:

H5: A product with a higher perceived health risk compared to a lower perceived health risk leads to a lower willingness to buy.

Because the experiment in this thesis takes place in an online supermarket setting and manipulates whether a short explanation is shown alongside the label, it is also important to consider how the online context and textual explanation may influence understanding of the label and, indirectly, these perceptions. This is discussed in the next section.

2.6 The role of textual explanation and understanding

The present study focuses on understanding as one of the key cognitive mechanisms. In the context of ultra-processed food labels in an online web shop, an explanation of what the different levels of processing mean and why it matters is expected to improve consumers' understanding of the label, which then influences how they evaluate the product. Because the study is conducted in an online supermarket interface, there is space to provide such a textual explanation, affecting the way labels are processed.

Apart from attracting attention, understanding also has a more basic effect: it changes how consumers perceive the product in the first place. Borgmeier and Westenhoefer (2009) found that when individuals understand front-of-pack labels, they also start to view the product differently. Understanding of labels made consumers judge certain foods as healthier, which suggests that understanding isn't just an extra piece of information but something that shapes the way people look at the product itself. A scoping review on front-of-package nutrient warning labels for sugary drinks and ultra-processed foods shows a similar pattern: nutrient warnings appear to shape behaviour by first catching their attention and helping consumers understand the risks, which then increases their perception of health danger and ultimately influences their intentions and choices (Taillie et al., 2020). In other words, clearer warnings first change how unhealthy a product feels, and this shift in perception is what makes people reconsider their choices. A similar pattern can be seen outside the food domain. In a study on remanufactured products, Wang and Hazen (2016) showed that knowing more about a product's cost, quality, or environmental benefits changed how valuable and risky the product felt to consumers. These perceptions, rather than knowledge alone, were what drove willingness to buy. Even though this research is about a different type of product, both studies show the same: understanding influences behaviour by shifting how the product is perceived, not by directly increasing purchase intentions on its own.

Concluding, providing a short textual explanation together with the label can increase consumers' understanding, making the label more meaningful. Therefore, it can be expected that:

H6a: Displaying an explanation next to the ultra-processed food label will lead to a better understanding of the label.

If explanations indeed increase understanding, this higher understanding is also likely to influence how strongly consumers perceive the differences between products. When understanding is low, differences in processing level may be noticed less clearly and have weaker effects on perceptions. However, when people understand the label well, they should be better able to distinguish between low- and high-processed products. This clarity is expected to intensify the differences in perceived naturalness and perceived health risk.

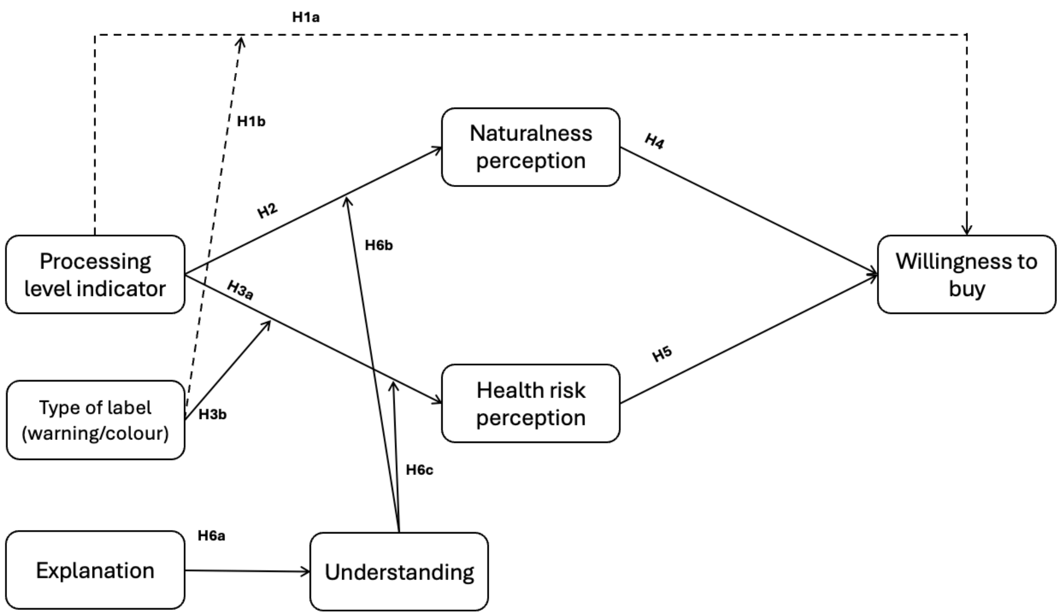
This leads to the following hypotheses:

H6b: The effect of processing level on perceived naturalness is moderated by understanding, such that the difference in naturalness between low- and high-processed products is larger when understanding is high.

H6c: The effect of processing level on perceived health risk is moderated by understanding, such that the difference in health risk between low- and high-processed products is larger when understanding is high.

Figure 6

Conceptual framework illustrating the hypothesised relationships.



3. Methodology

3.1 Participants and design

In order to investigate the suggested model and test the hypotheses, this study used a quantitative research approach. A cross-sectional online survey was conducted using Qualtrics. The survey used a 2 (type of label: warning vs. colour-coded) x 2 (level of processing: high vs. low) x 2 (textual explanation vs. no textual explanation) between-subjects design. Participants were randomly assigned to one of eight different groups. An overview of the groups is provided in table 2.

The research population of this study consisted of Dutch adults (aged 18 and over). Most participants reported doing their grocery shopping on a regular basis. For this research, "regularly" was defined as at least once every two weeks. The participants were recruited through non-probability convenience sampling. Snowball sampling was used; this means that the survey was sent via WhatsApp and Facebook and everyone filling in the survey was asked if they could forward it to their social networks.

An a priori power analysis was conducted using the free available program G*Power 3.1 (Faul et al., 2007) to determine the minimum required sample size for this study. The analysis was based on an F-test (ANOVA: fixed effects, special, main effects and interactions). The parameters included an effect size f of 0.25, an α level of 0.05, and a statistical power of 0.80. The number of degrees of freedom were set to 11, this number is derived from every group (8) plus three extra effects of the mediator on the independent variable. The analysis indicated a required total sample size of N = 270 participants, which makes approximately 34 participants per condition.

Table 2

Overview of the different design groups

Group	Label type	Processing level	Textual explanation yes/no	n (%)
1	Warning	High	No	34 (13.2)
2	Warning	High	Yes	32 (12.5)
3	Warning	Low	No	34 (13.2)
4	Warning	Low	Yes	31 (12.1)
5	Colour-coded	High	No	32 (12.5)
6	Colour-coded	High	Yes	31 (12.1)
7	Colour-coded	Low	No	33 (12.8)
8	Colour-coded	Low	Yes	30 (11.7)

3.2 Stimuli

Several potential product pairs were first brainstormed which were comparable in type but different in the level of processing. These products were pretested with a very small sample size (n = 5) to evaluate which products were perceived as most comparable and realistic for the experiment. That led to the selection of these products: oatmeal flakes and crunchy granola (the product images can be found in the Appendix). The participants were shown two products, both from national brands, that are most recognizable, and their prices were derived from multiple online supermarkets to be as realistic as possible. The online interface was developed using HTML code that was used in Qualtrics. This was to make the online supermarket as neutral as possible. The HTML code was generated using ChatGPT and can be found in the Appendix.

The four different labels that were shown on the food products were also generated using ChatGPT. An overview of all the labels is shown in figure 7.

Figure 7

An overview of all different labels shown to the participants. (From left to right: Warning label and high processing, warning label and low processing, colour-coded label and high processing, colour-coded label and low processing.) Generated with ChatGPT.

For the conditions including an explanation, ChatGPT was used to generate simplified descriptions of the different NOVA systems. This was done to get an easy definition of the different NOVA groups for people who are less informed. The groups receiving a textual explanation were presented with the following:
The label represents the degree of processing of this food product. The degree of processing can be divided into four groups:

- *Group 1 are foods close to how they come from nature*
- *Group 2 are foods that come from natural foods but are changed a bit to help us cook*
- *Group 3 are natural foods with a few added ingredients to make them last longer or taste better*
- *Group 4 are ultra-processed foods made mostly in factories with lots of extra stuff*

The consumption of ultra-processed foods can have certain negative health effects.

3.3 Measures

Willingness to buy was measured using a seven-point structured scale adapted from Kytö et al. (2019) ranging from 1 = *I certainly would not buy*, to 7 = *I certainly would buy*. Participants indicated the likelihood that they would purchase the food product. An adapted hedonic scale from Głuchowski et al. (2021) was used to measure overall liking of the product. This question was added to control for the willingness to buy variable.

Naturalness perception was measured using a four-item seven-point Likert scale adapted from Gonzalez Coffin et al. (2024). Participants indicated their agreement (1 = *strongly disagree*, 7 = *strongly agree*) with four statements, consisting of "this product is natural", "this product is artificial" (reversed), "this relies on science-based technology" (reversed), and "the making of this product involves humans altering naturally occurring processes" (reversed).

Health risk perception was assessed using an adapted three-item, seven-point Likert scale based on Clarke et al. (2020). Participants responded to the following statements: "consuming this food product often would… lead to weight gain, …increase your risk of cardiovascular diseases, …help you lead a healthier life (reversed). Agreement (1 = "strongly disagree", 7 = "strongly agree"). To assess overall perceived healthiness of the food product, an adapted one-item scale from Hässig et al. (2023) was used: "How healthy do you perceive this product? (reversed)" using a seven-point rating scale ranging from 1 = "very unhealthy" to 7 = "very healthy."

To measure the self-reported (subjective) understanding of the ultra-processed food label, the participants were asked "Do you find this label … with the answer options: 'very hard to understand,' 'hard to understand,' 'neither hard or easy to understand,' 'easy to understand,' or 'very easy to understand?'" (Bhawra et al., 2022). Objective understanding of ultra-processed foods was measured by asking: "According to you, ultra-processed foods are (more than one option can be selected): goods composed with more than 5 ingredients, food products submitted to a series of industrial processing, genetically modified products, food products that contain artificial ingredients, or I don't know what ultra-processed foods are" (Bolhuis et al., 2022). Responses were converted into a total score by adding up all correct answers, where points were awarded for the selection of correct answers and absence of selection for false answers.

To confirm that the participants perceived the manipulations as intended, two manipulation-check questions were included. Perceived level of processing was measured on a seven-point scale ranging from 1 = "not processed at all" to 7 = "very highly processed," adapted from Hässig et al. (2023). Participants were asked: "How processed do you perceive this product to be?". The other manipulation check was used to check if the participants noticed the label: "which type of label did you see on the product?" with response options (1) a warning label, (2) a colour-coded label, (3) not sure, (4) I did not see any label.

Shopping behaviour was assessed by asking participants how frequently they purchased groceries at a supermarket. The answering options were "7 times a week", "5-6 times a week", "3-4 times a week", "1-2 times a week", "2 times every 2 weeks", "once every 2 weeks", "less than once per month" and "never/rarely".

Questions about the demographics was about their gender, age, and completed education level

3.4 Procedure

Participants received an invitation link to fill in the questionnaire. When clicking the link, they first saw an introduction page with all relevant information about the study. After reading this information, the participants either agreed or disagreed with the informed consent. Those who disagreed were forwarded to the end of the questionnaire. The remaining participants were randomly assigned to one of the eight conditions using Qualtrics' randomization function. Participants first saw the food product with a label on a virtual webpage, one of the four different labels indicating the level of processing appeared in the upper-left corner of the image, as this placement has the highest attentional capture (Cabrera et al., 2017). Subsequently, they were asked directly about their willingness to buy the product and their overall liking of the product. These questions were presented first to ensure that their answers were based on their first impression, before their opinions might be influenced by the subsequent questions about the label. After the questions about the label and perceptions, a manipulation check was included to verify that the participants perceived the manipulations as intended. Questions about their understanding of the label and knowledge of the term "ultra-processed" were asked to measure understanding. The final questions addressed their grocery shopping behaviour and demographics. The duration of the questionnaire was approximately 5-10 minutes.

This research was conducted in accordance with the code of ethics for research in the social and behavioural sciences (Code of Ethics for Research in the Social and Behavioural Sciences Involving Human Participants, 2016). Participants were provided with an informed consent form before they started with the questionnaire. This informed consent included relevant information about the study, the intended use of data, and a note that the respondent could leave the questionnaire at any time. This consent was obtained before any data were collected. No personal information (e.g. name, address, IP address) was collected to ensure confidentiality and data protection. The data were used solely for academic research purposes.

3.5 Data analysis

The data were analysed using IBM SPSS statistics. Additionally, the PROCESS Macro by Hayes was used to conduct a mediation and moderation analyses. Before analysis, data cleaning was performed by applying specific inclusion criteria to ensure the quality and relevance of the results. First, only respondents who reported grocery shopping at least once every two weeks were included. Second, participants had to complete the final manipulation check (the last item prior to the demographics) to be included in the analysis. This ensured that only respondents who provided meaningful data for the core experiment were used. Participants who failed to complete the demographic section were still included, as these variables were not important for the main data analysis.

To prepare the data for analysis, several items were reverse-coded. Specifically, two items for health risk perception and three items for naturalness perception were recoded. Subsequently, reliability analyses were conducted. Both the naturalness perception scale (α = .877) and the health risk perception scale (α = .920) showed high internal consistency. Because the Cronbach's alphas were sufficient, the items were averaged into two variables: *NAT_total* and *HRP_total*. Additionally, the different conditions were transformed into three categorical factors: *Factor_Processinglevel*, *Factor_Labeltype*, *Factor_Explanation*. The factors processing level (-1 = low, 1 = high) and label type (-1 = warning, 1 = colour-coded) were effect-coded. Furthermore, the moderator "understanding" was operationalized through two dimensions: objective understanding and subjective understanding. To identify interesting

similarities or differences, the effect of understanding was analysed separately for each dimension. To enhance interpretability and reduce multicollinearity they were both grand-mean centred.
Randomization checks were also conducted for age and gender to ensure that these do not act as confounding variables. Finally, independent sample t-tests were conducted to test the manipulation checks. Correlational analyses were used to check if relationships between the constructs were present.

To test the proposed hypotheses, regression analyses were conducted to examine the main and interaction effects of label type, processing level, and understanding level on each dependent variable. In addition, mediation and moderation analyses were performed using the PROCESS macro (model 4 and model 7). Perceived naturalness, and perceived health risk were then tested as potential mediators of the effect of the independent variables on willingness to buy. Moderation analyses were conducted to test whether the label type and objective and subjective understanding moderated the effect. Finally, assumptions of normality, homogeneity of variance, and independence of observations were also verified.

4. Results

Initially, 315 responses were collected; however, after filtering for grocery shopping frequency and providing meaningful data, a final sample of 257 was retained for analysis. The sample consisted of 123 males (47.9%), 130 females (50.6%), and four individuals (1.5%) who either identified as 'other' or preferred not to indicate their gender. The mean age of the participants was 38.9 years (*SD* = 17.7, range: 16–82). Regarding educational level, the majority of the sample was highly educated, with 74.3% holding an HBO/WO bachelor's degree or higher.

The manipulation checks confirmed the effectiveness of the experimental design for processing level (t (255) = -21.718, p <.001), label type, (t (255) = -4.243, p <.001), explanation on subjective understanding (t (255) = 3.505, p <.001) and the independent sample t-test showed that this difference approached significance for explanation on objective understanding (t (255) = 1.880, p = .061). This manipulation check confirms indicates that the presence of an explanation about ultra-processed foods on the label increases subjective and objective understanding.

To ensure the effectiveness of the randomization process, the eight experimental conditions were compared on key demographic characteristics. Multiple tests indicated that the participants were successfully randomized across the conditions.
First, a One-Way ANOVA showed no significant differences in age between the conditions, p = .992. Second, Chi-square tests of independence were conducted for gender and educational level. No significant differences were found between the experimental conditions and gender, χ^2 (21) = 22.45, p = .374, and between condition and educational level, χ^2 (21) = 35.55, p = .154. These results indicate that the experimental groups did not differ insignificantly in terms of age, gender, and education.

Descriptive statistics like means, standard deviations, frequencies, were computed for all variables to summarize the sample characteristics and general response patterns. An overview of this can be found in table 3. The Pearson correlations between the variables are illustrated in table 4.

Table 3

Overview of the descriptive statistics. The 'yes' and 'no' account for either the presence of an explanation with the label or no presence with the label.

	Low processed				High processed			
	Warning label		Colour-coded label		Warning label		Colour-coded label	
	Yes	No	Yes	No	Yes	No	Yes	No
Willingness to buy	4.26 (1.93)	3.85 (2.25)	4.23 (2.24)	3.30 (1.98)	2.66 (1.86)	2.71 (1.72)	3.03 (1.60)	3.12 (2.04)
General liking	4.52 (1.73)	4.44 (2.08)	4.40 (1.79)	3.97 (1.65)	3.22 (1.79)	3.26 (1.68)	3.19 (1.45)	3.16 (1.74)
Health risk perception	2.31 (0.91)	2.45 (0.87)	2.40 (0.83)	2.71 (0.91)	5.14 (1.31)	5.09 (0.96)	4.94 (1.13)	5.05 (1.22)
Naturalness perception	5.61 (1.02)	5.18 (1.11)	5.69 (0.89)	4.95 (0.98)	2.79 (1.29)	2.47 (1.02)	2.93 (1.16)	2.96 (1.09)
Objective understanding	4.00 (0.86)	3.68 (1.15)	3.77 (0.90)	3.82 (0.85)	4.09 (0.86)	3.74 (1.05)	3.90 (0.75)	3.66 (1.10)
Subjective understanding	5.16 (1.73)	4.82 (1.70)	5.70 (1.62)	4.76 (1.37)	5.84 (1.48)	5.50 (1.56)	5.45 (1.09)	4.34 (1.54)

Table 4

The Pearson correlations between the main variables.

	Willingness to buy	General liking	Naturalness perception	Health risk perception	Objective understanding	Subjective understanding
Willingness to buy	1					
General liking	.813**	1				
Naturalness perception	.350**	.387**	1			
Health risk perception	-.410**	-.457**	-.794**	1		
Objective understanding	-.081	-.073	-.033	.070	1	
Subjective understanding	.090	.002	-.076	.064	.264**	1

**p <.01

Before testing the hypotheses, the statistical assumptions for linear regression were verified. Independence of observations was ensured by the experimental design and random assignment of participants. After inspection of the P-P plot, it was concluded that the there were no strong reasons to reject the assumption of normality.

H1a and H1b were tested with a factorial ANOVA with the processing level and label type and their interaction as predictor for willingness to buy. The ANOVA showed overall significance of the model $F(3,253) = 6.50$, $p < .001$, $\eta_p^2 = .072$. More specifically, the main effect of processing level on willingness to buy was significant $F(1,253) = 17.17$, $p < .001$, $\eta_p^2 = .064$ providing support for H1a. This suggests that consumers reported a significantly lower willingness to buy for products when they were shown a product with a high level of processing compared to a low level of processing.
However, the main effect of label type on willingness to buy ($F(1,253) = 0.15$, $p = .843$) was not significant and no significant interaction between processing level and label type was observed, $F(1,253) = 2.03$, $p = .156$. Therefore, H1b was not supported, indicating that the impact of the processing level on willingness to buy was not significantly moderated by the format of the label.

Multiple linear regression was used to test if processing level and objective- and subjective understanding significantly predicted naturalness perception. For this regression, the variables were grand mean-centred and effect-coded. The overall regression was statistically significant ($F(3,253) = 120.12$, $p < .001$, $R^2 = .583$).
It was found that processing level significantly predicted naturalness perception, $B = -1.28$, $t(254) = -18.861$, $p < .001$. This supports H2 indicating that consumers perceived products as significantly less natural when they were labelled as highly processed compared to low processed.
The interaction between processing level and objective understanding ($B = -0.14$, $t(253) = -1.999$, $p = .047$) as well as subjective understanding ($B = -0.14$, $t(253) = -3.327$, $p < .001$) was significant. This indicates that the negative impact of the processing level indicator on perceived naturalness is significantly moderated by the participant's level of objective understanding and even more strongly by subjective understanding, which supports H6b. There was no significant main effect found for the non-hypothesised objective ($B = -0.04$, $t(254) = -0.486$, $p = .627$) and subjective ($B = -0.03$, $t(254) = -0.725$, $p = .469$) understanding on naturalness perception.

A similar multiple linear regression analysis was conducted to test if processing level predicted health risk perception, with objective understanding, subjective understanding and label type as moderators. The regression showed overall significance of the model, $F(7,249) = 60.90$, $p < .001$, $R^2 = .621$. More specifically, a significant direct effect of processing level on health risk perception was found ($B = 1.29$, $t(253) = 20.207$, $p < .001$). This effect supports H3a, indicating that high-processing warnings significantly increased perceived health risk.
No significant direct effects of label type ($B = 0.02$, $t(253) = 0.300$, $p = .764$), objective understanding ($B = 0.10$, $t(253) = 1.469$, $p = .143$) and subjective understanding ($B = 0.02$, $t(253) = 0.441$, $p = .660$) was found.
The interaction between processing level for both objective understanding ($B = 0.14$, $t(250) = 2.128$, $p = .034$) and subjective understanding ($B = 0.12$, $t(250) = 2.931$, $p = .004$) was significant, providing support for H6c. This suggests that the impact of the processing level indicator on health risk perception is significantly amplified for consumers with higher levels of understanding; those who know (or think they know) more about food processing perceive even higher risks when confronted with the indicator. There was no significant interaction between processing level and label type found ($B = -0.07$, $t(250) = -1.088$, $p = .277$).

Therefore, H3b was rejected. This indicates that the effect of the processing level on the health risk perception was not influenced by the format of the label.

Furthermore, to examine the influence of the mediators on willingness to buy, a multiple linear regression analysis was conducted with naturalness perception and health risk perception as predictors for willingness to buy. The overall model was significant, $F(2,254) = 25.97$, $p <.001$, $R^2 = .170$. With health risk perception as predictor, a significant negative effect on willingness to buy was observed ($B = -0.44$, $t(254) = -3.799$, $p <.001$). This indicates that as consumers perceived higher health risk with the product, the willingness to buy significantly decreased, which supports H4. With naturalness perception as a predictor for willingness to buy, no significant effect was observed ($B = 0.08$, $t(254) = 0.705$, $p = .481$), rejecting H5.
Interestingly, while both perceived naturalness ($r = .350$) and health risk ($r = -.410$) correlated significantly with willingness to buy, the multiple regression showed that only health risk perception remained a significant predictor. The strong negative correlation between naturalness perception and health risk perception ($r = -.794$) suggests that these constructs share substantial variance; however, health risk perception appeared to be the primary driver, overshadowing the impact of perceived naturalness on willingness to buy. Despite this overlap, the Variance Inflation Factor (VIF = 2.71) confirmed that multicollinearity did not reach problematic levels for the overall model.

To test the mediation hypotheses (H4 and H5), a mediation analysis (PROCESS Model 4) was conducted using 5.000 bootstrap samples. The results showed a significant indirect effect of processing level on willingness to buy via health risk perception ($ab = -0.75$, 95% CI [-1.078, -0.419]). Since the bootstrap confidence interval did not include zero, H4 was supported. Conversely, the indirect effect via perceived naturalness remained non-significant ($ab = -0.24$, 95% CI [-0.576, 0.056]), leading to the rejection of H5. These results indicate that the decrease in willingness to buy is mainly driven by increased health risk perceptions rather than a decrease in perceived naturalness.

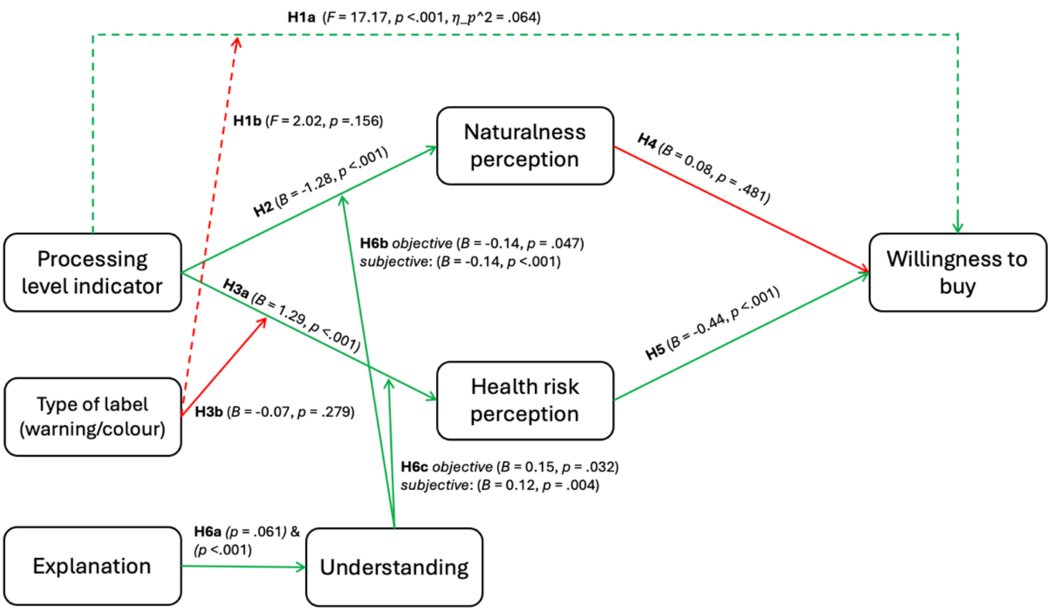
Additionally, a full moderated mediation analysis using bootstrapping (PROCESS Model 7) was conducted. The results showed that the previous moderating effects of objective understanding were also significant in the PROCESS analysis. Specifically, the interactions between processing level and objective understanding on perceived naturalness ($B = -0.14$, $p = .047$) and health risk perception ($B = 0.15$, $p = .025$) were significant. The index of moderated mediation for the naturalness path (Index = -.027, 95% CI [-0.087, 0.006]) included zero. However, the index for the health risk path did not include zero (Index = -.087, 95% CI [-0.185, 0.011]), meaning statistically significant. This supports the previous regression analysis, indicating that …..

When subjective understanding was used as a moderator, the interaction effects on naturalness perception ($B = -0.14$, $p = .001$) and health risk perception ($B = 0.12$, $p = .004$) remained significant. Similar to the objective understanding model, the overall moderation mediation indices did not reach significance for the naturalness path (Index = -.025, 95% CI [-0.079, 0.005]) but did for the health risk path (Index = -.0684, 95% CI [-0.136, -0.018]).

Finally, the moderating role of the label type was examined using PROCESS Model 7. The results showed no significant moderated mediation for either the non-hypothesized naturalness path (Index = .038, 95% CI [-0.014, 0.143]) or the health risk path (Index = .088, 95% CI [-0.058, 0.269]). The interactions between the processing level indicator and label type on perceived naturalness ($B = 0.10$, $p = .137$) and health risk perception ($B = -0.08$, $p = .235$) were also non-significant. These results suggest that the processing level indicator consistently influences consumer perceptions and willingness to buy, regardless of the format in which the label is presented.

Figure 8

An overview of the conceptual model used in this research. All paths are labelled with their respective p-values and effect sizes. Green lines indicate significant relationships, red lines mean non-significant relationships. The dotted line illustrates the total effect, which ignores the influence of mediations.



5. Discussion

5.1 Main findings

This research shows that displaying the level of food processing substantially influences consumers' purchasing behaviour in a virtual online supermarket by decreasing consumer willingness to buy ultra-processed products. This shift is mainly driven by an increase in perceived health risk for the ultra-processed product. The tested type of label did not differ in impact on health risk perception and willingness to buy. Providing an explanation about the label enhanced understanding of ultra-processed foods what the label meant, which in turn strengthened the negative effects of processing information on product perceptions. To understand these findings more deeply, the results are discussed below in relation to existing literature.

It was found that the product with a higher processing level indicator compared to a lower processing level led to a lower willingness to buy. This suggests that labelling breakfast cereal products with its level of processing effectively shifts consumers' purchase intention. This aligns with several recent studies; for instance, D'Angelo Campos, Ng, McNeel, et al. (2024) found that an "ultra-processed" label explicitly discouraged US consumers from buying processed yoghurts. Similarly, when a modified Nutri-Score with an ultra-processed mention was used on food product packaging, it shifted purchasing intentions towards less processed products (Srour et al., 2023). The fact that these studies used different label designs suggests that the specific format of the label may be less important in the context of creating awareness. This is consistent with the results of my research, as the specific format of the label showed no difference in effectiveness. This finding contrasts with Song et al. (2021) who reported that warning labels worked better in discouraging unhealthful purchasing behaviour compared to colour-coded labels (Nutri-Score). This difference might be explained by the fact that Song et al. (2021) focused on the distinction between healthy and unhealthy products, while this study focused specifically on the distinction between non-processed and ultra-processed products. This suggests that for ultra-processed food, the cognitive impact of the "processed" message itself is more important than the specific designs of the warning and colour-coded label.

Providing information about the level of processing did not only affect the respondents' willingness to buy but also their perceptions of the products. Specifically, the ultra-processed product was associated with a higher health risk perception and lower naturalness perception compared to the lower-processed product. This finding is consistent with previous literature (Aguirre et al., 2019; Bolhuis et al., 2022; Hartmann et al., 2022; Hässig et al., 2023). This suggests that the more processed a product is, the less natural and the riskier for someone's health it is perceived. Thus, by highlighting the processing level, the labels possibly triggered something in the participants' evaluation of the product. Specifically, the identification of a product as "ultra-processed" acted as a negative heuristic, leading to an increase in perceived health risk and a decrease in perceived naturalness, which in turn served as the primary driver for the decrease in willingness to buy.

Furthermore, lower naturalness perception and higher health risk perception were expected to lead to a lower willingness to buy (Binninger, 2017; Machado Nardi et al., 2020; Provencher et al., 2009). The results of this study showed that only health risk perception substantially predicted willingness to buy. No effect of naturalness perception was found. This suggests that health risk perception functions as a more dominant driver of purchasing behaviour than naturalness. This consistent with Lusk & Briggeman (2009) who listed eleven food values

based on previous literature, they concluded that safety and nutrition were the most important, naturalness was fifth on the list, confirming why health risk perception better predicted willingness to buy than naturalness.
A possible explanation for this is that consumers are more focused on avoiding choices that might harm their health than on how natural a product feels (Yeung & Morris, 2001). When someone perceives a health risk, this concern quickly becomes more important than any other feature of the food product. Therefore, the drive to stay safe is a stronger reason to not buy a product than a general preference for naturalness.

Furthermore, this study investigated the impact of providing an explanation about ultra-processed foods. Findings show that the presence of an explanation led to a better understanding of both the term "ultra-processed food" and the label itself. This supports the suggestion by Ares et al. (2016) that, to successfully communicate the message against ultra-processed foods, it is essential to provide a clear definition of the term and a description of their defining characteristics.

Finally, it appeared that this increased understanding played a crucial role in how consumers perceived the products. It was found that understanding moderated the effect of processing level on perceived health risk. The gap in health risk perception between low- and high-processed food increased when consumer understanding increased. This is supported by Hodgkins et al. (2015), they concluded that objective understanding is an important factor for consumers to detect a healthier alternative within a food category. They suggest that when health information is presented in a structured and legible way, it helps consumers to distinguish between products with different health levels. This supports my observation that the gap in health risk perception between processing levels increases only when consumers have a certain level of understanding.

5.2 Theoretical implications

This study contributes to the literature on food labelling and consumer behaviour in several ways. First, it reaffirms that the level of food processing serves as a powerful heuristic for consumers to estimate health risks (Bolhuis et al., 2022) and naturalness (Aguirre et al., 2019).

Another key theoretical contribution is the simultaneous examination of perceived naturalness and health risks as two mediators. While existing literature often explores these perceptions independently, my research provides a more integrated perspective by testing how these perceptions compete to drive willingness to buy. The findings show that while processing level information influenced both health risk and naturalness perception, only health risk perception directly predicted willingness to buy in this specific context. This suggests that for ultra-processed food products, the health risk cue may outweigh the naturalness cue, this finding adds nuance to the existing "naturalness halo" theories; the tendency to evaluate products based on the perception of the naturalness (Besson et al., 2025). The participants appeared to use the processing indicator mainly for the evaluation of health risks instead of the naturalness. This finding might be true for other food categories as well. In cases where labels trigger both health risk and naturalness perceptions, consumers likely prioritize health risk over naturalness as well.
Furthermore, the lack of evidence for differences between the warning label and colour-coded label suggests that the content of the message is more impactful than the format of the message. This indicates that once a product is perceived as ultra-processed, the specific visual warning becomes less important.

Finally, this research highlights the important role of understanding as a moderator, confirming that the impact of front-of-pack labels is strengthened when consumers have better understanding.

5.3 Practical implications

The findings of this study offer several practical contributions for online supermarkets. First, displaying processing level indicators can be an effective strategy to nudge consumers away from these products. This research shows that making the degree of processing explicit decreases the willingness to buy ultra-processed products. It should be considered to label unhealthy ultra-processed products as such.
Second, supermarkets should consider adding a "tooltip" that provides a short explanation of what the different processing levels mean. A tooltip is a small box with information that appears when a user hovers over a specific element, in this case the processing label. My results indicate that such an explanation improves both objective and subjective knowledge. Because higher understanding increased the gap in health risk perception between low- and high-processed products. Therefore, if this explanation is provided in such a tooltip feature, it could make the labels more impactful, indirectly influencing willingness to buy.
Finally, since no difference between the effectiveness of the labels was found, the label developers can design the labels themselves.

5.4 Limitations & future research

A few limitations in this study need to be discussed. First regarding the measurement of general product liking; the original intention was to measure general product liking independent from the level of processing. However during analysis it showed unexpectedly high correlation with the willingness to buy. After critical review of the specific question and structure, it raised the suspicion that the participants did not interpret the question as generic, but instead as stimulus specific. Future research should be careful to measure general product liking as truly separate from the stimulus-based liking, for example by making more explicit that the next question is no longer about the stimulus and/or placing this question in a different section of the survey.

Another limitation of this study is the potential visual interference with the Nutri-Score label. Although not measured, anecdotal feedback from participants suggested that the colour-coded labels were occasionally misinterpreted as the Nutri-Score. Future research should consider using alternative visual formats that are distinct from existing labelling systems to make sure that responses are based on the specific content of the labels instead of automatic associations with familiar labels.

The data collection process itself also had certain challenges. Notably, half of the dropouts (48 in total) occurred at the product webpage section. Feedback from several participants indicated that the 'add to cart' button was ambiguous, as some respondents perceived it as a mandatory task that had to be performed rather than a simulated interaction. This confusion may have contributed to the dropouts observed at this specific stage. For future research using virtual webpages, it is recommended to clarify that the 'add to cart' button is for simulation purposes only, and to ensure that navigation or 'continue' buttons are more prominently displayed.

Regarding the scope and generalisability of the findings, in this study, oatmeal and granola were used as the food products. This was a choice for this specific research. While these findings likely extend to other food categories, it remains uncertain whether the impact of processing labels is consistent across a broader variety of product categories. Future research should, therefore, explore this effect in other contexts. Furthermore, because convenience and snowball sampling was used in this study, the group of participants might not be a perfect representation of the Dutch population. This is something to consider when looking at the findings. To improve generalisability, future studies should use a more diverse and representative sample through random sampling techniques.

A further limitation relates to the research environment, which was a simplified virtual environment. This was less complex than a real-world online supermarket, where people are constantly distracted by other factors like price promotions and a larger assortment of products. This could have had influence on the participants' attention. For future research, testing these labels in a more advanced shopping simulation including realistic distractors would increase the external validity.

Another limitation concerns the measurement of the construct naturalness. The statements apply to ultra-processed foods in general, they do not particularly have to account for crunchy granola. Additionally, some of the statements were difficult to understand for respondents. An example is that the definition of 'technology' is vague and can be interpreted in multiple ways. These limitations might have caused inconsistency in how people answered those specific statements. To address this, future research should use clearer definitions for naturalness.

Finally, the definition of ultra-processed foods and its health impact remains a point of discussion. There are no fixed boundaries yet; some unhealthy products are not classified as ultra-processed, while some healthier options might still fall into the ultra-processed category. Future research should keep this in mind and investigate how consumers deal with products that are healthy but are still labelled as ultra-processed.

5.5 Conclusion

In conclusion, this research showed that displaying the degree of food processing in an online supermarket is an effective way to influence consumers' purchasing behaviour. The results show that a product with a higher processing level indicator led to a lower willingness to buy compared to a lower-processed product. This effect is driven by the fact that consumers use the "ultra-processed" label as a negative heuristic, which simultaneously increased participants' health risk perception and decreases their naturalness perception. Interestingly, while both perceptions are affected by the processing level, only health risk perception predicted the willingness to buy. This suggests that in the context of ultra-processed foods, consumers prioritize avoiding health risks over a high degree of naturalness.

Furthermore, the specific format of the label (colour-coded or warning) showed no difference in effectiveness. Thus, the information on the label is more important than its visual design. Additionally, providing a short textual explanation together with the label enhanced consumer understanding, which increased the differences in health risk perception between processing levels. Overall, this thesis suggests that online supermarkets can successfully nudge consumers away from ultra-processed foods by making the level of processing salient and ensuring that consumers have the necessary information to interpret these labels correctly.

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7. Appendices

7.1 Appendix I

ChatGPT was used for grammar corrections and revisions of sentence structures. It was also used to suggest alternative order or layout for alineas.
ChatGPT was used to generate multiple images. The images include the front-page image, the the product labels, and the stimuli.
ChatGPT was used to brainstorm about potential stimuli that is used in the survey.
ChatGPT was used to create HTML codes that were used in Qualtrics.

7.2 Appendix II

Below are the products shown to the participants.

7.3 Appendix III

This appendix contains a representative version of the HTML code used for the online interface. While eight variations were used in total (one for each condition), the code remained consistent across groups, with minor adjustments made only to the product and processing label, and the inclusion of the tooltip explanation.

U krijgt hieronder een virtueel product in een virtuele online supermarkt te zien. Hierna worden er vragen over dit product gesteld.

```
<div style="max-width: 480px; margin: 0 auto; font-family: Arial, sans-serif; background:#ffffff; box-shadow:0 4px 12px rgba(0,0,0,0.08); border-radius:6px;">

  <div style="padding:16px 20px; border-bottom:1px solid #eeeeee; font-size:18px; font-weight:700;">
    Online Supermarkt
  </div>


  <div style="padding:16px 20px 0 20px; margin-bottom:-35px; position:relative;">
    <img src="https://wur.az1.qualtrics.com/CP/Graphic.php?IM=IM_eDoyW7OW9QGnP4G" alt="Traffic light label" style="width:90px; height:auto; margin-left:25px; position:relative; z-index:10;">
  </div>


  <div style="padding:0 20px 20px 20px; text-align:center; position:relative; z-index:1;">
    <img src="https://wur.az1.qualtrics.com/CP/Graphic.php?IM=IM_tZh0nmcmqqTnUtB" alt="Krokante Muesli" style="width:220px; max-width:100%; height:auto;">
  </div>

  <div style="padding:0 20px 20px 20px;">

    <div style="font-size:18px; font-weight:700; margin-bottom:6px;">
      Krokante Muesli
    </div>

    <div style="font-size:14px; color:#555555; margin-bottom:2px;">
      1 kg · Ontbijtgranen
    </div>

    <div style="font-size:16px; font-weight:700; color:#388e3c; margin-bottom:10px;">
      €2.29
    </div>

    <div style="font-size:14px; color:#555555; line-height:1.5; margin-bottom:14px;">

    </div>
```

```
  <div style="display:inline-block; padding:10px 16px; background:#1976d2; color:#ffffff;
border-radius:6px; font-size:14px; font-weight:600; cursor:default;">
  Toevoegen aan mandje
</div>

  </div>
</div>
```