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## Perceived degree of food processing as a cue for perceived healthiness: The NOVA system mirrors consumers' perceptions

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### ABSTRACT

Demand for processed food is increasing, but at the same time, some of these products have been strongly criticised for causing non-communicable diseases. Only a few studies have analysed consumers' perceptions of food processing and, especially, ultra-processed foods. We examined consumers' associations with processed foods, as well as how their processing and healthiness perceptions are related to food classification systems (i.e. NOVA) and the nutritional value of foods (i.e. Nutri-Score). An online survey was conducted with 498 Swiss consumers, who indicated their associations with the term 'foods produced by the industry'. Furthermore, the respondents indicated how they perceived the healthiness and degree of processing of 27 foods that differed in how much they had been processed. The results suggest that consumers have rather negative associations with food processing. Consumers use the perceived degree of processing as a cue in their evaluation of the healthiness of foods. The use of this heuristic may result in biased decisions. Furthermore, we found a strong agreement between laypeople's perceived level of processing and the NOVA classification system.

### 1. Introduction

Food processing plays an important role in a safe and secure food system (Carretero et al., 2020; Forde & Decker, 2022; Knorr & Augustin, 2021). The technologies behind food processing not only reduced the incidence of food-borne diseases (Floros et al., 2010) but also contributed to more sustainable food production by reducing food waste along the supply chain (Augustin et al., 2016). Furthermore, food processing has made it possible to supply a growing world population with affordable food products (Floros et al., 2010).

However, not all processed foods have high nutritional value. The way our food products are processed by the food industry has been blamed for an increase in obesity in many countries (Monteiro, 2009). Numerous studies have examined the consumption of processed foods in various European countries including Switzerland and around the world (Bertoni Maluf et al., 2022; Mertens, Colizzi, & Peñalvo, 2022). These studies have consistently found that processed foods contribute to at least 14% of total calorie intake, although the intake varies widely across Europe (Bertoni Maluf et al., 2022; De Amicis et al., 2022; Mertens, Colizzi, & Peñalvo, 2022). Some studies have found that the

consumption of processed foods, particularly those that are ultra-processed, can have negative health effects, such as overweight and obesity (Monteiro et al., 2018), cardio-vascular diseases (Rauber et al., 2018), and cancer (Chang et al., 2023). However, other studies have not found a relationship between country-level burden of high body mass index and the consumption of highly processed foods (De Amicis et al., 2022; Mertens, Colizzi, & Peñalvo, 2022).

Researchers have coined the term 'ultra-processed foods' (UPFs), referring to foods that are low in nutritional value. Notably, Monteiro and colleagues introduced the NOVA food classification system, which classifies foods according to the degree and purpose of processing (Monteiro et al., 2018) rather than their nutritional composition. The NOVA system has four categories: (1) unprocessed or minimally processed foods, (2) processed culinary ingredients, (3) processed foods, and (4) UPFs. Under this categorisation, UPFs contain more than five ingredients, including those that are not typically used in a normal household kitchen, such as artificial flavorings, colorings, and preservatives, which are intended to make products cheaper and hyper-palatable, as well as to give them longer shelf lives. In addition, it is claimed that they contain large amounts of low-quality ingredients, such

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as salt, sugar, and fat, and that they are energy dense and have a bad nutritional profile (Monteiro et al., 2010). It should be emphasised that Monteiro's definition refers to the number of ingredients and the formulation of a food product, not the actual processing method or degree of processing itself (Astrup & Monteiro, 2022; Petrus et al., 2021; Sadler et al., 2021).

A growing number of nutritional scientists and public health organisations have adopted the NOVA classification system for their public dietary guidelines, even though there are serious concerns about this system (Astrup & Monteiro, 2022; Fitzgerald, 2023; Sadler et al., 2021). In particular, these scholars believe that the NOVA classification system simplifies the classification of food products too greatly, without taking evidence from the fields of food science and food technology into account (Petrus et al., 2021). Moreover, the NOVA classification system postulates a causal relationship between the consumption of processed foods and negative health outcomes, without providing evidence that, after controlling for the nutritional value of food, the degree of processing has an additional impact on people's health (Astrup & Monteiro, 2022; Sanchez-Siles et al., 2022). It has also been argued that a combination of unhealthy lifestyle factors, such as low physical activity levels and smoking, rather than the consumption of processed foods, is likely to explain the negative health outcomes observed (Asfaw, 2011; de Deus Mendonça et al., 2017; Knorr & Augustin, 2021; Scaranni et al., 2021).

Only recently scholars paid attention to consumers' perceptions of processed foods. These studies have mainly focused on exploring how consumers understand the term 'UPFs' (Aguirre et al., 2019; Ares et al., 2016; Machín et al., 2018, 2020). The results of this novel stream of research suggest that consumers are generally unaware of the benefits of food processing in terms of safety and nutritional properties (Hüppe & Zander, 2021; Knorr & Augustin, 2021; Sadler et al., 2021), and processed foods are associated with the presence of many artificial ingredients and additives. In general, previous studies indicate that consumers see processed foods as less healthy as compared to unprocessed foods (Evans et al., 2010).

The present study aims to provide additional insights into how consumers perceive food processing and what influence it has on the evaluation of industrial food products. Specifically, the first objective is to explore how consumers perceive the foods produced by the food industry through spontaneous associations. A second and related objective of this study is to examine how consumers perceive the degree of processing for various foods, ranging from home-made products to industrial products in which the food is fundamentally changed during processing, as well as how this evaluation is linked to perceived healthiness. A final objective is to analyse the relationship between consumers' perceptions of processing, the NOVA classification system, and an objective measure of food healthiness.

## 2. Material and methods

### 2.1. Survey participants

The data collection in Switzerland took place via an online survey distributed in November and December 2021. Swiss participants were recruited through an online access panel (Bilendi, former Respondi AG), which was also responsible for the financial compensation of the participants. Quotas were set to achieve a representative sample of the Swiss population in terms of age and gender. Participants received the information that the survey was examining the perception of processed foods at the beginning of the questionnaire. For each question participants received the required instructions at the beginning of the respective question. Of the original 584 participants who completed the survey, 86 participants were excluded. Participants were excluded if they did not finish the survey ( $n = 51$ ) or answered the survey in less than half of the median time ( $n = 35$ ). After excluding the participants described above, the sample consisted of 498 participants. Of these,

50.2% were women. The participants' ages ranged from 20 to 70 years, and participants had an average age of 48 years ( $SD = 14$ ). The socio-demographic characteristics of the study sample, including education and place of residence, are shown in Table 1. The ETH Zurich Ethics Commission approved this study (EK 2021-N-173).

### 2.2. Survey procedure

The survey was conducted on the online survey platform Qualtrics (Qualtrics, Provo, UT). After answering some sociodemographic questions, participants had to answer more specific questions about foods processed by the food industry.

In a free-association task, participants had to answer the following question: 'When thinking about food products produced by the food industry, what are the first associations (words, pictures, and thoughts) that come spontaneously to your mind?' (Original question in German: Wenn Sie an industriell verarbeitete Lebensmittel denken, was ist Ihre erste Assoziation (Wörter, Bilder oder Gedanken), die Ihnen spontan in den Sinn kommt?).

Participants were provided with an open blank space and were not limited to a given number of terms. This free-association method is widely used to investigate consumer associations and has been used before (Etale et al., 2020; Michel et al., 2021; Wassmann et al., 2023). In a second step, the participants had to indicate whether their feelings associated with the term 'foods processed by the food industry' were positive or negative. Respondents indicated their feelings on an 11-point Likert scale ranging from  $-5$  (extremely negative) to  $+5$  (extremely positive).

In a next section, participants' evaluations of the processing and healthiness levels of 27 food products were assessed. For each of the 27 food products, participants had to answer the following two questions: 'How processed do you perceive this product?' and 'How healthy do you perceive this product?' Respondents indicated their answers using a slider ranging from 0 (not at all) to 100 (very much). No information about the ingredient compositions of the products was shown to the respondents. An example of the type of question that was presented to the participants is shown in Fig. 1. The food products were chosen from five food categories: vegetables, fruit, meat and meat alternative products, grain products, and infant food. In each category, several products were selected that all contained the same base product (i.e., strawberries, pies, and wheat) but differed in their processing methods. The different processing methods contained: frozen, canned, dried, fresh/unprocessed, pre-prepared, or home made. Furthermore, the food products were selected from the largest grocery stores in Switzerland. Because familiarity and marketing labels, such as organic or additive-free labels, may influence participants' perceptions, brand names and

**Table 1**  
Description of participants in our sample.

Variable	Switzerland (N = 498)
<b>Gender</b>	
Female	50.2%
Male	49.4%
Other/non-binary	0.4%
<b>Age range</b>	
20–39 years	31.0%
40–59 years	43.4%
60–70 years	25.6%
<b>Education level</b>	
Low	4.0%
Middle	48.6%
High	47.0%
No answer	0.4%
<b>Place of residence</b>	
City	25.3%
Suburbs	28.7%
Rural	45.4%
No answer	0.6%



*Getrocknete Aprikosen*

**Fig. 1.** Example of a food product (dried apricots) presented to the participants. Respondents had to indicate their perceived degree of processing and healthiness for the current food product on a slider ranging from 0 (not at all) to 100 (very much).

labels were removed. The respondents' perceptions of processing degree and healthiness were compared to the objective classification based on NOVA (processing) and the Nutri-Score (healthiness). For the calculation of the NOVA classification and Nutri-Score points, the guidelines proposed by Monteiro et al. (2019) and Santé publique France (2020) were applied, respectively. Because the proposed guidelines only apply to industrially processed foods, home-made food products were excluded from the calculation. Furthermore, no products from NOVA category 2, which contains processed culinary ingredients, such as butter or oil, were used in this study, because these products are not consumed on their own.

### 2.3. Statistical analysis

The data were analysed with IBM SPSS Statistics Version 27 and Microsoft Excel Version 16. If the participants wrote down more than one association, only the first term was considered for analysis, as not all participants provided several answers and we specifically asked for the first association that came into their minds. The terms were spell-checked, translated into English, and then classified into 16 categories according to their meaning. Categories were not defined beforehand. An inductive approach was chosen, and a small number of categories were defined to cover the meaning of the associations named as good as possible. The first author coded and analyzed the data in addition to a second independent researcher that was otherwise not involved in this study. The interrater reliability (Cohen's kappa) was calculated and had a good value of  $\kappa = 0.61$ ,  $p < .001$ .

Further data were analysed on the participant and product levels. For each product, the mean values and standard deviations for perceptions of processing and healthiness were calculated. To examine the relationship between the processing and healthiness perceptions of the food products, a scatterplot was generated. Furthermore, the relationship between the subjective and objective classifications of the food products was illustrated using boxplots. For this, the food products produced by the food industry, that is, the products that remained after excluding the home-made products, were classified into the NOVA categories using the guidelines provided by (Monteiro et al., 2019). Boxplots were generated on the participant level and with aggregated data. A one-way analysis of variance (ANOVA) was used to determine whether the processing and healthiness perceptions of the different NOVA categories differed significantly. P-values less or equal to 0.05 were considered significant.

## 3. Results

### 3.1. Associations with 'foods produced by the food industry'

The associations mentioned by the respondents were classified into 16 categories according to their meaning (Table 2). The associations mentioned the most commonly were 'convenience food' (18.7%), 'unhealthy' (16.5%), and 'additives' (10.4%). As expected, only a very small number of participants mentioned positive associations, which were mainly categorised into the 'unspecific positive evaluations' (3.0%) or 'healthy' (0.4%) categories. Furthermore, 11.8% of the participants responded to this task with 'I don't know' or left the provided spot blank. The mean affect for the term evoked by 'foods produced by the food industry' was somewhat negative, with  $M = -1.06$ ,  $SD = 2.32$  (scale ranging from  $-5$  to  $+5$ ). The mean affect for the 16 categories are also shown in Table 2.

**Table 2**  
Participants' associations with the term 'foods produced by the food industry' (N = 498).

Association category	Association examples	Frequency	%	Affect association	
				M	SD
Convenience food products	Packaged food, Ready to eat pizza, canned products, frozen products, convenience, simple preparation	93	18.7%	-1.1	1.9
Unhealthy	Overweight, cardiovascular diseases, too much salt, sugar, fat	82	16.5%	-2.4	1.9
Additives	Chemistry, E-numbers, preservatives	52	10.4%	-2.0	2
Other food products	Yoghurt, milk, string cheese, bread, pasta, ravioli	37	7.4%	1.3	2.4
Other unspecific associations	Gene technology, hunger, corruption, restaurant, regional, farmers,	31	6.2%	-	-
Meat and meat alternative products	Hamburger, sausages, cold cuts, tofu, vegan meat, vegan products,	28	5.6%	-0.2	2.6
Production process	Industry, mass production, assembly line	26	5.2%	-1.4	2.1
Artificial	Better natural, not natural	24	4.8%	-2.2	1.3
Brands	Nestle, Betty Bossi, Dr. Oetker	22	4.4%	-0.1	2.8
Unspecific positive evaluation	Good, quality, hygienic	15	3.0%	0.7	1.8
Environmental impact	Transportation, plastic, aluminum, packaging	9	1.8%	-2.9	1.8
Unspecific negative evaluation	Keep hands away from products, avoiding, bad	8	1.6%	-3.8	1.7
Taste	Tasty	6	1.2%	-1.0	1.8
Price	Good price, cheap, expensive	4	0.8%	0.2	0.5
Healthy	Increases health	2	0.4%	-0.5	0.7
Don't know/No answer		59	11.8%	-	-

Note. Effect association was measured on a 11-point scale ranging from 'extremely negative' (-5) to 'extremely positive' (+5). No effects for 'don't know/no answer' and 'other unspecific associations' are shown, as the associations within these categories were too heterogeneous.

### 3.2. Perceived degree of processing and perceived healthiness

Participants' processing and healthiness perceptions regarding the 27 food products are shown in Table 3. The products that were perceived to be the most processed were the following: ketchup in a bottle ( $M = 81.2$ ,  $SD = 19.8$ ), a meat substitute burger ( $M = 80.8$ ,  $SD = 21.4$ ), chili con carne in a can ( $M = 80.8$ ,  $SD = 21.0$ ), and tomato sauce Bolognese in a jar ( $M = 71.9$ ,  $SD = 21.8$ ). The products that were perceived to be the least processed were the home-made fruit salad ( $M = 26.0$ ,  $SD = 30.3$ ) and home-made baby food that consisted of fruit ( $M = 34.3$ ,  $SD = 31.2$ ).

Fig. 2 shows the scatterplot for the mean values of perceived processing and healthiness degree for the 27 food products. The data show a strong negative linear relationship ( $r = -0.96$ ,  $p < .01$ ) between the two variables. Furthermore, the graph shows that home-made products were perceived to be the least processed and most healthy food products, whereas the ready-to-use and industrially pre-cooked food products, such as ready-to-use pizza dough, baby food composed of fruit in a pouch, or tomato sauce Bolognese, were perceived to be highly processed and unhealthy. The results suggest, therefore, that participants based their healthiness evaluations on the perceived degree of processing.

### 3.3. Associations between NOVA, Nutri-Score, and consumer perceptions

The boxplots in Fig. 3 show the mean values for the products categorised according to NOVA. For processing perceptions, the ANOVA was significant,  $F(2,22) = 20.42$ ,  $p < .001$ . Post-hoc-tests with a Bonferroni correction showed significant differences for all possible group comparisons. The mean value for perceived processing was lowest in

NOVA category 1 ( $M = 47.6$ ,  $SD = 9.8$ , range 0–100) and highest in NOVA category 4 ( $M = 73.9$ ,  $SD = 9.1$ , range 0–100). This result suggests that, at the aggregated level, a strong agreement between consumers' perceptions and the NOVA classification could be observed.

For healthiness perceptions, the ANOVA was also significant  $F(2,22) = 20.35$ ,  $p < .001$ . Furthermore, post-hoc tests with a Bonferroni correction showed significant differences for all possible group comparisons. The mean value for healthiness perceptions was highest in NOVA category 1 ( $M = 62.5$ ,  $SD = 9.1$ , range 0–100) and the lowest in NOVA category 4 ( $M = 36.3$ ,  $SD = 5.8$ , range 0–100).

Consumers' perceptions of the products were also significantly correlated with the Nutri-Score of the products. The Pearson correlation between perceived processing and Nutri-Score was 0.65 ( $p < .05$ ,  $N = 22$ ). The better the nutritional value of a product was, the less processed it was perceived by consumers. The correlation between the Nutri-Score and perceived healthiness was  $-0.71$  ( $p < .05$ ,  $N = 22$ ). This result suggests that average consumers' perceptions were in agreement with the objective assessment of the nutritional value of the food products.

Furthermore, a Pearson's Correlation was performed to evaluate the agreement between the NOVA system and the Nutri-Score for the 22 industrially processed products. The Correlation analysis showed a significant correlation between the two classification systems ( $r = 0.58$ ,  $p < .01$ ). The NOVA category and Nutri-Score for each product can be found in Table 3.

In the next step, the data were analysed at the participant level to determine whether similar results could be observed as with the aggregated data. For each participant, we calculated a mean value of perceived processing for the products belonging to Nova categories 1, 3, and 4. The boxplots in Fig. 4 show the participants' mean values for each

**Table 3**

Participants' ranking of the processing perceptions of 27 food products amongst Swiss consumers.

Product	Perception						Objective	
	Processing <sup>a</sup>			Healthiness <sup>b</sup>			NOVA <sup>c</sup>	Nutri-Score <sup>d</sup>
	M	SD	95% CI	M	SD	95% CI		
Fruit salad home-made	26.0	30.3	[23.3, 28.6]	85.4	16.9	[84.0, 87.3]	–	–
Baby food fruits home-made	34.3	31.2	[31.5, 37.0]	79.4	20.0	[77.4, 81.3]	–	–
Fresh meat butcher	35.2	28.7	[32.7, 37.7]	64.3	23.9	[61.2, 66.0]	1	–3
Tomato sauce home-made	37.4	30.5	[34.4, 40.1]	77.2	18.6	[75.5, 79.1]	–	–
Bread home-made	38.8	29.1	[36.2, 41.3]	73.4	20.4	[70.6, 74.8]	–	–
Fruit frozen	39.1	27.6	[36.7, 41.5]	71.9	20.2	[71.1, 75.0]	1	–9
Peas frozen	41.8	28.0	[39.3, 44.2]	72.8	20.3	[71.8, 75.8]	1	–13
Jam home-made	44.4	29.9	[41.7, 46.7]	59.8	26.1	[57.4, 62.6]	–	–
Peas dried	45.4	26.4	[43.0, 47.7]	67.6	21.0	[66.0, 70.2]	1	–12
Peas in jar	56.0	24.0	[52.3, 54.6]	58.3	20.8	[57.1, 61.3]	3	–10
Fruit dried	54.5	23.4	[52.5, 56.6]	57.6	21.0	[56.1, 60.4]	1	1
Fresh fruit salad supermarket	56.0	25.6	[53.8, 58.3]	58.0	23.6	[56.4, 61.1]	3	–5
Minced meat supermarket	56.1	25.4	[54.0, 58.4]	49.1	23.3	[47.7, 52.5]	1	–3
Peas in can	57.3	24.5	[55.1, 59.4]	57.3	20.9	[56.2, 60.4]	3	–9
Tomato sauce frozen	61.2	24.1	[59.1, 63.3]	54.0	20.5	[52.9, 57.0]	1	–2
Fruit in can	65.0	23.8	[62.8, 67.0]	43.3	22.9	[42.1, 46.7]	3	–6
Jam in jar supermarket	65.1	21.1	[63.2, 67.0]	41.6	22.2	[40.2, 44.7]	3	11
Baby food fruits supermarket	66.8	22.3	[64.8, 68.7]	52.2	21.6	[51.2, 55.5]	3	–1
Toast bread	68.9	22.0	[67.0, 70.9]	33.1	22.5	[31.7, 36.3]	4	3
Ready to use pizza dough	69.4	20.7	[67.6, 71.2]	40.7	21.0	[39.1, 43.3]	4	1
Bread for self-baking	70.8	21.0	[68.9, 72.6]	36.9	22.0	[35.3, 39.7]	4	2
Baby food fruits in pouch	71.5	23.4	[69.4, 73.6]	37.9	24.1	[36.6, 41.6]	3	–4
Meat burger frozen	72.0	21.5	[70.1, 73.9]	37.5	22.0	[36.6, 41.0]	4	4
Tomato sauce Bolognese in jar	71.9	21.8	[69.9, 73.8]	43.2	20.9	[42.9, 46.5]	4	1
Chilli con Carne in can	76.2	21.0	[74.4, 78.0]	35.9	21.2	[35.0, 39.4]	4	4
Meat substitute burger	80.8	21.4	[78.9, 82.7]	39.2	23.5	[38.0, 42.8]	4	6
Ketchup in bottle	81.2	19.8	[79.5, 83.0]	24.9	21.1	[23.3, 27.7]	4	8

Note.  $N = 498$ .

<sup>a</sup> Scores on a 100-point scale ranging from 'not processed at all' (0) to 'extremely processed' (100).

<sup>b</sup> Scores on a 100-point scale ranging from 'not healthy at all' (0) to 'extremely healthy' (100).

<sup>c</sup> NOVA classifies food products into four groups based on their extend of processing: 1) Unprocessed foods, 2) Processed culinary ingredients, 3) Processed foods, 4) Ultra-processed foods.

<sup>d</sup> The Nutri-Score classifies processed food based on their nutritional value. The Nutri-Score ranges from –15 (very good nutritional value) to 40 (very bad nutritional value).

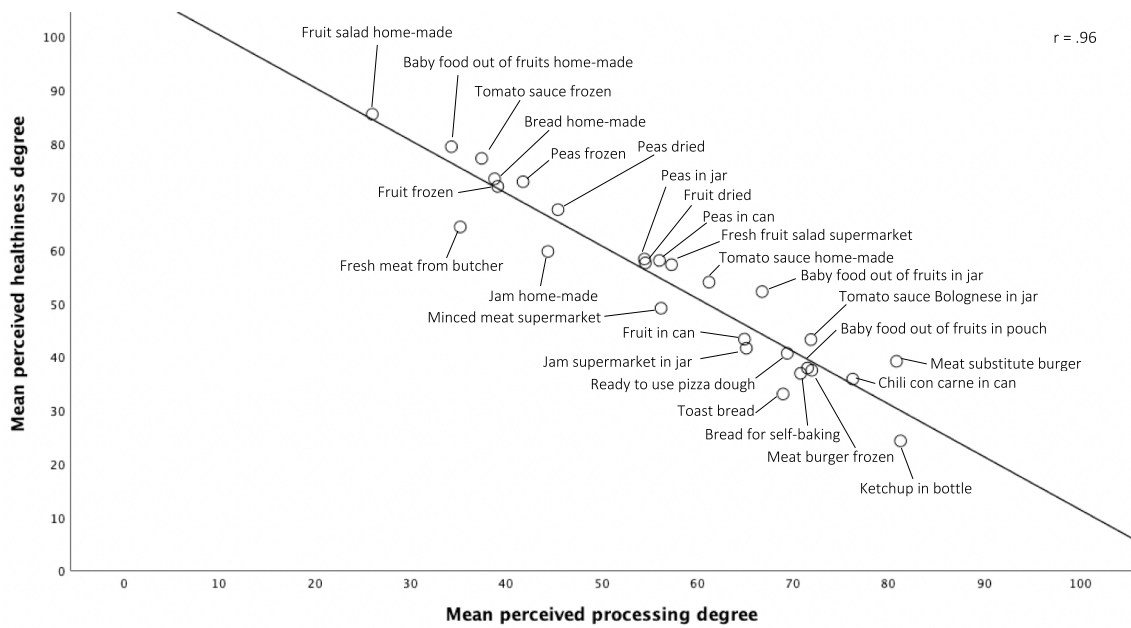


Fig. 2. Correlation between mean processing perception and mean healthiness perception of 27 food products.

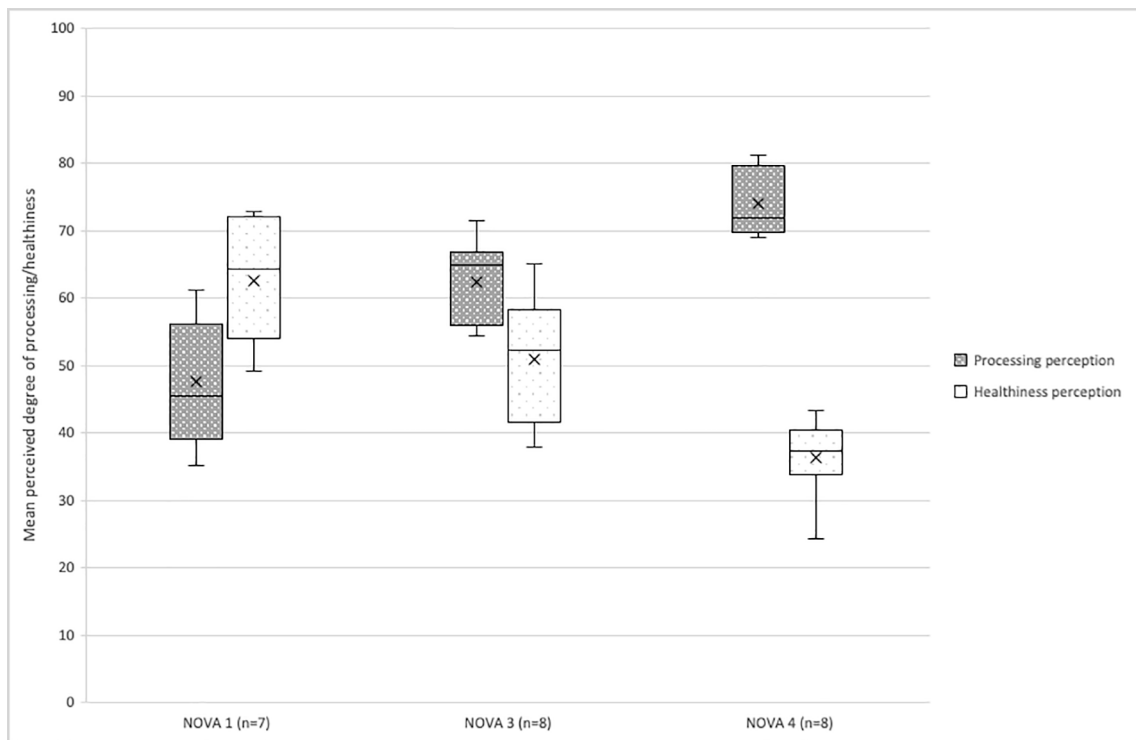


Fig. 3. Mean processing and healthiness perception of industrially processed food products (n = 22) according to their corresponding NOVA group.

NOVA category. The results are very similar to those shown in Fig. 3 for the aggregated data. The result of the one-way analysis of variance with repeated measures for perceived processing was significant,  $F(2,994) = 815.05, p < .001$ . Moreover, the post-hoc tests with a Bonferroni correction showed significantly different evaluations between all three groups. The lowest mean values for processing perceptions were observed for NOVA group 1 ( $M = 43.7, SD = 18.7, \text{range } 0\text{--}100$ ). Similar results were found for healthiness perceptions,  $F(2,990) = 1,507.94, p < .001$ . Whereas foods in NOVA category 1 were perceived as healthiest and foods in NOVA category 4 as unhealthiest. The post-hoc tests with a

Bonferroni correction showed significant differences between all groups regarding healthiness perceptions.

#### 4. Discussion

The current study provides new insights into consumers' perceptions of industrially processed foods. Our results suggest that consumers' associations with the term 'foods produced by the food industry' tend to have a negative valence, which is consistent with previous research (Aguirre et al., 2019; Ares et al., 2016). While these studies referred in

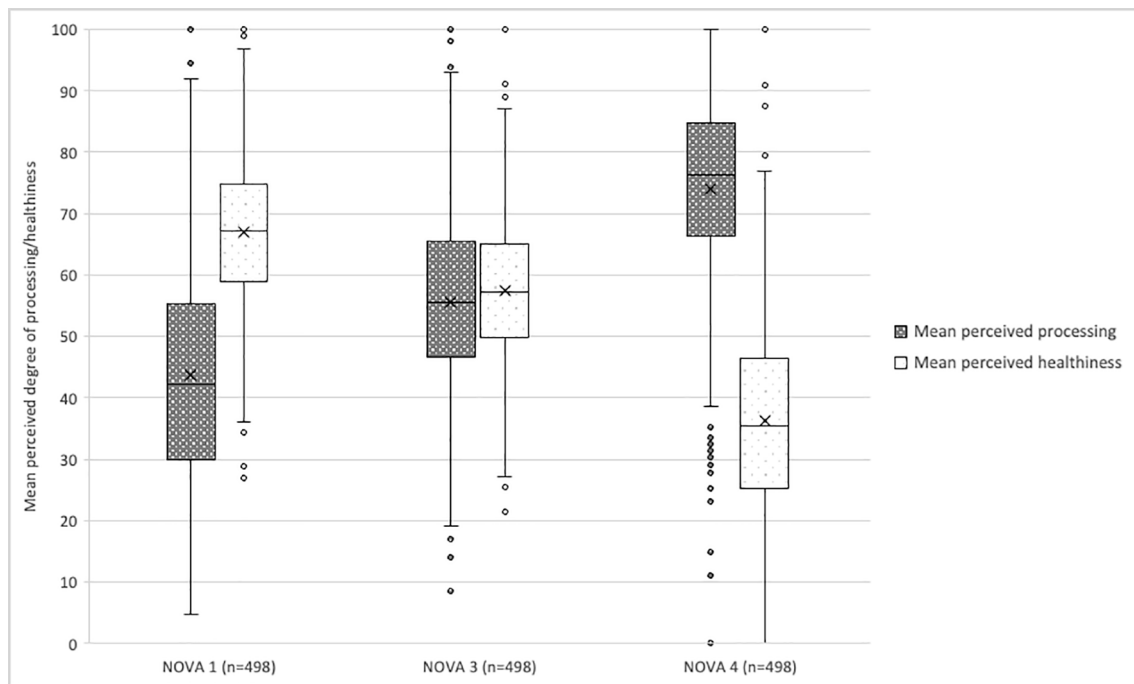


Fig. 4. Participants mean value of perceived degree of processing and healthiness for products categorized in each NOVA group.

particular to ultra-processed foods, our research focuses on foods produced by the industry, although similar results were achieved despite the slightly different wording. The words most commonly mentioned by the participants were ‘convenience products’ and ‘unhealthy’. The former suggests that many respondents saw processed foods as whole pre-cooked meals and did not consider the inevitable food processing involved when confronted with the term ‘foods produced by the food industry’. In addition, various participants did not associate ‘foods produced by the food industry’ with anything or simply answered with ‘I don’t know’. This indicates that they were not aware of the processes foods go through before reaching the store.

Interestingly, home-made products were viewed as an ‘own category’ by the participants, even though, from a processing point of view, there is not always a large difference in terms of the processing steps and processing methods when food is prepared at home or by the food industry, other than in large-scale production. In some cases, food industry processing techniques such as shock freezing or high-pressure processing can preserve bioactive compounds more effectively than home-used methods when it comes to maintaining food texture integrity (Knorr & Augustin, 2021; Salazar-Orbea et al., 2023). Our results are similar to those of Devia et al. (2021), which showed a halo effect for home-made food products. Nevertheless, studies have shown that home-made foods are not necessarily superior to products produced by the food industry in terms of nutritional quality (Bernal et al., 2021; Kerr et al., 1978; Randhawa, 2012; Van den Boom et al., 1997).

We found a very strong association between the perceived processing and perceived (un)healthiness of foods. The less processed a food was perceived to be, the healthier its evaluation. Our results are in line with the idea that consumers rely on simple heuristics to evaluate the healthiness of foods (Beath & Siegrist, 2019; Michel & Siegrist, 2019). The degree of processing is a key factor influencing the perceived naturalness of foods (Román et al., 2017). Therefore, a mediation effect could exist. That is, processing is perceived as unnatural, and perceived unnaturalness influences perceived healthiness. Our results are in line with a recent qualitative study that also found that the degree of processing is a cue for (un)healthiness for laypeople (Machín et al., 2020).

Our results suggest that consumers’ perceptions of different types of processed foods are in line with the classification system proposed by

Monteiro (2009). Food products belonging to NOVA group 1 were perceived as the least processed and the healthiest, while those in group 4 were perceived as the most processed and the unhealthiest. Our results were based on only 22 commercial products; however, despite this limitation, the strong agreement between laypeople’s perceptions and the NOVA classification is surprising. This suggests that the NOVA classification system is a reflection of laypeople’s perceptions. Therefore, there may be no need to provide consumers with information about the NOVA classification of a product, since laypeople’s perceptions are already very much in line with this classification. It should also be noted that one reason for the acceptance of the NOVA classification system for nutrition recommendations may be that the system reflects laypeople’s perceptions well. Thus, the NOVA system has some credibility because it confirms people’s expectations.

A limitation of the present work is that it did not include the willingness to buy certain food products. The products were carefully selected, but we could only include a limited number; otherwise, the task would have been too time consuming for the study participants. In addition, the wording of the association task (‘foods produced by the industry’) may have influenced the associations that were triggered. It is possible that the wording used created negative associations, and therefore, it should be considered as a potential bias. Moreover, only images of the products were presented to the participants, since we wanted to investigate their perceptions. However, it is possible that due to the lack of ingredient information, participants’ health and processing perceptions of the products were influenced.

Future research should further examine consumers’ perceptions of processed food. In the present study, we used various food categories, and whether similar results would be observed if different foods from the same food category were examined remains to be investigated (e.g. savoury or sweet snacks). Furthermore, additional research could analyse whether information about food-processing technologies changes perceptions of processed foods. Lastly, due to recruitment being carried out through a panel provider, selection bias cannot be ruled out.

## 5. Conclusions

Consumers perceive food processing in a negative way, even though

some of these processes help to increase food safety and contribute to cheaper food products. Our results suggest that the NOVA classification system is very similar to laypeople's perceptions of processed foods. Furthermore, our results show that people use the degree of processing as a cue in their evaluation of the healthiness of food products. This heuristic does not necessarily result in accurate assessments, however, because foods that are classified as UPFs and perceived as highly processed by consumers may differ considerably in terms of their nutritional value. It is therefore important that food manufacturers and food scientists help consumers to understand better the nutritional value of foods.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Data availability

Data will be made available on request.

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