Digital nudges to stimulate healthy and pro-environmental food choices in E-groceries

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ABSTRACT

In response to the detrimental health- and environmental impacts of European consumers' dietary patterns, Nutri-Scores and Eco-Scores have been introduced on packages as guidance for choices. Whereas the scores are promising to improve food choices from a nutritional point of view, the scant available literature suggests very limited effects on the environmental impact of food choices. Therefore, there remains a need to explore ways to bring about improvements in both areas. As a growing share of consumers buys food groceries online, new opportunities to steer food choices are being created. This article explores the potential of several digital functionalities to further stimulate healthier and pro-environmental food choices amongst consumers. These functionalities included product recommendation agents, product scores, a real-time average impact score of the chosen food basket and a personalised social norm. Those were tested in a two-stage randomized controlled trial with 1000 Belgian household food decision makers in a mock-up E-grocery. Indices reflecting the nutritional quality (NQI) and environmental impact (EII) of the selected food baskets were calculated. The results indicate that at first, displaying a combined Nutri- and Eco-Score at product level led to improved NQI's, but not EII's. However, the scores also led to shifting behaviour in EII's when facilitated with recommendation agents. The display of the average impact scores of the selected basket and of social norms did not lead to additional improvements. Hence, a combined Nutri- and Eco-Score labelling system is recommended, but an enabling environment to consider both scores is important to realise a shift towards more healthy and environmentally friendly food choices. Apart from manifesting healthier and environmentally friendly products with a centralised labelling system, improving their accessibility should be considered at least as important for behavioural changes.

1. Introduction

Our food system is an important driver for climate change and environmental degradation on the one hand, and is linked to several (deadly) chronic diseases due to affluent dietary habits on the other hand (Gerten et al., 2020; Poore & Nemecek, 2018; Westhoek et al., 2014). These threats to the environment and public health, can be attributed to dietary patterns including relatively high intakes of (red) meat, processed food and total calories and low intake of fruits and vegetables (Tilman & Clark, 2014). Several studies on the environmental impact of our food system support the notion that inducing changes in consumption patterns has more impact-reducing potential than increasing production efficiency (Gerten et al., 2020; Keating, Herrero, Carberry, Gardner, & Cole, 2014). Moreover, such a demand-driven transition towards more environmentally friendly diets can simultaneously reduce pressure on our health system and on the global environment (Biesbroek et al., 2014).

Throughout the past decades, a switch to healthy and environmentally friendly diets has been promoted by countless Front-of-Package labels (FOP) on food products. Unfortunately, a growing body of

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literature has been pointing out the limited role of such FOP labels in consumers' food choices (Grunert, Hieke, & Wills, 2014; Ikonen, Sotgiu, Aydinli, & Verlegh, 2019). Confusion and mistrust amongst consumers, caused by the wide diversity of existing FOP-labels, could partly explain this limited role (Askew, 2018; Tonkin, Webb, Coveney, Meyer, & Wilson, 2016). A need for more uniform communication has been widely recognised by consumers, industry and policy makers. Therefore, the European Commission (EC) committed in their Farm-to-Fork strategy to develop a harmonised and activating labelling system, covering health, environmental and social impacts of food (European Commission, 2020).

From a nutrition point of view, the introduction of Nutri-Score in various European countries has been contributing to this harmonisation. Moreover, recent evidence has shown that Nutri-Score could lead to healthier food choices amongst consumers and reformulation amongst producers (Egnell et al., 2018; Vandevijvere et al., 2020; Vermote, Bonnewyn, Matthys, & Vandevijvere, 2020). A similar standardisation is ongoing with the spread of Eco-Scores, reflecting products' environmental footprints (PEF) (European Commission, 2019). A few studies report more pro-environmental food choices due to Eco-Scores alone (Vlaeminck, Jiang, & Vranken, 2014; Weber, 2021). However, an increasing number of retailers and manufacturers are now jointly displaying Nutri-Scores and Eco-Scores on products. The literature on the effects of dual-labelling is very scarce (De Bauw, Matthys, Poppe, Franssens, & Vranken, 2021; Osman & Thornton, 2019). However, there is evidence that a combined Nutri-Score & Eco-Score improves nutritional values of food choices, but hardly affects the environmental impact of those (De Bauw et al., 2021). On the one hand, sustainability information remains less important for consumer decisions, in contrast to taste as most important driver (Buhrau & Ozturk, 2018; Honkanen & Frewer, 2009; Kourouniotis et al., 2016; Maehle, Iversen, Hem, & Otnes, 2015). On the other hand, due to halo-effects, sustainability information could simultaneously affect the health perception of products (Grunert, 2005). Being aware of these interactions between both scores, the goal of this study is to provide insights on the effectiveness of displaying both scores simultaneously, which is now increasingly done by retailers.

A substantial part of our food consumption decisions is gradually changing scenery from brick-and-mortar stores to E-grocery stores (Gunday et al., 2020). Apart from a growth in sales volumes through the online channel, a diversification of consumer profiles doing their groceries online has also been observed, with a remarkable growth amongst elder people recently (OECD, 2020, pp. 1–10). In 2019, the share of online food groceries varied amongst EU countries, from 6% and 12% in Italy and Belgium respectively to 32% and 36% in UK and the Netherlands (Statista, 2021). The recent COVID-19 pandemic is most likely an accelerator of this growth. Online food decision processes are typically more reflective than decisions made in physical stores, since a large set of sensory appeals and heuristics are being eliminated. This allows E-groceries to focus more on cognitions through education and learning. In addition, E-groceries have the capability to influence food choices by using smart and personalised nudges (Coffino, Udo, & Hormes, 2020; Karlsen & Andersen, 2019). The growth in E-grocery purchases entails emerging opportunities to face the existing challenges of our food system, related to health- and environmental damage (Blom, Gillebaart, De Boer, van der Laan, & De Ridder, 2021).

Therefore, the present study aimed to explore the potential of several digital functionalities in an E-grocery environment to stimulate more healthy and pro-environmental food choices.

2. Conceptual approach

As with all human behaviour, healthy- and environmentally friendly food choices are roughly driven by one's motivations, opportunities and ability (MOA) to make such choices (Aschemann-Witzel et al., 2013; Grunert et al., 2014; Rothschild, 1999). Stimulating this behaviour might require improvements in all three dimensions (MOA). A motivated and capable consumer still has to be given the opportunity, as will the opportunity alone not necessarily lead to better choices. Therefore, this study explores several interventions that either aimed to increase motivations, provide opportunities or enable better choices.

First of all, FOP-labels provide consumers the *opportunity* to objectively consider health- and/or environmental information in their food choices. The nutritional content and environmental impact of products are per definition credence attributes, as they cannot directly be observed. From this perspective, Nutri-Scores and Eco-Scores could be seen as opportunities to account for that information. Consumers have been found to perceive products with beneficial Nutri-Scores (Eco-Scores) as healthier (more sustainable) (De Temmerman, Heeremans, Slabbinck, & Vermeir, 2021; Vandevijvere et al., 2020; Weber, 2021). Therefore, the present study applies a combined Nutri- and Eco-Score for healthier and more environmentally friendly food choices. Providing this opportunity does however not necessarily lead to its usage. As described by dual-process theories, like the Elaboration Likelihood Model (ELM), the extent of information searching and processing strongly depends on consumers' motivations and ability (Petty & Cacioppo, 1986).

Secondly, consumers' *motivations* to consider health- and/or environmental information in their food choices are often driven by a more general interest in healthy and/or sustainable living (Dean et al., 2012; Van Loo, Hoefkens, & Verbeke, 2017; Wardle & Steptoe, 1991). Increasing those motivations therefore remains a major challenge (Hung, Grunert, Hoefkens, Hieke, & Verbeke, 2017). In general, motivations to look for certain information depends on individually anticipated values of that information (Sharot & Sunstein, 2020). Increasing the perceived personal relevance of health/environmental information can raise those anticipated values and lead to higher motivations amongst consumers to actively search for it and use it. A practical way to make health/environmental information more relevant, is by providing personalised feedback on past behaviour and by explicitly comparing this feedback to peers. Both the provision of feedback and social norms have been widely described in the literature as very effective nudges to steer behaviour (Sunstein, 2014), particularly in the context of food consumption (Celis-Morales et al., 2017; Czajkowski, Zagórska, & Hanley, 2019; Higgs, Liu, Collins, & Thomas, 2019; Johannes, Marci, & Patricia van, 1999; Vermeir & Verbeke, 2006). Given the proven success of these nudges, this study questions whether real-time average basket impacts, be it compared to those of peers or not, could motivate health- and environmental considerations in food choices in E-groceries. The use of such dynamic cues is one of the features that E-groceries can easily accommodate.

Thirdly, consumers' *ability* to make more healthy and environmentally friendly food choices based on FOP-labels depends on their ability to process information. This ability is usually considered as an inherent characteristic of the individual, linked to knowledge and skills (Lähteenmäki, 2013; Moorman & Matulich, 1993; Petty et al., 2009). However, it could be argued that due to the highly interpretative format of Nutri-Score and Eco-Score, the role of knowledge and skills becomes relatively less important (Egnell et al., 2018). In contrast, the ability to consider both scores (Nutri- & Eco) to make informed choices remains hampered by an overload of information and a limited amount of time willing to spend in the food environment. Therefore, a more enabling food environment could be an effective way to improve food choices. A functionality which is extensively being used to reduce complexity in e-commerce environments are recommendation agents. Recommendation agents are defined as *"Software agents that elicit the interests or preferences of individual users for products […] and make recommendations accordingly"* (Xiao & Benbasat, 2007, p. 137, p. 137). Their ability to influence consumers' behaviour and purchase intentions has been supported by scientific studies and is being widely exploited by online retailers (Breugelmans, Köhler, Dellaert, & de Ruyter, 2012; Häubl & Murray, 2003; Punj & Moore, 2007; Xiao & Benbasat, 2007). Only recently has the inclusion of nutritional criteria into the matching

algorithms between preferences and recommended products received more attention (Gunaratne & Nov 2017; Ngoc et al., 2018). However, literature covering empirical user testing remains very scarce and focusses only on nutritional indicators while also from an environmental viewpoint there is a strong need for such facilitating strategies (Trattner & Elsweiler, 2017).

Based on this conceptual background, the following hypotheses were put forward:

H1. Nutri- and Eco-Scores at product level improve nutritional values of food choices more than environmental impacts

H2. Supporting these scores with personalised feedback and social norm increases their effectiveness

H3. Facilitating food environment with recommendation agents increases effectiveness of scores, personalised feedback and social norm

3. Methods

A randomized control trial was conducted in a mock-up E-grocery. A representative sample of Belgian consumers (n = 1000) selected food products for one meal for their daily household. As in real E-groceries, this selection process was subdivided into two stages. Consumers apply different decision strategies in different phases of product choice (Gilbride & Allenby, 2004). Therefore, two focus groups preceded this study to get insights in which phase the nudges would be most favoured by consumers. This has led to a design in which, in the first stage, participants selected food products from a longlist, while the presence of Nutri-Scores and Eco-Scores was manipulated. In a second stage, the initial selections were verified and could be adjusted. During this second stage, the presence of recommendation agents, product scores, impact scores of the food basket and social norm were manipulated. Consumers' selected food baskets were recorded at the end of both stages. Treatment effects were evaluated based on the (shift in) overall nutritional quality and environmental impact of the selected baskets between stages. A more detailed description of individual elements in this approach is given below.

3.1. Participants

The experiment was conducted in November 2019 in Flanders (the northern half of Belgium), with a representative sample of 1000 consumers. Participants were recruited by a subcontracted market research agency and were randomly assigned to one of the experimental cells, adding up to 125 participants per cell (Fig. 1). The target population were Dutch speaking Flemish adults, being household food decision-makers. People working in market research, marketing, advertising or in the food sector in general were excluded to prevent demand effects. The experiment was single blinded: respondents were not informed on the exact aim of the research in order to prevent any self-selection and/ or forewarning bias. A financial reward was provided after participation but no real payment for the food products was required after the

shopping task and products were not actually delivered either. The study was ethically approved by SMEC, host institute of the principal investigator (reference code: **G- 2018 11 1425**). All participants signed an informed consent and complete anonymity was guaranteed. After the removal of observations with extremely implausible consumption quantities, the final sample contained 994 respondents of which the socio-demographic characteristics are given in Appendix D (Table D.1). The sample was roughly representative for the Belgian population in terms of gender and age while being slightly overrepresented by respondents from higher income and educational classes. None of the treatment groups were significantly over- or underrepresented by particular gender, age or educational classes.

3.2. Manipulations

The first factor included the provision of several layers of information and featured four levels: *(1)* a control level without additional information, *(2)* Product Scores (PS), *(3)* Product Scores and Basket Scores (PS & BS), *(4)* Product Scores and Basket Scores and Social Norm (PS & BS & SN). The individual layers are described below.

- *Product Scores (PS)* Both Eco-Scores (top-left) and Nutri-Scores (top-right) were displayed on every product tile. These products scores were tested both in stage 1 and stage 2 (Appendix A Fig A.1 & Fig A.2). The product scores used in this experiment were based on standard calculation methodologies for Nutri-Score and PEF (Chantal & Hercberg, 2017; European Commission, 2019; FPS, 2019). Seemingly identical products, differing only in terms of a score were provided with some extra information that could explain the difference in scores. An overview of the included products and corresponding scores are reported in Table B1 in Appendix B.
- *Basket Scores (BS)* A total Nutri- and Eco-Score of the selected basket was displayed in the top-right corner (Fig A2). The basket scores were only tested in stage 2 of the experiment. These scores at basket level were instantly recalculated with every adjustment and were expressed both as 5-level scores (A-E) and as numeric values between 0 and 100. In the latter expression, 0 corresponded to the lowest possible environmental impact or the best nutritional quality and 100 to the highest possible impact or the poorest nutritional quality. The calculation and cut-off values used to obtain these basket scores are reported in Appendix C.
- *Social Norm (SN)* A descriptive social norm on average basket scores was displayed (Fig A2). This treatment was only tested in stage two. Respondents were informed about the scores of consumers of the same age, gender and province. It was stated that: *"In (province), most (gender) between (age segment) have an average Nutri-Score of 35% and an Eco-Score of 25%."* Depending on respondent's socio-demographic data, this message was tailored in such a way that it matched their profile. The average values of 35 and 25 were the same for all respondents because such specific information was not available before conducting the experiment. The values of 35 (Nutri)
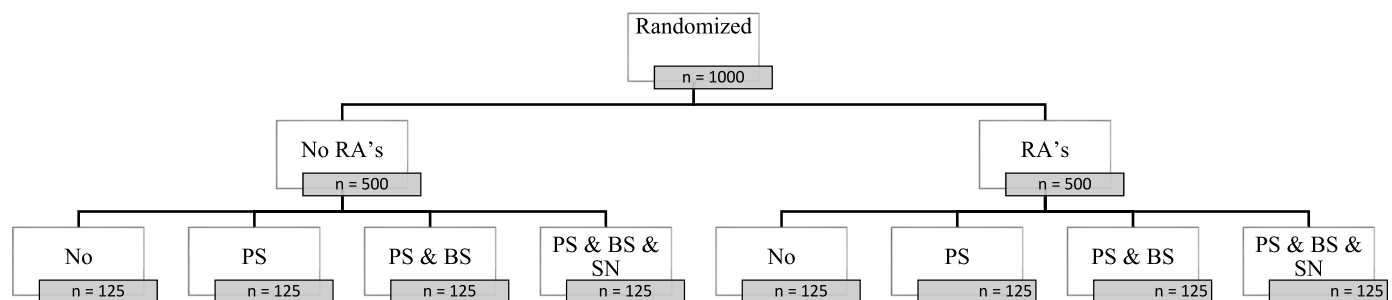
Fig. 1. Overarching experimental design. Respondents were randomly assigned to a treatment group. Treatment groups were characterized by combinations of recommendation agents (RAs), product scores (PS), basket scores (BS) and social norm (SN).

and 25 (Eco) corresponded to average baskets in terms of nutritional quality and environmental impact, based on repeated plausible product selections. This provided a range of realistic scores and the scores 35% and 25% were rather a the lower end of the range. This was done on purpose, to induce a norm that could encourage respondents with average and poor scores to improve. Respondents who already had good scores were expected to be less or unaffected by this norm.

The second factor included the suggestion of healthier and/or more environmentally friendly alternatives with recommendation agents (RAs) (Fig A.3). Two levels were featured (with RAs vs without RAs). RAs were only tested in stage two of the experiment. Products having alternatives with better Nutri-score and/or Eco-score were equipped with a button to *"Improve your scores"*. If no scores were displayed, this button said "Improve your basket" to avoid confusion. Once a respondent clicked this button, up to three comparable products with better nutritional quality or lower environmental impact were suggested next to the originally selected product. Suggested alternatives had a better Nutri-score or Eco-score (or both) but never a worse score (Table B.2). This avoided trade-offs between nutrition and environmental sustainability. Without recommendation agents, respondents were still able to make adjustments in their selection but only by reducing or increasing quantities of already selected products. Two levels were tested: with RAs (treatment) and without (control).

3.3. Experimental design

The experiment entailed between-subject manipulations in a two-stage factorial RCT. Throughout the first stage, some respondents were exposed to Product Scores (n = 750), while others were not (n = 250). In the second stage, respondents were exposed to one of the eight factor level combinations defined by a 2 × 4 design [2 (*RAs*: present vs not) x 4 (*Information layer*: Control, PS, PS & BS, PS & BS & SN)]. If a respondent was exposed to Product Scores in the first stage, these also appeared in the second stage and vice versa.

The basket scores were calculated based on the product scores and the social norm compared the basket score of the participant to the average basket score of its peers. The information captured by the social norm thus builds on the basket score which, in turn, is determined by the product scores. Hence, only additive effects could be considered. Meaningless combinations, like the combination of the average basket score without product scores or the combination of the social norm without the average basket scores were precluded. This led to one 4-level factor instead of three 2-level factors. Contrastingly, the Recommendation Agents could be manipulated independently of the level of information. As a consequence, the overarching 2 × 4 design in Fig. 1was obtained.

The wireframes used to develop the simulated E-grocery were provided by a large Belgian retailer, involved as partner in this study. In which of the two stages the functionalities were tested was decided based on multiple co-creation sessions with consumers. Consumers expressed a strong aversion of additional information cues or recommendations during the selection of products, while they were rather open for interventions assisting the verification of their selected basket. A comprehensive description of these co-creation sessions falls beyond the scope of this paper. Although such positioning of the different nudges across both stages appeared to be most preferred by consumers, this design does not allow for assessing effects of the nudges independent of stage.

3.4. Experimental procedure

Briefing: Before starting the experiment, respondents were requested to imagine themselves doing food purchases for one meal for their household, and to select food products accordingly. After this explanation, they were notified about the possible occurrence of Nutri- and Eco-Scores and the meaning of these were explained very briefly. As the task was stated to be hypothetical, cheap talk scripts were applied. Participants were highly encouraged once more to imagine themselves doing real purchases and to behave as close to reality as possible.

Experiment stage one: Subsequently, respondents were directed to a simulated E-grocery from which they could choose their preferred food products and quantities. As in real E-groceries, the selection process was subdivided in two main stages. The first stage included the selection of products from a longlist of food products (Fig A1 & Table B.1). The inclusion of products in this list started for each product from a reference product. Case by case, a slight variation to the reference product was then specified. Products could alter in different aspects, resulting in different scores (e.g. production method, certificate, origin, reduced calories, sugars, etc.). Compared to the reference product, only one aspect was varied for each alternative to avoid that the alternative has, for example, a better Nutri-Score but a worse Eco-Score. Seventeen product pairs (consisting of a reference product and alternative product) were shown. Of the 17 pairs, three were different in Nutri-Score and 14 in Eco-Score. This imbalance was intentionally set because environmental impacts within-products typically vary much more widely than for nutritional values. A perfectly paired set of products was considered unrealistic and therefore, next to 17 product pairs (34 products in total), six single products were added. As such a total of 40 products were shown to the participants. Price levels (low, average, high) were randomly rotated between similar alternatives to avoid lower/higher impacts corresponding systematically to higher/lower prices. This justifies not further considering price effects, while these are certainly important attributes in food purchasing. To avoid order effects, we ensured that products with better scores did not systematically appear first on the screen than those with poorer scores or vice versa. Products were selected by using "+" and "–" buttons, which operated per piece or per gram depending on the product type. Once finished, respondents were asked to confirm their initial selection and were led to the second stage. At this point, the selected basket was recorded a first time.

Experiment *stage two:* Thereafter, respondents were led to an overview of their selection and had the opportunity to make adjustments by removing products or changing quantities (Appendix A Fig A.2 & A.3). All participants had the opportunity to alter their product choices. However, this process was encouraged and/or facilitated by means of the functionalities described earlier. After verifying their baskets, another confirmation was requested and selections were recorded a second time.

Follow-up: Eventually, in a brief follow-up survey, respondents were asked to what extent they (1) considered Nutri-Score (Eco-Score) in their choices and (2) to what extent they were willing to see a Nutri-Score (Eco-Score) in their food environment (both 6 point Likert scales). These variables served as a proxy for the attention paid to the scores during the task and for their anticipated values respectively. Furthermore, questions on dietary habits, food related motivations and socio-demographic information were filled out.

3.5. Data

The average nutritional quality and environmental impact per person were considered as main outcome variables of interest. For both variables, an index was calculated as the weighted sum of all food products' scores per person. For the nutritional quality index (NQI), an energy-weighted sum was used (Eq (1)). A lower NQI corresponds to a better nutritional quality. The NQI could be negative or positive and is dimensionless. For the environmental impact index (EII), a mass-weighted sum was used (Eq (2)). This index was strictly positive and also dimensionless. A higher environmental impact index corresponds to a larger environmental impact. To calculate the index per household member for every respondents, the weighted sums were divided by household size.

$$Nutritional\ quality\ index\ (NQI) = \frac{\frac{\sum Nutri-Score_i\ *(kJ\ of\ product\ selected)_i}{\sum (kJ\ of\ product\ selected)_i}}{HHSize} \quad (1)$$

$$Environmental\ impact\ index\ (EII) = \frac{\frac{\sum Eco-Score_i\ *(kg\ of\ product\ selected)_i}{\sum (kg\ of\ product\ selected)_i}}{HHSize} \quad (2)$$

To evaluate shifting behaviour in the second stage, difference-in-differences were considered: differences in NQI and EII between measurement one and two were compared across different treatments (Eq. (3) & Eq (4)). These indices reflect how much shifting has occurred in the basket screen.

$$\Delta NQI = (NQI)_{Measurement\ 2} - (NQI)_{Measurement\ 1} \quad (3)$$

$$\Delta EII = (EII)_{Measurement\ 2} - (EII)_{Measurement\ 1} \quad (4)$$

The statistical analysis was performed using Stata 15. Based on $\chi 2$ – association tests, the balance in age, gender and educational level between the eight different treatment groups was evaluated. To evaluate the effects of products scores on NQI and EII after the first stage, independent sample t-test were used, preceded by a Levene's test to verify the assumption of variance equality. To evaluate the effects of the four treatments on ΔNQI and ΔEII in the second stage, two-way ANOVA models were performed followed by planned contrasts. Under the central limit theorem, the use of two-way ANOVA's was considered justified. However, since no changes at all during stage 2 were very likely to occur ($\Delta NQI = 0$ & $\Delta EII = 0$), the emergence of a strongly leptokurtic distribution was expected. Therefore, in addition to the two-way ANOVA's, we validated the results by a non-parametric Kruskal-Wallis H-tests followed by post-hoc Mann-Whitney tests where possible.

4. Results

4.1. Stage 1: initial product selection

During the initial selection of products, participants were exposed to the Product Scores (n = 745) vs not (n = 249). Total NQI's and EII's of this initial selection are shown in Fig. 2 and Fig. 3 respectively.

In terms of NQI, participants being Nutri- and Eco-Scores (M = −4.54, SD = 2.7) made significantly better selections than those were not (M = −3.41, SD = 6.92), t(493.63) = 2.12, p = 0.03 (unequal variances assumed).

Contrastingly, in terms of EII, participants exposed to the scores (M = 3.22, SD = 2.81) did not differ from those who were not (M = 3.17, SD = 2.67), t(992) = 0.21 p = 0.83 (equal variances assumed).
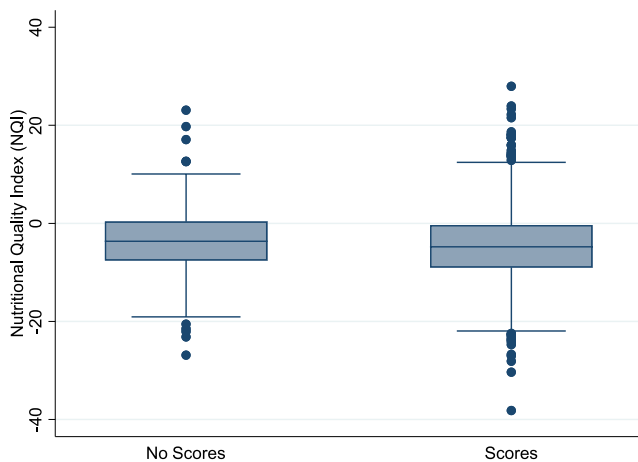

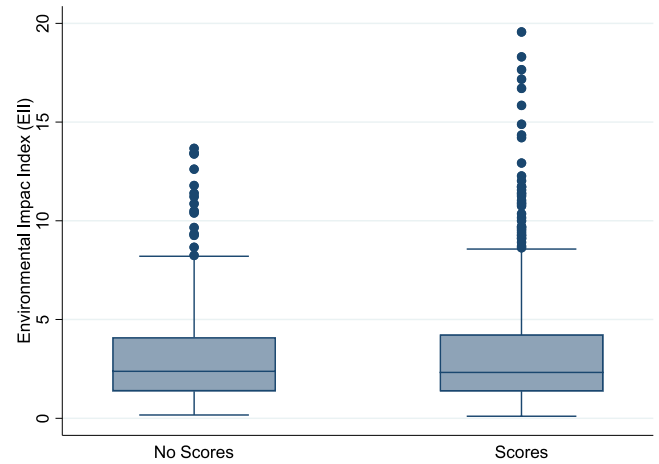**Fig. 2.** NQI after stage 1 with and without product scores.

Fig. 3. EII after stage 1 with and without product scores.

4.2. Stage 2: shifting behaviour in basket screen

4.2.1. Shift in nutritional quality indicator (ΔNQI)

Differences in NQI between the second and the first measurement (ΔNQI) were considered to study healthy shifting behaviour in the basket overview screen. Fig. 4 shows ΔNQI per experimental cell. Individually, none of the experimental cells showed significant changes in NQI, as ΔNQI did not differ statistically from zero. A two-way ANOVA revealed no significant main effects of the Recommendation Agents (F (1,986) = 2.47, p = 0.11) and the information levels (F(3,986) = 0.03, p = 0.99) on ΔNQI, similarly the interaction effect was non-significant (F (3,986) = 1.07, p = 0.36). A non-parametric Kruskal-Wallis H-test confirmed that ΔNQI was not significantly affected by the eight treatment groups (H(7) = 4.762, p = 0.69). This also held when considering the Recommendation Agents or the levels of information provision as grouping variables (H(1) = 0.572, p = 0.45 and H(3) = 0.610, p = 0.89 respectively).

4.2.2. Shift in environmental impact indicator (ΔEII)

Differences in EII between the second and the first measurement (ΔEII) were considered to evaluate environmentally friendly shifting behaviour in stage 2. Fig. 5 shows mean ΔEII's per experimental cell. Negative values correspond to improvements, positive values to deteriorations. In absolute terms, only in the experimental cell with Recommendation Agents and Product Scores & Basket Scores & Social Norms desired shifting behaviour towards lower environmental impacts was observed. However, comparisons should be made with control conditions to draw conclusions on effects. A two-way ANOVA revealed a significant main effect of the Recommendation Agents (F(1,986) = 4.46, p = 0.04) and a significant interaction effect between the Recommendation Agents and the level of information (F(3,986) = 2.59, p = 0.05). The main effect of the information layer was non-significant (F(3,986) = 1.93, p = 0.12). Since these results entail a significant interaction, a non-parametric test could not be used to validate the findings.

On average, treatments with the Recommendation Agents led to greater reductions in environmental impact than those without the Recommendation Agents. Furthermore, the Recommendation Agents also influenced the effect of the informational treatments (Fig. 5). Without the Recommendation Agents, the average ΔEII did not differ significantly across levels of provided information. With the Recommendation Agents, the conditions with Product Scores, Product Scores & Basket Scores and Product Scores & Baskets Scores & Social Norms all showed significantly better shifting behaviour than the control condition without information (respectively t(246) = 1.91, p = 0.03; t(242.1) = 2.11, p = 0.02 and t(157.1) = 2.46, p = 0.007). The impact of these

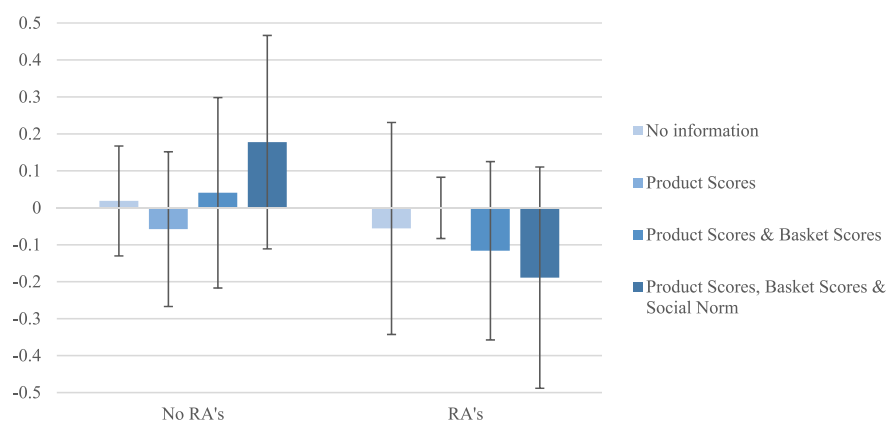**Fig. 4.** Mean ΔNQI per treatment group with 95% confidence interval.

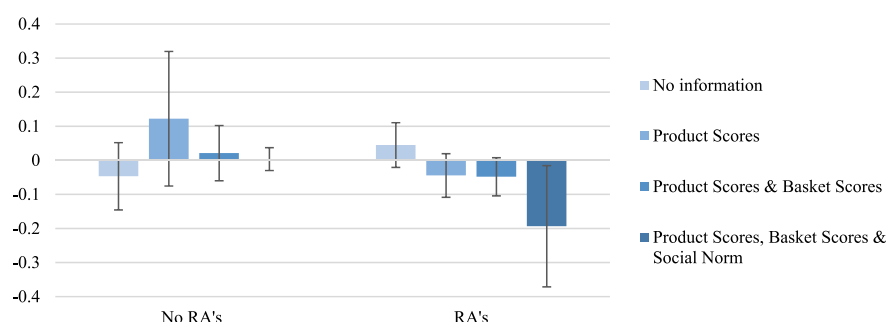**Fig. 5.** Average ΔEII per treatment group with 95% confidence interval.

three levels did not differ significantly from each other. With the Recommendation Agents, the Product Scores led to significantly improved ΔEII's compared to no information (t(246) = 1.91, p = 0.03). However, the addition of the Basket Scores to the Product Scores had no effect (t(246) = 0.08, p = 0.9) neither did the addition of the Social Norm to the Product- & Basket Scores (t(148.3) = −1.2, p = 0.12).

Alternatively, the influence of Recommendation Agents also depended on the level of information (Fig. 5). Follow-up contrasts demonstrated that Recommendation Agents only led to improvements in combination with the PS & BS & SN (t(247) = 2.12, p = 0.018). Without the information, with only PS and with PS & BS, the Recommendation Agents had no effect (respectively t(214.12) = −1.51, p = 0.13; t (149.68) = 1.57, p = 0.11 and t(217.50) = 1.38, p = 0.17).

4.3. Manipulation checks

Conceptually, it was hypothesised that by using personalised feedback and social norms, the perceived personal relevance of the scores would increase. This would increase (1) participants' willingness to see the scores as well as (2) the extent to which the scores are accounted for in decision making. To examine whether this mechanism actually took place, proxy-variables were compared across treatments. Following the experiment, these proxy-variables measured to what extent respondents (1) wanted to see Nutri- (Eco-) Scores in the food environment (Fig. 6) and (2) accounted for these scores during the task (Fig. 7), both on 6 point Likert scales.
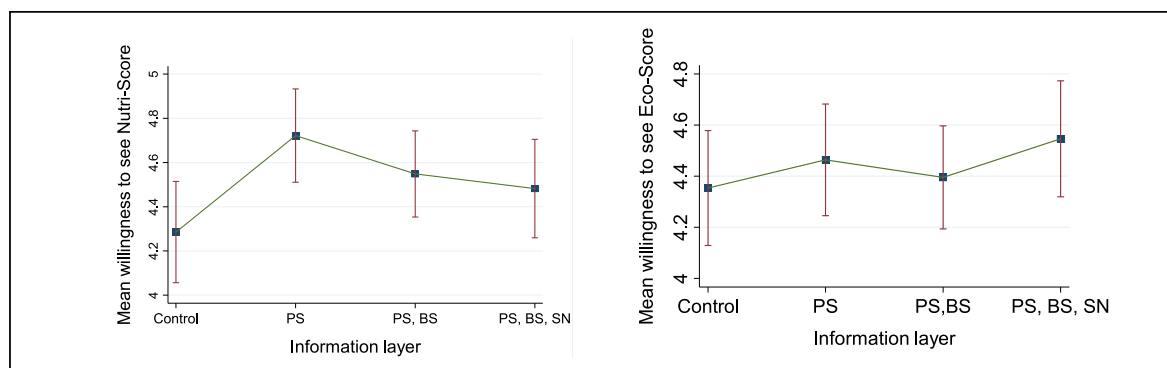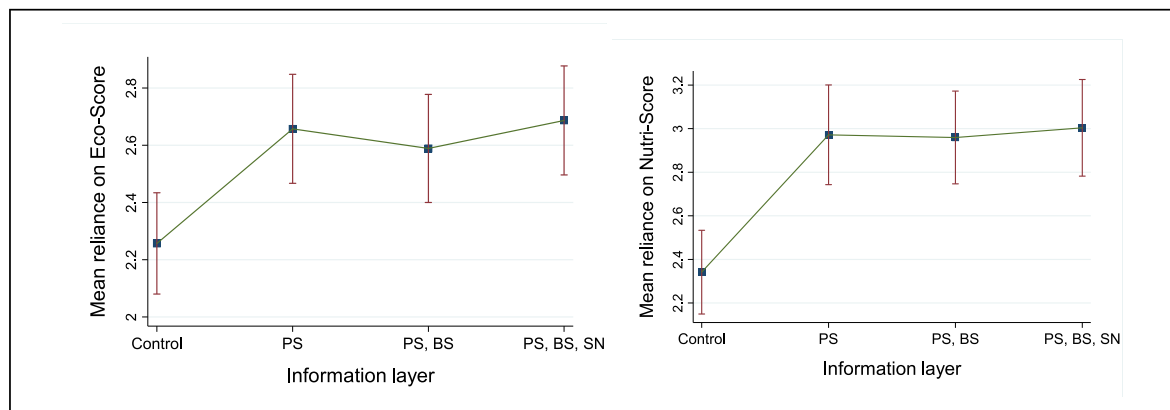

Fig. 6. Mean willingness to see Nutri-Score (left) and Eco-Score (right) on a 6 point scale per layer of information: Product Scores (PS), Product Scores and Basket Scores (PS, BS) and Product Scores, Basket Scores and Social Norm (SN).

Fig. 7. Mean stated reliance on Eco-Score (left) and Nutri-Score (right) during choice task on a 6 point scale per layer of information: Product Scores (PS), Product Scores and Basket Scores (PS, BS) and Product Scores, Basket Scores and Social Norm (SN).

4.3.1. Willingness to see scores

A one-way ANOVA revealed significant differences in willingness to see Nutri-Scores across the different levels of provided information (F $(3,990) = 2.71$, p $= 0.04$). With the PS, the mean willingness to see Nutri-Score ($M = 4.72$, $SD = 1.70$) was significantly higher compared to the control ($M = 4.29$, $SD = 1.84$, p $= 0.005$). However, for the PS & BS ($M = 4.55$, $SD = 1.56$), this difference with the control group was only marginally significant (p $= 0.09$) and for the PS, BS & SN ($M = 4.48$, $SD = 1.79$) was insignificant (p $= 0.20$). Opposite to what has been intended with basket scores and social norm, the willingness to see Nutri-Score decreased instead of increasing with the addition to the Product Scores.

No significant differences in willingness to see Eco-Scores across the different levels of provided information were observed (F$(3,990) = 0.57$, p $= 0.63$).

4.3.2. Stated focus on scores

One-way ANOVA's revealed significant differences in participant's reported reliance on Nutri-Score [Eco-Score] during the task (F$(3,990)$ $= 8.52$, p $= 0.000$ [F$(3,990) = 4.33$, p $= 0.005$]). Unsurprisingly, a stronger reliance on Nutri-Score [Eco-Score] was reported with the PS, ($M = 2.9$, $SD = 1.83$ [$M = 2.66$, $SD = 1.53$]) than in the control condition ($M = 2.34$, $SD = 1.54$; p $= 0.000$ [$M = 2.25$, $SD = 1.42$; p $= 0.003$]). The same held for the PS, BS ($M = 2.96$, $SD = 1.711$; p $= 0.000$ [$M = 2.58$, $SD = 1.51$; p $= 0.014$]) and the PS, BS, SN ($M = 3.00$, $SD = 1.78$; p $= 0.000$ [$M = 2.68$, $SD = 1.53$; p $= 0.001$]). However, when comparing the PS to the PS &BS or to the PS & BS & SN, no additional increments in reported reliance on Nutri-Score [Eco-Score] was observed (p $= 0.938$ and p $= 0.835$ respectively [p $= 0.61$ and p $= 0.827$ respectively]).

5. Discussion

5.1. Interpretation

In the first stage of the experiment, the effect of a dual scoring system on the NQI and EII of food choices was examined. The findings suggest that displaying Nutri- and Eco-Score at product level led to improved nutritional qualities of food choices, while the environmental impact was not reduced. Respondents being exposed to the scores report to have relied significantly more both on Nutri-Score and on Eco-Scores compared to those who were not. Therefore, this discrepancy could not be explained by stated levels of attention being paid to the scores. Furthermore, the absence of an effect on EII could potentially be explained by halo-effects, although those were not tested. For example, information on sustainability could affect consumers' taste perceptions of products, both in positive and negative ways (Luchs, Naylor, Irwin, & Raghunathan, 2010; Napolitano, Caporale, Carlucci, & Monteleone,

2007). Due to the lack of information on potential mediating variables, the results only allow to attribute the observed effect on NQI to the scores, but not to explain how it took place, neither to explain why no effect on EII was observed.

On the one hand, the findings corroborate the growing body of literature indicating that Nutri-Score would be an effective communication tool for inducing healthier food choices amongst consumers (Egnell, Boutron, et al., 2019; Egnell et al., 2018; Egnell, Talati, et al., 2019; Poquet et al., 2019; Vandevijvere et al., 2020). On the other hand, it confirms recent evidence that jointly displaying Nutri-Score and Eco-Score would improve the NQI of food choices but not the EII (De Bauw et al., 2021). Even with a more prominent visual position given to the Eco-Score, the present study came up with the same findings. This suggests that there is something inherent to Eco-Score that makes it less activating in the product screen than the Nutri-Score. One the one hand, this could relate to the fact that respondents might have been familiar with the Nutri-Score while this is was impossible for the Eco-Score as the experiment was conducted in 2019, before Eco-Scores were introduced by retailers. On the other hand, consumers' overall relatively low importance attached to environmental aspects in food consumption might have been driving this (Maehle et al., 2015). Simply adding an analogous Eco-Score to the Nutri-Score would, at least in the short term, not be sufficient to reduce the environmental impact of consumers' food choices. However, this does not imply that providing the Eco-Score had no effect at all throughout the experiment.

In the second stage of the experiment, the Recommendation Agents led to shifting behaviour associated with a reduced environmental impact. This held, however, only in combination with all the other treatments (product scores, basket scores and social norm). Similarly, the conditions with product scores, product scores and basket scores, and product scores, basket scores and social norm did lead to reduced environmental impacts, but only if combined with the Recommendation Agents. In addition, the basket scores and social norm did not lead to additional improvements. This conditionality of effects might be an indication of facilitated informed choices rather than entirely unconscious choice steering. These findings demonstrate the importance of an integrated approach, combining both motivation, opportunity and ability factors to have the highest responses. None of the individual treatments but rather their combinations led to improvements.

During the first stage of the experiment improvements only in terms of nutritional quality were observed, whereas the improvements in terms of environmental impact were observed only in the second stage. The absence of effects on nutritional qualities in the second step might not surprise, as the improvements were already induced in the preceding step, and hence, there remained less room for improvement in the second stage. These findings could be linked to nutritional values of food being often prioritised over environmental impacts by consumers.

However, the finding that environmental improvements, although less prioritised, could be achieved in a later stage of the purchase process are promising. By applying different interventions across the consumers' decision process, it might become possible to bring less prioritised considerations into play. However, this is speculative and would need further testing to be validated.

As discussed earlier, the product scores in presence of Recommendation Agents led to improved shift in the environmental scores (ΔEII). In contrast, the addition of personalised basket scores to the product scores or the addition of social norms to the product- & basket scores norm did not lead to additional shifting behaviour as regards neither the nutritional quality nor the environmental impact. This difference in effects between additional cognitively-oriented nudges (basket scores and social norm) and behavioural-oriented nudges (RAs) accords with the recent meta-review by Cadario and Chandon (2020). With these additional functionalities, attempts were made to improve the perceived personal relevance of nutritional/environmental information. However, considering the willingness to see Nutri- and Eco-Scores did not increase by providing additional cognitively-oriented nudges (basket scores and social norm) compared to the control situation. As this willingness to see Nutri- and Eco-Scores can be seen as a proxy for perceived personal relevance, the attempted effect was not realized. Still, due to the lack of further mediator variables, we can only suggest some potential reasons why this was not observed. Though it cannot be tested whether this was due to failed manipulations, or due to a real absence of effect. For the basket scores, it could be argued that the use of percentages, in which 0% corresponded to the best possible score, might have felt contra intuitive. As a result, the respondent may have become confused and decided not to pay any attention to it. The social norm conceivably might have failed in activating the perception of an actual norm as respondents might not have identified sufficiently with the described peers. In addition, the respondent might have had little faith in the veracity of the social norm. We also do not know whether they even looked at and considered the basket score and/or social norm. Since there might be various reasons behind this lack of effect, which could not be tested, these results should not be generalised.

5.2. Implications for policy and industry

First, our results strongly endorse a further expansion of Nutri-Score to a wide range of products for a transition towards more healthy dietary patterns. The more food products are labelled with the score, the more beneficial its prospected effects. Not only is this in line with the accumulating literature on Nutri-Score, but it also demonstrates that the addition of an Eco-Score does not diminish Nutri-Score's effectiveness.

Second, very useful observations were made regarding the point throughout the purchasing process at which effectiveness could be achieved. Nutri-Score could be considered as a full-fledged attribute during food choices, as it instantly led to the selection of a healthier basket. In contrast, Eco-Scores were only found to be effective as an optimisation criterion to improve selected baskets. This has implications for retailers who want Eco-Scores to be actually reflected in consumers' food choices. While environmental impacts are generally considered important amongst consumers, this is often overruled by more important characteristics like price, taste or health impact. As it is no top priority, failure to be considered in initial food choices is likely to occur. However, as low environmental impacts are generally considered favourable, introducing this aspect at a later phase of the decision process could still lead to desirable outcomes.

Third and finally, Eco-Score's effectiveness might be conditional. Alterations in the food environment that minimised efforts of shifting behaviour were required for the Eco-Score to actually lower the environmental impacts. Therefore, despite the promising advances being made concerning the creation of a uniform labelling system (Nutri-Score & Eco-Score), an enabling food environment (e.g. recommendation agents) should be ensured. Although people are increasingly open to

sustainable food choices, it must not take too much effort. Therefore, the crucial next step towards dietary transition should focus on visibility and availability of low-impact products. The example of a recommender system that integrates nutritional and environmental criteria in its algorithms could hereby be used as an example of how widely used digital marketing tools could be used for public health- and sustainability purposes.

5.3. Strengths and limitations

While plenty of research emerged during the last years on the effect of Nutri-Score on consumers' food choices, this study took a step forward and added on the limited literature on a combined Nutri- and Eco-Score approach. On top of that, attempts were made to stimulate the use of both scores by using smart and personalised nudges. We make use of objective outcome measures to measure healthy food choices and environmentally friendly food choices. This study adds to the scarce empirical experiments on the performance of recommendations agents in the light of healthy and sustainable food consumption.

However, this study is also subject to some limitations. First, the data was collected through a web-survey and with every survey one has to be aware about the potential social desirability bias and hypothetical bias. The authors tried to minimise this effect by replicating the E-grocery environment as accurate as possible, rather than explicitly asking how healthy/environmentally friendly they usually consume and by using cheap talks scripts. Even given these efforts, it is plausible that respondents reacted differently to the treatments than would have been the case in a real E-grocery. Second, the experiment was not incentive-based, as respondents were not asked to pay their final basket selection. This may also have biased the results since price is usually much more important factor in food decision than are health and sustainability. Third, the limited amount of mediator variables impede a proper evaluation of the manipulations. Hence, not all observed effects could be attributed to a certain mechanism and it remains unclear whether the absence of effects were indeed due to actually missing effects or rather due to failed manipulations. Eye-tracking would have been extremely useful to limit this shortcoming. Finally, the functionalities introduced in the second stage, i.e. when participants were presented with an overview of their selection and could make adjustment, could not be assessed independent of the decision phase. Future studies could further explore the observed potential of Recommendation Agents and product scores across different phases of decision making.

6. Conclusions

This study observed healthier and more environmentally friendly food choices due to the display of a combined Nutri- and Eco-Score. Improvements in nutritional values were observed during the initial selection of products. Improvements in environmental impacts were only observed at the later stage of basket verification and only if facilitated with recommendation agents. Therefore, recommendation agents can be considered as an effective tool to enhance the potential of a dual scoring system in reducing environmental impacts of food choices. The potential of such a recommender functionality therefore urgently needs further investigation and application in the context of dietary transition. In contrast, supporting information that sought to increase the personal relevance of the scores did not lead to additional improvements in terms of nutritional quality or environmental impact. The intended increase in personal relevance and thereby increased focus on scores were also not observed but it could not properly be explained why this was the case. The potential of these cognitively oriented nudges, at least in their specific manifestation of this study, could neither be supported nor generally contradicted. This study illustrates how smart interventions on the visibility and proximity of products with better Nutri- and or Eco-Scores in the food environment can still affect food choices, where more cognitively oriented nudges may fail. Once a uniform labelling is in

place, these effort reducing strategies could be key to realize dietary transition.

CRediT author statement

Michiel De Bauw: Conceptualization, Methodology, Software, Formal Analysis, Investigation, Writing – Original Draft, Visualization **Lucia Segovia de la Revilla:** Conceptualization, Methodology, Investigation, review & editing – **Veerle Poppe:** Validation, Supervision, Project administration, Funding acquisition **- Christophe Matthys**: Validation, Writing – review & editing, Funding acquisition - **Liesbet Vranken:** Term; Conceptualization, Methodology, Validation, Data curation, Writing - review & editing, Supervision, Funding acquisition.

Ethical Statement

Hereby, I Michiel De Bauw consciously assure that for the manuscript "Digital nudges to stimulate healthy and pro-environmental food choices in E-groceries" the following is fulfilled:

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

The violation of the Ethical Statement rules may result in severe consequences.

To verify originality, your article may be checked by the originality detection software iThenticate. See also http://www.elsevier.com/editors/plagdetect.

I agree with the above statements and declare that this submission follows the policies of Solid State Ionics as outlined in the Guide for Authors and in the Ethical Statement.

Acknowledgement

Appendix A
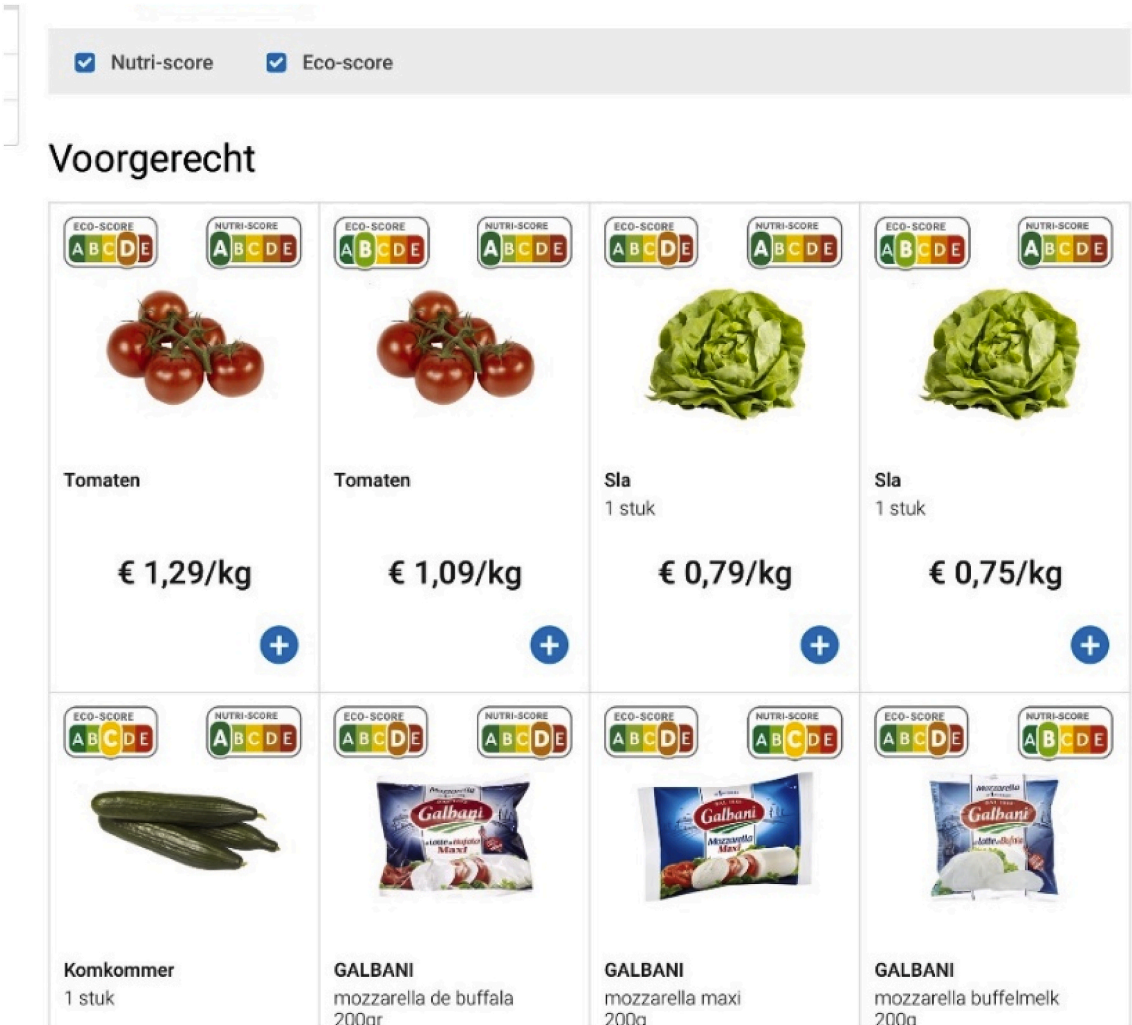
Fig. A.1. Wireframe of products with scores in first stage of Experiment
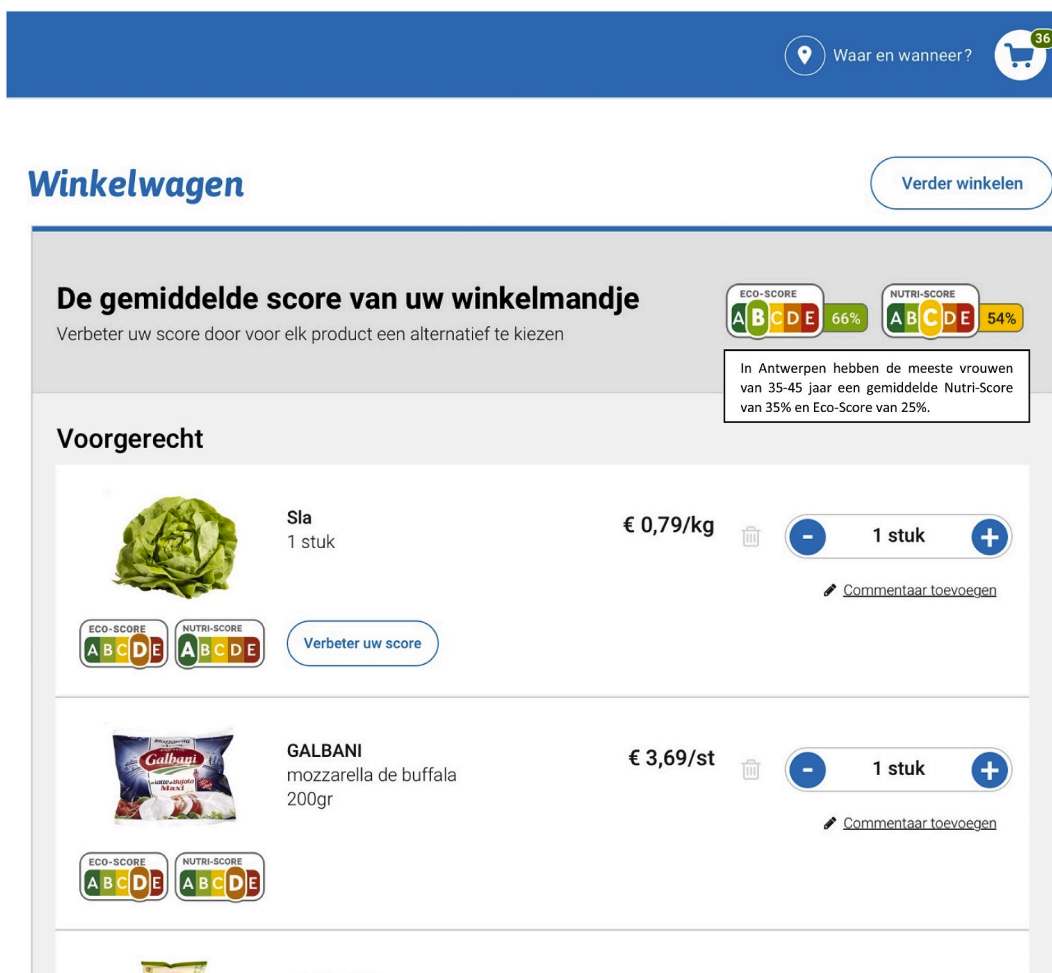
Fig. A.2. Wireframe of selected products in stage 2 with product scores, basket scores and social norm
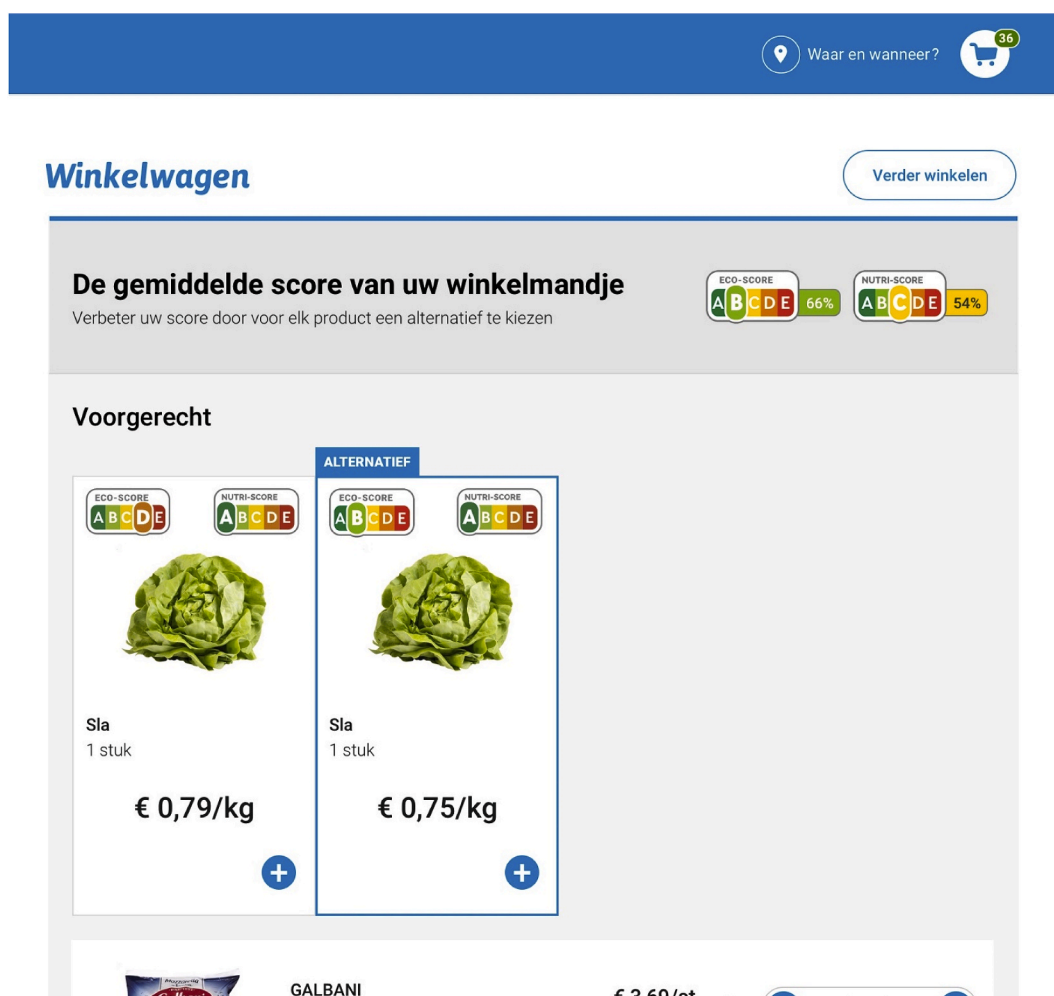
Fig. A.3. Wireframe of stage 2 with suggested alternative by RA in blue box

Appendix B

Table B.1
Included products and corresponding scores

Number	Code	Enviro-Score	Nutri-Score	Product	Extra info	Enviro-Score	Nutri-Score	Energy (kJ)	F·U.	Weight per unit (g)	Price	Group
1	TDA01	**5.32**	**−10**	Tomato	Origin: Spain	**D**	**A**	**74**	**piece**	**123**	€ 1.29/ kg	Side
2	TBA01	**0.9**	**−10**	Tomato	Origin: Belgium	**B**	**A**	**74**	**piece**	**123**	€ 1.09/ kg	Side
3	SDA01	**2.38**	**−8**	Lettuce		**D**	**A**	**58**	**piece**	**539**	€ 0.79/ kg	Side
4	SBA01	**0.67**	**−8**	Lettuce	greenhouse Flandria	**B**	**A**	**58**	**piece**	**539**	€ 0.75/ kg	Side
5	KCA01	**1.9**	**−5**	Cucumber		**C**	**A**	**65**	**piece**	**201**	€ 0.69/ pc.	Side

Table B.1 (*continued*)

Number	Code	Enviro-Score	Nutri-Score	Product	Extra info	Enviro-Score	Nutri-Score	Energy (kJ)	F·U.	Weight per unit (g)	Price	Group
6	MDD01	2.5	10	Mozzarella	the buffala	D	D	1084	piece	125	€ 3.29/ pc.	Side
7	MDC01	2.5	11	Mozzarella	maxi	D	C	989	piece	125	€ 2.55/ pc.	Side
8	CBE01	1.96	22	Bread croutons		B	E	2293	piece	75	€ 1.19/ pc.	Side
9	PDD01	4.05	18	Prosciutto	di Parma	D	D	1060	piece	90	€ 2.80/ pc.	Side
10	PCD01	1.84	18	Prosciutto	crudo	C	D	1060	piece	175	€ 3.27/ pc.	Side
11	TDA02	5.32	−10	Tomato	Origin: Spain	D	A	74	piece	123	€ 1.29/ kg	Main
12	TBA02	0.9	−10	Tomato	Origin: Belgium	B	A	74	piece	123	€ 1.09/ kg	Main
13	PDA02	5.32	−7	Passata		D	A	145	piece	690	€ 1.39/ pc.	Main
14	PBA02	0.9	−7	Passata	BIO	B	A	145	piece	700	€ 0.85/ pc.	Main
15	PDC02	5.32	3	Pasta sauce	Miracoli Italiano	D	C	209	piece	500	€ 3.65/ pc.	Main
16	PBC02	0.9	3	Pasta sauce	BIO	B	C	209	piece	500	€ 3.80/ pc.	Main
17	MBA02	0.57	−5	Mushrooms		B	A	104	piece	500	€ 1.49/ pc.	Main
18	ZCA02	1.9	−6	Zucchini		C	A	70	piece	320	€ 0.99/ kg	Main
19	CBA02	1.1	−8	Carrots		B	A	166	piece	61	€ 0.89/ kg	Main
20	VDA02	4.39	−8	Vegetarian minced meat	from soy	D	A	485	gram	.	€ 8.11/ kg	Main
21	VBA02	0.9	−8	Vegetarian minced meat	from Quorn	B	A	485	gram	.	€ 12/kg	Main
22	CDB02	2.01	2	Chicken mince		D	B	605	gram	.	€ 7.18/ kg	Main
23	CCB02	1.96	2	Chicken mince	BIO	C	B	605	gram	.	€ 7.60/ kg	Main
24	PDD02	4.05	13	Minced pork	Origin: Poland	D	D	848	gram	.	€ 7.50/ kg	Main
25	PCD02	1.84	13	Minced pork	Origin: Belgium	C	D	848	gram	.	€ 7.20/ kg	Main
26	BEB02	30.12	2	Minced Beef	Soy fed	E	B	843	gram	.	€ 14.45/ kg	Main
27	BDB02	16,00	2	Minced Beef	Grass fed	D	B	843	gram	.	€14.90/ kg	Main
28	BED02	30.12	14	Minced pork and beef	Soy fed	E	D	911	gram	.	€ 7.58/ kg	Main
29	BDD02	16,00	14	Minced pork and beef	Grass fed	D	D	911	gram	.	€7.95/kg	Main
30	BDE02	4.05	21	Bacon	Origin: America	D	E	1133	piece	200	€ 2.04/ pc.	Main
31	BCE02	1.84	21	Bacon	Origin: France	C	E	1133	piece	200	€ 2.04/ pc.	Main
32	SBA02	1.43	−5	Spaghetti		B	A	1567	piece	500	€ 0.49/ pc.	Main
33	SWBA02	1.43	−6	Spaghetti		B	A	1446	piece	250	€ 0.49/ pc.	Main
34	GDD02	2.5	12	Grated Cheese		D	D	1185	piece	250	€ 1.99/ pc.	Main
35	GDC02	2.5	10	Grated Cheese	LIGHT	D	C	1657	piece	250	€ 3.73/ pc.	Main
36	TBD03	0.41	13	Tiramisu		B	D	1049	piece	500	€ 3.75/ pc.	Dessert
37	ODA03	4,00	−7	Orange	Origin: South Africa	D	A	207	piece	131	€ 1.49/ kg	Dessert
38	OBA03	0.95	−7	Orange	Origin: Spain	B	A	207	piece	131	€ 1.33/ kg	Dessert
39	YBC03	0.41	3	Yoghurt	Strawberry	B	C	396	piece	200	€ 0.79/ pc.	Dessert
40	YBA03	0.41	−2	Yogurt	Skimmed	B	A	140	piece	200	€ 0.46/ pc.	Dessert

Table B.2
Suggested alternatives. Grey product is best alternative of the two and was offered when the other was selected

Code	Product	Enviro-Score	Nutri- Score	Alternative
TDA01	Tomato	**D**	**A**	1
TBA01	Tomato	**B**	**A**	2
SDA01	Lettuce	**D**	**A**	1
SBA01	Lettuce	**B**	**A**	2
KCA01	Cucumber	**C**	**A**	1
MDD01	Mozzarella	**D**	**D**	1
MDC01	Mozzarella	**D**	**C**	2
CBE01	Bread croutons	**B**	**E**	1
PDD01	Prosciutto	**D**	**D**	1
PCD01	Prosciutto	**C**	**D**	2
TDA02	Tomatoes	**D**	**A**	1
TBA02	Tomatoes	**B**	**A**	2
PDA02	Passata	**D**	**A**	1
PBA02	Passata	**B**	**A**	2
PDC02	Pasta sauce	**D**	**C**	1
PBC02	Pasta sauce	**B**	**C**	2
MBA02	Mushrooms	**B**	**A**	1
ZCA02	Zuccinni	**C**	**A**	1
CBA02	Carrots	**B**	**A**	1
VDA02	Vegetarian meat	**D**	**A**	1
VBA02	Vegetarian meat	**B**	**A**	2
BED02	Beef and pork meat	E	D	1
BDD02	Beef and pork meat	D	D	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
BDD02	Beef and pork meat	D	D	2
BDB02	Beef meat	D	B	2
PCD02	Pork meat	C	D	2
VBA02	Vegetarian meat	B	A	2
BEB02	Beef meat	E	B	1
BDB02	Beef meat	D	B	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
BDB02	Beef meat	D	B	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
PDD02	Pork meat	D	D	1
PCD02	Pork meat	C	D	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
PCD02	Pork meat	C	D	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
CDB02	Chicken meat	D	B	1
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
CCB02	Chicken meat	B	C	2
VBA02	Vegetarian meat	A	B	2
BDE02	Bacon	D	E	1
BCE02	Bacon	C	E	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
BCE02	Bacon	C	E	2
CCB02	Chicken meat	C	B	2
VBA02	Vegetarian meat	B	A	2
PCD02	Pork meat	C	D	2

Appendix C

$$Nutri-Score\ Basket = \frac{\sum Nutri-Score\ product \ \times Energy\ product}{Energy\ basket}$$

Equation C .1

$$Energy\ product = \frac{Energy(kJ)x\ quantity\ product}{100}$$

Equation C .2

$$Nutri-Score\ Basket\ (\%) = \frac{100*(Nutri-Score\ Basket + 15)}{37}$$

Equation C .3

Table C.1
Cut-off values basket Nutri-Scores

Nutritional impact		
Letter		Nutri-Score basket
A	<	3
B	≥	41
C	≥	49
D	≥	70
E	≥	92

$$Eco - Score\ basket = \frac{\sum Eco - Score\ product\ x\ quantity\ product}{Quantity\ basket}$$

Equation C .4

$$Eco - Score\ Basket\ (\%) = \frac{20*(\textbf{Eco} - \textbf{Score basket} - \textbf{UpLevel})}{(\textbf{UpLevel} - \textbf{LowLevel}))} + \textbf{UpLevelRescale}$$

Equation C .5

Table C.2
Cut-off values basket Eco-Scores

Environmental impact				
Letter	LowLevel	UpLevel	ReScaleLowLevel	ReScaleUpLevel
A	0	0,4	0	20
B	0,4	1,45	20	40
C	1,45	2	40	60
D	2	10	60	80
E	10	30	80	100

Appendix D

Table D. 1
Socio-demographics sample. Reference values sourced from Statistiek Vlaanderen 2020

Participants (n = 994)		Flemish population
Gender		
Male	496 (49.9%)	49.5%
Female	498 (50.1%)	50.4%
Other	0%	
Age (years)		
	52.05 (14.38)	41.5
Education (highest completed degree)		
None/Primary school	36 (3.4%)	17.7%
Secondary education	386 (38.8%)	39.6%
Tertiary education	561 (56.5%)	42.7%
Other	11 (1.1%)	.
Household size		
1	164 (16.5%)	.
2	472 (47.5%)	.
3	146 (14.7%)	.
4	163 (16.4%)	.
5	43 (4.0%)	.

Table D. 1 (*continued*)

Participants (n = 994)		Flemish population
>5	6 (0.6%)	.
Employment state		
Student	15 (1.5%)	
Full time employee	436 (43.9%)	69.4%
Part time employee	96 (9.7%)	
Self-employed/Liberal profession	46 (4.6%)	
Unemployed and searching	18 (1.8%)	2.5%
Unemployed and non-searching	34 (3.4%)	
Unemployable	51 (5.1%)	
Retired	298 (30.0%)	28.1%
Net household income per month		
< €1000	11 (1.4%)	3.7%
€1001 - €2000	182 (23.0%)	36.2%
€2001 - €3000	202 (25.5%)	41.8%
€3001 - €4000	182 (23.0%)	13.1%
€4001 - €5000	132 (16.6%)	2.7%
> €5000	83 (10.4%)	2%
Don't know	29	
Prefer not to answer	173	

References

Aschemann-Witzel, J., Grunert, K. G., van Trijp, H., Bialkova, S., Raats, M. M., Hodgkins, C., et al. (2013). Effects of nutrition label format and product assortment on the healthfulness of food choice. *Appetite, 71*, 63–74. https://doi.org/10.1016/j.appet.2013.07.004

Askew, K. (2018). Consumers do not trust food labels and they have good reason": EU consumer organisation calls for tougher labelling regulation. Retrieved February 1, 2021, from https://www.foodnavigator.com/Article/2018/06/13/Consumers-do-no t-trust-food-labels-and-they-have-good-reason-EU-consumer-organisation-calls-for-tougher-labelling-regulation.

Biesbroek, S., Bas Bueno-De-Mesquita, H., Peeters, P. H. M., Monique Verschuren, W. M., Van Der Schouw, Y. T., Kramer, G. F. H., et al. (2014). Reducing our environmental footprint and improving our health: Greenhouse gas emission and land use of usual diet and mortality in EPIC-NL: A prospective cohort study. *Environmental Health: A Global Access Science Source, 13*(1). https://doi.org/10.1186/1476-069X-13-27

Blom, S. S. A. H., Gillebaart, M., De Boer, F., van der Laan, N., & De Ridder, D. T. D. (2021). Under pressure: Nudging increases healthy food choice in a virtual reality supermarket, irrespective of system 1 reasoning. *Appetite, 160*, 105116. https://doi.org/10.1016/j.appet.2021.105116. May 2020.

Breugelmans, E., Köhler, C. F., Dellaert, B. G. C., & de Ruyter, K. (2012). Promoting interactive decision aids on retail websites: A message framing perspective with new versus traditional focal actions. *Journal of Retailing, 88*(2), 226–235. https://doi.org/10.1016/j.jretai.2011.10.003

Buhrau, D., & Ozturk, T. C. (2018). Motivating healthy eating: The role of presentation format and health consciousness. *Food Quality and Preference, 64*, 167–171. https://doi.org/10.1016/j.foodqual.2017.09.011. September 2017.

Cadario, R., & Chandon, P. (2020). Which healthy eating nudges work best? A meta-analysis of field experiments. *Marketing Science, 39*(3), 465–486. https://doi.org/10.1287/mksc.2018.1128

Celis-Morales, C., Livingstone, K. M., Marsaux, C. F., Macready, A. L., Fallaize, R., O'donovan, C. B., et al. (2017). Effect of personalized nutrition on health-related behaviour change: Evidence from the Food4Me European randomized controlled trial. *International Journal of Epidemiology*, 578–588. https://doi.org/10.1093/ije/dyw186

Chantal, J., & Hercberg, S. (2017). Development of a new front-of-pack nutrition label in France: The five-colour nutri-score. *Public Health Panorama*, 712–725, 03(04).

Coffino, J. A., Udo, T., & Hormes, J. M. (2020). Nudging while online grocery shopping: A randomized feasibility trial to enhance nutrition in individuals with food insecurity. *Appetite, 152*, 104714. https://doi.org/10.1016/j.appet.2020.104714. November 2019.

Czajkowski, M., Zagórska, K., & Hanley, N. (2019). Social norm nudging and preferences for household recycling. https://doi.org/10.1016/j.reseneeco.2019.07.004.

De Bauw, M., Matthys, C., Poppe, V., Franssens, S., & Vranken, L. (2021). A combined nutri-score and 'eco-score' approach for more nutritious and more environmentally friendly food choices? Evidence from a consumer experiment in Belgium. *Food Quality and Preference, 93*, 104276. https://doi.org/10.1016/j.foodqual.2021.104276. April.

De Temmerman, J., Heeremans, E., Slabbinck, H., & Vermeir, I. (2021). The impact of the Nutri-Score nutrition label on perceived healthiness and purchase intentions. *Appetite, 157*, 104995. https://doi.org/10.1016/j.appet.2020.104995. September 2020.

Dean, M., Lampila, P., Shepherd, R., Arvola, A., Saba, A., Vassallo, M., et al. (2012). Perceived relevance and foods with health-related claims. *Food Quality and Preference, 24*(1), 129–135. https://doi.org/10.1016/j.foodqual.2011.10.006

Egnell, M., Boutron, I., Péneau, S., Ducrot, P., Touvier, M., Galan, P., et al. (2019). Front-of-pack labeling and the nutritional quality of students' food purchases: A 3-arm randomized controlled trial. *American Journal of Public Health*. https://doi.org/10.2105/AJPH.2019.305115

Egnell, M., Ducrot, P., Touvier, M., Allès, B., Hercberg, S., Kesse-Guyot, E., et al. (2018). Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: Comparisons with other format labels. *PLoS One*. https://doi.org/10.1371/journal.pone.0202095

Egnell, M., Talati, Z., Gombaud, M., Galan, P., Hercberg, S., Pettigrew, S., et al. (2019). Consumers' responses to front-of-pack nutrition labelling: Results from a sample from The Netherlands. *Nutrients*. https://doi.org/10.3390/nu11081817

European Commission. (2019). The development of the PEF and OEF methods. Retrieved from https://ec.europa.eu/environment/eussd/smgp/dev_methods.htm.

European Commission. (2020). COMMITTEE AND THE COMMITTEE OF THE REGIONS A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system CONTENTS. Retrieved from https://agridata.ec.europa.eu/Qlik_Downloads/Jobs -Growth-sources.htm.

FPS. (2019). *Nutri-Score calculation tool*.

Gerten, D., Heck, V., Jägermeyr, J., Bodirsky, B. L., Fetzer, I., Jalava, M., et al. (2020). Feeding ten billion people is possible within four terrestrial planetary boundaries. *Nature Sustainability*. https://doi.org/10.1038/s41893-019-0465-1

Gilbride, T. J., & Allenby, G. M. (2004). A choice model with conjunctive, disjunctive, and compensatory screening rules. *Marketing Science, 23*(3), 391–406. https://doi.org/10.1287/mksc.1030.0032

Grunert, K. G. (2005). Food quality and safety: Consumer perception and demand. *European Review of Agricultural Economics, 32*(3), 369–391. https://doi.org/10.1093/eurrag/jbi011

Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. *Food Policy, 44*, 177–189. https://doi.org/10.1016/j.foodpol.2013.12.001

Gunaratne, J., & Nov, O. (2017). Using interactive "Nutrition labels" for financial products to assist decision making under uncertainty. *Journal of the Association for Information Science and Technology, 68*(8), 1836–1849. https://doi.org/10.1002/asi.23844

Gunday, G., Karabon, M., Kooij, S., Moulton, J., & Omeñaca, J. (2020, December). How European shoppers will buy groceries in the next normal. Retrieved February 1, 2021, from https://www.mckinsey.com/industries/retail/our-insights/how-europe an-shoppers-will-buy-groceries-in-the-next-normal.

Häubl, G., & Murray, K. B. (2003). Preference construction and persistence in digital marketplaces: The role of electronic recommendation agents. *Journal of Consumer Psychology, 13*(1–2), 75–91. https://doi.org/10.1207/s15327663jcp13-1&2_07

Higgs, S., Liu, J., Collins, E. I. M., & Thomas, J. M. (2019). Using social norms to encourage healthier eating. *Nutrition Bulletin, 44*(1), 43–52. https://doi.org/10.1111/nbu.12371

Honkanen, P., & Frewer, L. (2009). Russian consumers' motives for food choice. *Appetite, 52*(2), 363–371. https://doi.org/10.1016/j.appet.2008.11.009

Hung, Y., Grunert, K. G., Hoefkens, C., Hieke, S., & Verbeke, W. (2017). Motivation outweighs ability in explaining European consumers' use of health claims. *Food Quality and Preference, 58*, 34–44. https://doi.org/10.1016/j.foodqual.2017.01.001

Ikonen, I., Sotgiu, F., Aydinli, A., & Verlegh, P. W. J. (2019). Consumer effects of front-of-package nutrition labeling: An interdisciplinary meta-analysis. *Journal of the Academy of Marketing Science.* https://doi.org/10.1007/s11747-019-00663-9

Johannes, B., Marci, C., & Patricia van, A. (1999). The application and impact of computer-generated personalized nutrition education: A review of the literature. *Patient Education and Counseling, 36*(2), 145–156. Retrieved from http://linkinghub.elsevier.com/retrieve/pii/S0738399198001311?showall=true.

Karlsen, R., & Andersen, A. (2019). Recommendations with a nudge. *Technologies, 7*(2), 45. https://doi.org/10.3390/technologies7020045

Keating, B. A., Herrero, M., Carberry, P. S., Gardner, J., & Cole, M. B. (2014). Food wedges: Framing the global food demand and supply challenge towards 2050. *Global Food Security, 3*(3–4), 125–132. https://doi.org/10.1016/j.gfs.2014.08.004

Kourouniotis, S., Keast, R. S. J., Riddell, L. J., Lacy, K., Thorpe, M. G., & Cicerale, S. (2016). The importance of taste on dietary choice, behaviour and intake in a group of young adults. *Appetite, 103*, 1–7. https://doi.org/10.1016/j.appet.2016.03.015

Lähteenmäki, L. (2013). Claiming health in food products. *Food Quality and Preference, 27*(2), 196–201. https://doi.org/10.1016/j.foodqual.2012.03.006

Luchs, M. G., Naylor, R. W., Irwin, J. R., & Raghunathan, R. (2010). The sustainability liability: Potential negative effects of ethicality on product preference. *Journal of Marketing, 74*(5), 18–31. https://doi.org/10.1509/jmkg.74.5.18

Maehle, N., Iversen, N., Hem, L., & Otnes, C. (2015). Exploring consumer preferences for hedonic and utilitarian food attributes. *British Food Journal, 117*(12), 3039–3063. https://doi.org/10.1108/BFJ-04-2015-0148

Moorman, C., & Matulich, E. (1993). A model of consumers' preventive health behaviors: The role of health motivation and health ability. *Journal of Consumer Research, 20*(2), 208–228. https://doi.org/10.1086/209344

Napolitano, F., Caporale, G., Carlucci, A., & Monteleone, E. (2007). Effect of information about animal welfare and product nutritional properties on acceptability of meat from Podolian cattle. *Food Quality and Preference, 18*(2), 305–312. https://doi.org/10.1016/j.foodqual.2006.02.002

Ngoc, T., Tran, V., Usï Um Atas, M., Felfernig, Alexander, S., Martin, Atas, M., & Stettinger, M. (2018). An overview of recommender systems in the healthy food domain. *Journal of Intelligent Information Systems, 50*, 501–526. https://doi.org/10.1007/s10844-017-0469-0

OECD. (2020). *E-commerce in the time of COVID-19.* Unpacking E-Commerce. October).

Osman, M., & Thornton, K. (2019). Traffic light labelling of meals to promote sustainable consumption and healthy eating. *Appetite, 138*, 60–71. https://doi.org/10.1016/J.APPET.2019.03.015

Petty, R. E., Barden, J., & Wheeler, S. C. (2009). The Elaboration Likelihood Model of persuasion: Developing health promotions for sustained behavioral change. In *Emerging theories in health promotion practice and research.*

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. In *Communication and persuasion.* https://doi.org/10.1007/978-1-4612-4964-1_1

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science, 360*, 987–992. Retrieved from http://science.sciencemag.org/.

Poquet, D., Ginon, E., Goubel, B., Chabanet, C., Marette, S., Issanchou, S., et al. (2019). Impact of a front-of-pack nutritional traffic-light label on the nutritional quality and the hedonic value of mid-afternoon snacks chosen by mother-child dyads. *Appetite, 143*(March), 104425. https://doi.org/10.1016/j.appet.2019.104425

Punj, G. N., & Moore, R. (2007). Smart versus knowledgeable online recommendation agents. *Journal of Interactive Marketing, 21*(4), 46–60. https://doi.org/10.1002/dir.20089

Rothschild, M. L. (1999). Carrots , sticks , and promises : A conceptual framework for the management of public health and social issue behaviors. *Journal of Marketing, 63*(4), 24–37.

Sharot, T., & Sunstein, C. R. (2020). How people decide what they want to know. *Nature Human Behaviour, 4*(1), 14–19. https://doi.org/10.1038/s41562-019-0793-1

Statista. (2021). *Share of consumers who purchased food or groceries online in selected countries in Europe from 2006 to 2019.* Retrieved August 10, 2021, from https://www.statista.com/statistics/915391/e-commerce-purchase-rate-of-food-or-groceries-in-europe-by-country/.

Sunstein, C. R. (2014). Nudging: A very short guide. *Journal of Consumer Policy, 37*(4), 583–588. https://doi.org/10.1007/s10603-014-9273-1

Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature, 515*(7528), 518–522. https://doi.org/10.1038/nature13959

Tonkin, E., Webb, T., Coveney, J., Meyer, S. B., & Wilson, A. M. (2016). Consumer trust in the Australian food system - the everyday erosive impact of food labelling. *Appetite, 103*, 118–127. https://doi.org/10.1016/j.appet.2016.04.004

Trattner, C., & Elsweiler, D. (2017). *Food recommender systems: Important contributions, challenges and Future research Directions, (November).* Retrieved from http://arxiv.org/abs/1711.02760.

Van Loo, E. J., Hoefkens, C., & Verbeke, W. (2017). Healthy, sustainable and plant-based eating: Perceived (mis)match and involvement-based consumer segments as targets for future policy. *Food Policy.* https://doi.org/10.1016/j.foodpol.2017.03.001

Vandevijvere, S., Vermote, M., Egnell, M., Galan, P., Talati, Z., Pettigrew, S., et al. (2020). Consumers' food choices, understanding and perceptions in response to different front-of-pack nutrition labelling systems in Belgium: Results from an online experimental study. *Archives of Public Health, 78*(1). https://doi.org/10.1186/s13690-020-00404-3

Vermeir, I., & Verbeke, W. (2006). Sustainable food consumption: Exploring the consumer "attitude - behavioral intention" gap. *Journal of Agricultural and Environmental Ethics, 19*(2), 169–194. https://doi.org/10.1007/s10806-005-5485-3

Vermote, M., Bonnewyn, S., Matthys, C., & Vandevijvere, S. (2020). Nutritional content, labelling and marketing of breakfast cereals on the belgian market and their reformulation in anticipation of the implementation of the nutri-score front-of-pack labelling system. *Nutrients, 12*(4). https://doi.org/10.3390/nu12040884

Vlaeminck, P., Jiang, T., & Vranken, L. (2014). Food labeling and eco-friendly consumption: Experimental evidence from a Belgian supermarket. *Ecological Economics, 108*, 180–190. https://doi.org/10.1016/j.ecolecon.2014.10.019

Wardle, J., & Steptoe, A. (1991). The European health and behaviour survey: Rationale, methods and initial results from the United Kingdom. *Social Science & Medicine, 33*(8), 925–936. https://doi.org/10.1016/0277-9536(91)90263-C

Weber, A. (2021). Mobile apps as a sustainable shopping guide: The effect of eco-score rankings on sustainable food choice. *Appetite, 167*(July), 105616. https://doi.org/10.1016/j.appet.2021.105616

Westhoek, H., Lesschen, J. P., Rood, T., Wagner, S., De Marco, A., Murphy-Bokern, D., et al. (2014). Food choices, health and environment: Effects of cutting Europe's meat and dairy intake. *Global Environmental Change, 26*(1), 196–205. https://doi.org/10.1016/j.gloenvcha.2014.02.004

Xiao, B., & Benbasat, I. (2007). e-commerce product recommendation agents: Use, characteristics, and impact. *MIS Quarterly: Management Information Systems, 31*(1), 137–209. https://doi.org/10.2307/25148784