Effects of Digital Food Labels on Healthy Food Choices in Online Grocery Shopping

Completed Research Paper

Introduction

Over the course of the past two decades, the so-called obesity epidemic (Hill and Peters 1998) has reached a global extent and represents one of the major health challenges of the 21st century (Blüher 2019). The continuously rising prevalence of obesity and other diet-related diseases stands in stark contrast to the large proportion of people trying to control their body weight and change their food choices (Lowry et al. 2000; Weiss et al. 2006), threatens individual health (Hruby et al. 2016) and represents a significant financial burden on health systems worldwide (Tremmel et al. 2017). Although consumers' self-reported ambitions of wanting to pursue healthy diets are almost omnipresent, the behavior of most individuals – driven by factors such as prices, tastiness, and practical considerations – remains largely unchanged (Baudry et al. 2017; Milkman et al. 2008; Sproesser et al. 2018; Vidgen and Gallegos 2010).

Prior research suggests that when making food-related decisions, people use non-compensatory, simple heuristic strategies that rely on few, easily accessible pieces of information (Scheibehenne et al. 2007; Schulte-Mecklenbeck et al. 2013). Hence, also during grocery shopping in supermarket aisles as well as online, consumers typically pay attention only to a subset of salient product attributes (Scheibehenne et al. 2007; Schulte-Mecklenbeck et al. 2013), among which health considerations only play a subordinate role (Baudry et al. 2017; Sproesser et al. 2018). More concretely, when selecting products, decision-making is usually occupied with processing a plethora of information pertaining to package designs, advertisement claims, price promotions, and other short-term information regarding pleasure and taste – all of them being much more salient than the potential long-term health effects of nutrients which can merely be estimated from nutrient tables on products' backsides (Chandon and Wansink 2012).

In the past, measures aimed at increasing the healthiness of food choices have been centered around educational campaigns (Jahns et al. 2018), with very limited impact on improving dietary intake (Vidgen and Gallegos 2010). First, the aforementioned *lack of salience* of nutritional aspects at the point of the purchase decision hinders the translation of health-relevant information into purchase transaction. Second, a general *lack of food literacy* leaves many shoppers incapable of interpreting the information that is provided on food packages, and acting on this information (Pelletier et al. 2004; Shine et al. 1997). Third, even if nutritional aspects of food products were more salient and users were better able to understand them, the *search costs for retrieving nutritional information* from individual product packages and for comparing dozens of alternatives represent a high barrier to healthy consumer choices. To overcome these shortcomings, front-of-package labels (FoPL) have been introduced as an alternative strategy to increase the healthiness of consumers' food choices. To increase the salience of health-related information in food choices and to ultimately improve the nutritional quality of food purchases, effective front-of-package labels (FoPL) such as the Nutri-Score (NS) have been proposed, but still remain unmandated in most regions of the world (Ducrot et al. 2016; Julia and Hercberg 2017; Talati et al. 2019). FoPLs like the Nutri-Score or the Australian Health Star Rating present nutritional information in directly visible, condensed and easy-to-interpret form, and therefore stand in stark contrast to the often small-printed back-of-package declarations (Julia and Hercberg 2017). Compared to other food labels, the Nutri-Score label has advantages due to its simplicity of summarizing the interpreted content of energy, sugar, saturated fatty acids, sodium, proteins, fiber and fruit, vegetable and nut content inside a product within a simple five-step scale (see Figure 1) (Julia and Hercberg 2017). Like other FoPLs, the Nutri-Score label increases the salience of health-relevant product attributes, decreases search costs and reduces the level of food literacy necessary for making healthy choices. A plethora of recent studies indicate that the Nutri-Score label leads to larger behavioral effects regarding healthier product choices compared to other interpretive summary indicators currently also debated for implementation (Ducrot et al. 2016; Julia and Hercberg 2017; Talati et al. 2019).

Given its effectiveness, it seems counter-intuitive that in most regions of the world, the provision of the Nutri-Score and similar FoPL is still voluntary. So far, only few countries have successfully managed to introduce them on a large-scale. As political decisions in the realm of food policy are typically very controversial (Carter et al. 2013; Temple and Fraser 2014) and influenced by powerful stakeholder groups, the mandatory introduction of front-of-package labels may take a long time. In particular, more empirical studies are needed to determine how effective these measures are in inducing healthier product choices among consumers.

Figure 1. Nutri-Score labels (Julia and Hercberg 2017)

Information systems (IS) such as Web-based systems can play a pivotal role in overcoming this. First, they can provide valuable tools that consumers worldwide can use as an alternative route to get access to the information represented in FoPL like the Nutri-Score in their purchase processes. In fact, a growing number of consumers order an ever-increasing share of their of groceries online and have retailers deliver purchased food items to their doorsteps (Eurostat 2020; IGD 2018). In parallel, recent legislation by the European Union (EU-1169/2011 2014) on mandatory declaration of nutrients for groceries sold online requires online grocery retailers to display nutritional data to their consumers. This regulation has led to a growing availability of structured product data via private and public food composition databases (FCDB), such as 1WorldSync, Atrify, and Openfoodfacts. With structured nutritional data available for grocery products, information systems can be developed that display the Nutri-Score label on such online grocery websites. Hence, such IS can support users' decision making by displaying relevant information during the purchase process, thereby potentially leading to health-beneficial behavior changes (Clemons 2008; Granados et al. 2010; Han and Kim 2019; Li et al. 2014). As such IS can be installed on the end user's client device, the Nutri-Score could be displayed in the purchase decision without requiring any changes by retailers on their website or by food producers on product packages themselves. Second, IS may be used to empirically evaluate the effectiveness of nutritional labels. User and transaction data collected through grocery e-commerce systems can lead to valuable insights into how such purchase-related IS of potentially different designs affect actual grocery shopping behavior (Ding et al. 2015; Johnson et al. 2004). For this, clickstreams, product views, and the time spent on the decisions as well as subjects from different regions can be taken into account (Moe 2003; Senecal et al. 2005). Therefore, such Web-mediated IS enabling users to implement the Nutri-Score themselves using an IS approach could be promising approach towards increasing the healthiness of their food choices.

The present study therefore investigates the following research questions (RQ).

RQ_1: *Does displaying product-specific Nutri-Scores during the shopping process in an e-commerce environment lead to healthier immediate shopping behavior?*

While individuals with low food literacy often did not benefit from nutrition-related awareness campaigns and other policy measures introduced in the past, several studies indicate that the Nutri-Score label is an effective instrument also among this group (Egnell et al. 2020; Egnell et al. 2018; Méjean et al. 2014). Therefore, our second research question is as follows:

RQ_2: *Does displaying product-specific Nutri-Scores during the shopping process lead to healthier immediate shopping behavior among individuals with low food literacy?*

Selective attention towards product attributes and information provided is considered as pivotal in determining the impact of a piece of information on subsequent decisions (Lurie and Mason 2007). Therefore, the study further investigates the following research question:

RQ$_3$: *Does displaying product-specific Nutri-Scores during the shopping process have a particularly large impact on individuals who consciously perceived the Nutri-Score during the shopping process?*

Finally, labeling food products with the Nutri-Score might lead to reactance among consumers (Clee and Wicklund 1980; Dillard and Shen 2005), which could cause negative attitudes towards the Nutri-Score and non-compliance with its suggestions. Therefore, our fourth research question is:

RQ$_4$: *Does displaying product-specific Nutri-Scores during the shopping process generate negative emotions and resistance towards their introduction?*

Related work

Salience and search costs

Salience of information, which refers to the vividness of information in the decision environment (Lurie and Mason 2007), has a significant impact on food-related decisions (e.g Bialkova and Trijp 2010; Dai et al. 2020; Peschel et al. 2019; Wilson et al. 2016), and consumer behavior in other domains including resource consumption (Tiefenbeck et al. 2018), driving behavior (Dahlinger et al. 2018) and product choice (Bordalo et al. 2016). Consequently, IS that support consumers in their product choices need to provide relevant information during the decision process in a way that it automatically captures the user's attention (Itti and Koch 2001; Jarvenpaa 1990; Lurie and Mason 2007). Beyond that, the search costs typically involved in collecting nutritional information from back-of-package declarations and in comparing products to a plethora of available substitutes hinders healthy food choices (Kiesel and Villas-Boas 2013). Given the complexity and efforts typically associated with comparing multiple product offerings in a product assortment, IS that support consumers in the nutrition-related purchases should facilitate the process of identifying relevant information on nutritional quality. Being able to easily and correctly identify the nutritional quality, increases the informedness of consumers regarding the available products, which can lead to better-founded product choices, as research in IS has shown (Clemons 2008; Granados et al. 2010; Han and Kim 2019; Li et al. 2014).

IS in food labeling

As effective food labels remain unmandated in most regions of the world, IS systems have been proposed in supporting food choices, but still lack adoption due to high manual effort involved (Dunford et al. 2014; Julia and Hercberg 2017; König et al. 2018). As FoPLs are salient and easy to understand, they are a promising approach to increase the nutritional quality of individual's food choices. First, they capture the decision-maker's attention (Becker et al. 2016; Bialkova and Trijp 2010; Peschel et al. 2019). Second, food labels aggregate complex nutritional composition declarations into color-coded labels in a comprehensible and easy-to-interpret way (Ikonen et al. 2020; Muller and Prevost 2016), thereby reducing search costs (Julia and Hercberg 2017; Kiesel and Villas-Boas 2013). Today, there is growing consensus that, compared to several other FoPL (Egnell et al. 2019; Egnell et al. 2018), the Nutri-Score label leads to a higher nutritional quality of food choices (Ducrot et al. 2016; Finkelstein et al. 2019) and is understood more easily by consumers (Egnell et al. 2019; Egnell et al. 2018). In addition, the Nutri-Score was found to reflect the nutritional quality of food products accurately (Julia et al. 2015; Julia and Hercberg 2017; Szabo De Edelenyi et al. 2019), and has potential for reducing the risk for non-communicable chronic diseases (Egnell et al. 2019). Despite such promising effects, most countries and retailers have still not decided to introduce food labels such as the Nutri-Score (Ni Mhurchu et al. 2018). Hence, IS such as mobile applications (Dunford et al. 2014; Ni Mhurchu et al. 2017) were proposed, as they enable users to scan food products and see their respective food labels displayed on the screen. However, probably due to the high effort involved in having to scan a large number of food items, previous studies on purchase-related food labels IS did not succeed in finding significant effects on the healthiness of the food products bought (Ni Mhurchu et al. 2017). Hence, there is a need for research that determines whether digital food labels could be an effective measure to alter consumers' food choices in online grocery shopping environments, where IS can display digital food labels without requiring active input or efforts on the user's side. Furthermore, automatically-triggered digital food labels have the potential to receive attention from food-illiterate users, a vulnerable socio-demographic segment that is especially exposed to diet-related diseases. As such users usually have little interest in nutrition, they tend to not use diet-related IS that require active user input (König et al. 2018). First randomized controlled trials (RCT) by Ducrot et al. (2016) and Finkelstein et al. (2019) using hypothetical online supermarkets already led to promising results. However, these studies used a restricted assortment of food products in a fabricated online supermarket with limited external validity. Finally, current research on IS for supporting food choices has yet failed to demonstrate the technical feasibility of non-invasive, passively triggered, scalable solutions that allow for just-in-time interventions and that are ready for mass adoption by consumers.

To answer these questions, we developed an approach that leverages food composition databases inside a Web browser extension. In an RCT, we assess whether an easy-to-install browser-based extension that displays digitally food labels in the form of Nutri-Score can help consumers to increase the healthiness of their shopping baskets. In the light of the ongoing political debate on Nutri-Score, the increasing popularity of online grocery shopping, and the goal of many consumers to buy healthier products, our study addresses a timely topic. It contributes to research on IS in food labelling by exploring a novel path towards urgently needed IS that support consumers at the point of their purchase decisions. Beyond that, our research provides empirical evidence for the role that IS-mediated tools can play in mitigating the ongoing obesity pandemic.

Methodology

Instrumentation

To prepare for our assessment of the impact of digital food labels on actual food choices, we designed and implemented a Web browser extension [blinded for review] that can mediate shoppers' interactions with the website of a popular Swiss grocery chain. During the shopping process, the extension enriches individual product pages as well as product overview pages from the retailer's e-Commerce system (at **1** in Figure 2) with the appropriate Nutri-Score label with the respective pages (at **2**) by obtaining products' Global Trade Item Numbers (GTINs) and resolving them to nutritional information through an FCDB (at **3**). We further adjusted product pages by removing promotions, customer ratings, guideline daily amount labels, and links to other websites. Beyond these adjustments, the Web browser extension does not affect individuals' shopping experience other than the fact that users of our system are exposed to enriched versions of product pages and product overviews as they navigate through the underlying e-commerce system. With respect to enabling the usage of this application within user studies, the system furthermore contains mechanisms to create user IDs, assign users to control and treatment groups, track users' shopping process, and to display introductory and post-study information and questionnaires. The collected data from interactions with users is persisted (at **4** in Figure 2).

User study

The user study was conducted in two on-campus, computer-equipped behavioral laboratories at Universities in Switzerland and Germany. In both labs, our Nutri-Score browser extension was pre-installed on all workstations. We recruited 135 participants who received financial compensation of 20 CHF or 10 EUR, depending on the lab location, as an incentive for completing the experiment (shopping task and subsequent questionnaire) that lasted one hour. To achieve incentive-compatibility and induce participants' truth-telling regarding their actual product preferences, they entered a lottery for winning the products they chose during the task. After giving consent and completing a demographic questionnaire, we asked participants to do their weekly grocery shopping in an online supermarket with a predefined, fixed budget (55 EUR in Germany and 100 CHF in Switzerland; values adjusted for the difference in purchasing power). To minimize misunderstandings, the task description was read out aloud before the study began and could also be displayed

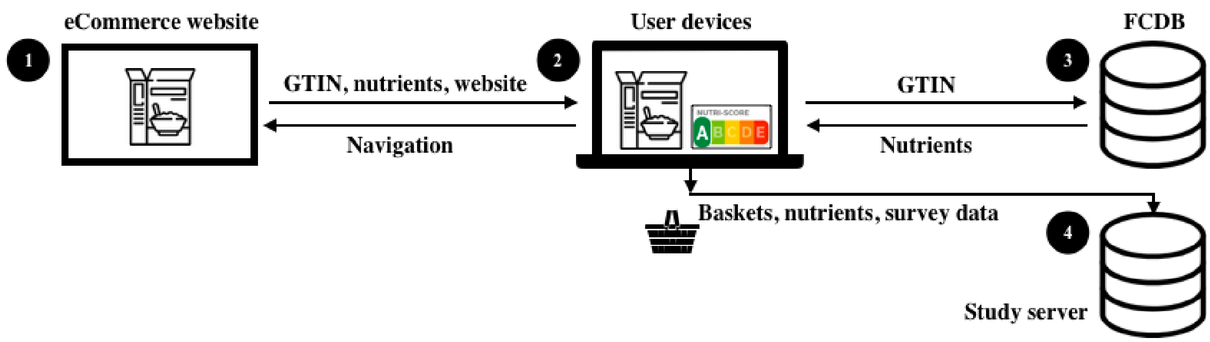

Figure 2. Nutri-Score IS: Architecture and information flow

during the shopping phase. Next, participants received instructions on how to use their virtual shopping cart for adding and removing products, and about the pieces of information displayed in the detailed view of a product. For the treatment group, the Nutri-Score was briefly and unobtrusively described among other elements.

Participants then started to shop in the online store of a large Swiss retail company. The assortment of food products was not restricted and contained well over ten thousand products. For the German sample, the online supermarket showed prices converted to Euro. The conversion factor comprised the currency exchange rate and a product category-specific factor adjusting for the different price levels in the two countries. There was no time limit set for the shopping task. Once participants submitted their shopping basket, they were redirected to a post-task online questionnaire that assessed specific dietary restrictions of the participants and multiple aspects regarding trust toward the retailer, self-reported food literacy, and the participant's approval of the Nutri-Score.

To evaluate the impact of the Nutri-Score on participants' product choices and shopping experience, we manipulated whether products in the online supermarket were labeled with their corresponding Nutri-Score or not. In the treatment group (TG), Nutri-Scores were visible on all products, as would be the case for a mandatory introduction of the Nutri-Score. More precisely, Nutri-Scores were displayed in the treatment group both in the category overviews (see Figure 3) and in the individual product views (see Figure 4). By contrast, no Nutri-Scores were displayed in the Control Group (CG) (see Figure 5).

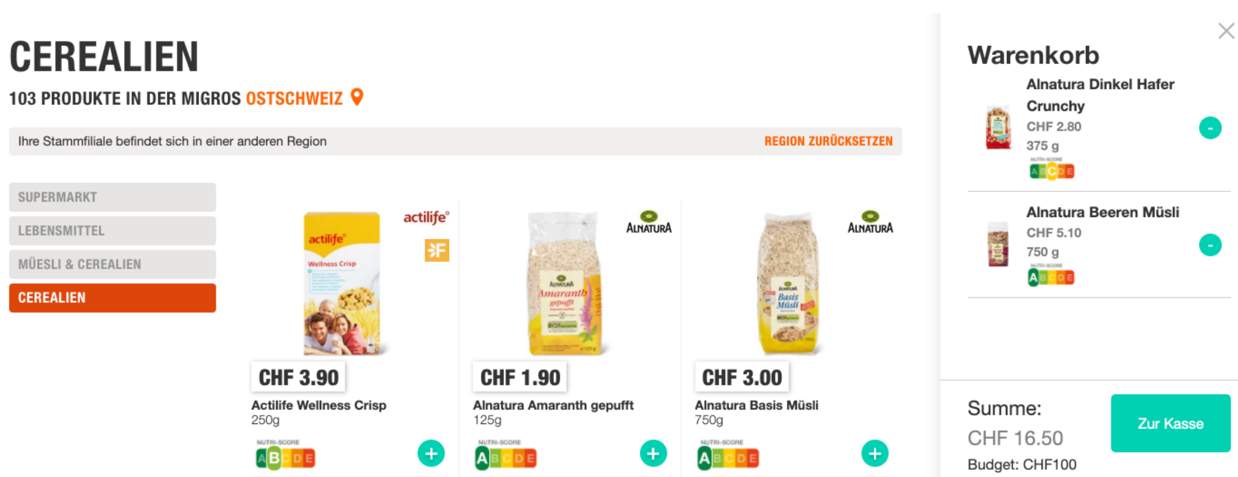

Figure 3. User study: Treatment group view on a category in online grocery shopping website

Participants were assigned to the experimental conditions using randomization, aiming for a similar distributions of gender, age, food literacy and income level across the treatment and control groups. Based

Figure 4. User study: Information available for treatment group on specific product view in online grocery shopping website (information composed and descriptions added)

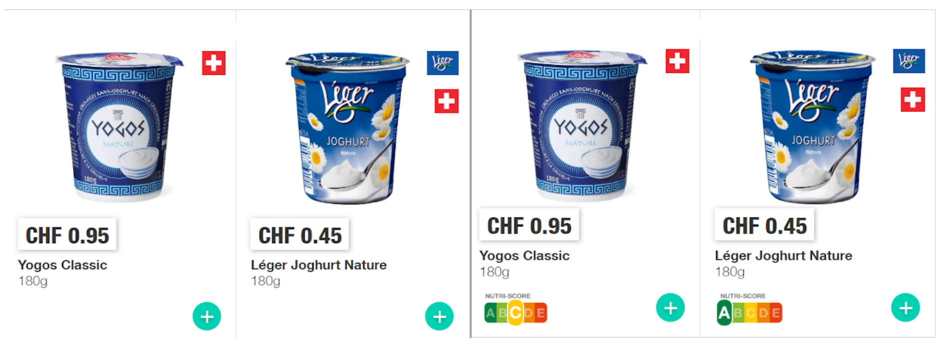

Figure 5. Comparison of two products as seen by the control group (on the left) and treatment group (on the right)

on prior research, we expected participants in the labeling condition to choose healthier food products than participants in the control condition. Further, we hypothesized that participants with low food literacy in the treatment group would choose healthier food products than those with low food literacy in the control group. Finally, our last hypothesis was that those users in the treatment group who consciously perceive the Nutri-Score during their shopping choose particularly healthier food products than participants in the control group. The study protocol was approved by our universities' ethics commissions [blinded for review] .

Dependent variables

To assess whether labeling food products with their Nutri-Score leads to healthier immediate product choices, multiple dependent variables were analyzed. In particular, the proportion of healthy food products (i.e. products labeled with a Nutri-Score of A or B) and unhealthy food products (i.e. products labeled with a Nutri-Score of D or E) in the shopping baskets based on weight, the average Nutri-Score of the shopping basket adjusted for weight, and the Healthy Trolley Index (HETI; Taylor et al. 2015) of the shopping basket based on weight were compared between the experimental groups and the control group. Further, we evalu-

Sample	**Total (N=126)**		**Switzerland (N=53)**		**Germany (N=73)**	
	CG (N=67)	TG (N=59)	CG_{CH} (N=29)	TG_{CH} (N=24)	CG_{DE} (N=38)	TG_{DE} (N=35)
Age [yrs]	23.42 ± 3.31	23.34 ± 3.41	23.24 ± 3.45	22.63 ± 2.69	23.55 ± 3.23	23.83 ± 3.86
Female (%)	33 (49.25)	36 (61.02)	10 (34.48)	10 (41.47)	23 (60.53)	26 (74.29)
Male (%)	34 (50.75)	23 (38.98)	19 (65.52)	14 (58.53)	15 (39.47)	9 (25.71)
Sec. school[1] (%)	40 (59.70)	33 (55.93)	17 (58.62)	12 (50)	23 (60.53)	21 (60)
Tert. school (%)	27 (40.30)	26 (44.07)	12 (41.38)	12 (50)	15 (39.47)	14 (40)
Income[2]	1‘543 ± 1’137	1‘687 ± 1’303	1’700 ± 1442	1‘738 ± 1‘444	1’440± 876	1’657 ± 1‘226
Food Literacy[3]	35.29 ± 6.66	35.90 ± 7.12	33.54 ± 6.79	35.22 ± 8.53	36.66± 6.22	36.37± 5.93

Mean values with SD, relative frequencies in parentheses
[1]Secondary school completed, [2]total in Germany in EUR (1 EUR = 1.05 CHF), [3]SFLQ

Table 1. Demographic summary of participants

ated which elements of the product information the participants had actually perceived during the shopping process and elicited their opinion towards the online supermarket based on the (Retailer trust scale by Chen and Dibb 2010, extended by two items: ”The online supermarket offers a healthy assortment” and ”The online supermarket is transparent”). Moreover, we assessed to what extent they approved the introduction of the Nutri-Score label by different agents (i.e. manufacturers, nutrition experts, retailers, politicians). These items were implemented as multiple-choice questions, using 5- or 7-point Likert scales. In the treatment group, we further elicited the emotional reaction to displaying the Nutri-Score using a 7-point Kunin scale (Kunin 1955); in both groups, we collected perceived or anticipated intrusiveness and trustworthiness of the Nutri-Score label.

Participants

We recruited 135 participants who took part in the study in one of 12 sessions. Our sample consisted of university students who were invited to participate in the study through emails sent from the behavioral laboratories to their database of registered interested students. Due to incomplete data, implausible overall duration of the experiment, and technical difficulties, the data of nine participants had to be excluded. The final sample consisted of 126 participants. Table 1 provides an overview of demographic data of the participants.

Results

Randomization check

The treatment and the control group did not differ significantly regarding gender distribution ($\chi^2(1) = 1.07$, $p = .301$), age ($t(124) = 0.13$, $p = .895$), education level ($p = .700$) or income level ($p = 1$). There were further no differences regarding the distribution of specific diets across the two groups, except for a high protein diet that was more prevalent in the treatment group compared to the control group ($n = 22$ vs. $n = 12$; $\chi^2(1) = 5.04$, $p = .025$).

Manipulation check

To check if participants perceived the Nutri-Score and thus our experimental manipulation, the post-task questionnaire asked participants to state which out of 10 product information elements they had perceived during the shopping task, resembling an aided recall task. 71.2% of the TG participants recalled having seen the Nutri-Score element. In the control group, where none of the participants had in fact been exposed to the Nutri-Score, a single participant (falsely) affirmed having seen that element.

Healthiness of food choices

We used t-tests to compare the the treatment and the control group regarding the healthiness of their food choices. Prior research shows that significant differences between groups are in general hard to obtain for RCTs in the food and nutrition context (see for example Hébert et al. 2016; Ni Mhurchu et al. 2017; Zeilstra et al. 2018) due to the large variance in general in food and nutrition data. Therefore, we are using a significance level α of .1 as threshold in evaluating differences between the two groups. As we did not find significant differences in the effects between the Swiss and German sample, we merged the data of the two samples and do not differentiate between the two countries.

The analysis of the participants' shopping baskets, summarized in Table 2, indicates that displaying the Nutri-Score on food products during the shopping process led to healthier shopping behavior: The mean HETI in the treatment group is significantly higher than in the control group (p=.068). For the three other indicators, average Nutri-Score and proportion of healthy and unhealthy food products, the results point in the same direction, but did not reach statistical significance. We further analyzed whether the two groups differ regarding the mean nutritional characteristics of the purchased food items per 100g. The results are summarized in Table 3. For saturated fat, sugar, and unhealthy sugar, the treatment group showed a significant reduction compared to the control group, which is associated with healthier food product choices. For all other nutrients, the treatment effects point in the same direction but are not significant. Overall, these results are in line with our first hypothesis.

To assess the effect of our Nutri-Score instrumentation on individuals with low food literacy, we compared the shopping baskets of participants whose subjective food literacy score was in the lowest third (first tertile) in the treatment and the control group. The general results in Table 2 do not indicate a significant effect of the Nutri-Score IS on the food choices among that subgroup. However, a more detailed analysis of the purchased products' nutritional characteristics in Table 3 reveals that the mean amount of sugar and unhealthy sugar was significantly lower in the TG shopping baskets, compared to the CG. For all other nutrients, the treatment effect was non-significant, but points in the same direction. Generally, these results are in line with our second hypothesis, supporting it merely on a descriptive level, however.

With regard to our third hypothesis, we tested the effects of our Nutri-Score IS on the healthiness of product choices for participants in the treatment group who stated that they had perceived the Nutri-Score label during the shopping process. Compared to participants in the control group, these participants chose a significantly higher proportion of healthy food, a significantly lower proportion of unhealthy food, and had a marginally significant higher HETI. The difference in the average Nutri-Score was not significant, but points in the same direction. The more detailed analysis of the purchased products' nutritional characteristics in Table 3 shows that participants who stated that they saw the Nutri-Score bought products with a significantly lower amount of saturated fat compared to the control group. For all other nutrients, there was no significant difference between both groups. These results are in line with our third hypothesis.

Effects on user perception

To gain a deeper understanding of the effects of displaying Nutri-Score labels on the participants' perception of the Nutri-Score and the online supermarket, we analyzed whether the treatment and the control group differed regarding the dependent variables assessed in the post-experimental questionnaire. We did not find significant differences between the two groups in the rating of their overall shopping experience ($t(124) = -0.24$, $p = .813$). Regarding the retailer trust scale adapted from (Chen and Dibb 2010), extended by two items (overall Cronbach's $\alpha = .72$), the two groups did also not differ significantly ($t(124) = -0.31$, $p = .758$). No significant difference between both groups was further found for the assessment of the Nutri-Score as being intrusive ($t(124) = -0.40$, $p = .687$) or trustworthy ($t(124) = -0.14$, $p = .890$).

To investigate our fourth research question, we analyzed the treatment group's responses on the 7-point Kunin scale (Kunin 1955) assessing the emotional response that displaying the Nutri-Score triggered. The analysis reveals that the emotional response was slightly positive ($M = 4.90$, $SD = 1.00$), and differed significantly from the neutral response of 4 ($t(58) = 6.94$, $p < .001$). Regarding the implementation of Nutri-Score by food producers, support in the treatment group ($M = 4.86$, $SD = 1.69$) was marginally

All users	**CG (N=67)**	**TG (N=59)**	*p*
Purchased food quantity (g)[1]	16'299±4'742	15'762±742	
Average Nutri-Score[1,5]	3.673±0.466	**3.749**±0.301	.33
Healthy food[2,3]	77.1±12.9	**80.4**±12.1	.15
Unhealthy food[2,3]	12.5±10.2	**10.495**±9.873	.26
HETI[4]	54.92±13.1	**59.3**±13.4	.068 *
Low food literacy users	**CG_{LFL} (N=27)**	**TG_{LFL} (N=21)**	*p*
Purchased food quantity (g)[1]	15'636±620	16'232±5'820	
Average Nutri-Score[1,5]	3.528±0.692	**3.704**±0.526	.75
Healthy food[2,3]	76.6±12.6	**77.8**±13.7	.75
Unhealthy food[2,3]	14.4±9.7	**12.7**±10.7	.57
HETI[4]	53.6±13.5	**59.5**±15.8	.19
Conscious perception	**$CG_{\text{not-perceived}}$ (N=66)**	**$TG_{\text{perceived}}$ (N=42)**	*p*
Purchased food quantity (g)[1]	16'329±6'513	16'326±4'765	
Average Nutri-Score[1,5]	3.636±0.472	**3.769**±0.372	.76
Healthy food[2,3]	77.1±13.1	**81.5**±11.7	.077*
Unhealthy food[2,3]	12.6±10.3	**9.4**±9.0	.094*
HETI[4]	54.9±13.2	**59.1**±12.8	.11

[1]mean + SD, [2]% ± SD, , * significant at $\alpha = .1$
[3]share of weight of (un-)healthy food items with Nutri-Score A or B (D or E) among all food in total basket
[4]Healthy trolley index (HETI), by weight, food only, scale from 0 (unhealthy) to 100 (healthy)
[5]Nutri-Score averaged by product weights, scale 0.5 (E) to 4.5 (A)
bold marks healthier values in direct comparison of group G_1 and G_2, if: $|n_{G_1} - n_{G_2}| / |n_{G_1}| \geq 2\%$.

Table 2. Results of shopping basket analysis for control (CG) and treatment group (TG)

significantly higher ($t(124) = -1.82$, $p = .071$) compared to the control group ($M = 4.28$, $SD = 1.87$). For an introduction by other groups of stakeholders, the differences were non-significant (politicians: $t(124) = -1.01$, $p = .314$; independent nutrition experts: $t(124) = 0.04$, $p = .967$; retailers: $t(124) = -1.46$, $p = .147$. Averaging the approval scores of the multiple agents to a general approval score (CG: $M = 4.41$, $SD = 1.70$; TG: $M = 4.92$, $SD = 1.55$) revealed a marginally significant higher general approval of a Nutri-Score implementation by the treatment group ($t(124) = -1.76$, $p = .081$) compared to the control group. These results suggest that displaying the Nutri-Score via the Nutri-Score IS does not lead to negative emotional responses or resistance towards its introduction.

Discussion

Summary

In this study, we proposed a Web-based information system (IS) in the form of a browser extension that can be installed on end users' client devices to automatically display digital food labels in the form of food items' Nutri-Scores during online grocery shopping in order to increase salience and reduce search costs for making healthy food choices. To assess how this IS can affect actual grocery shopping behavior, we conducted a user study with 135 participants. We divided our participants into control (CG) and treatment (TG) groups and proposed a set of dependent variables including the proportion of healthy food products, the proportion of unhealthy food products, the average Nutri-Score of the shopping basket and the Healthy Trolley Index (HETI) to compare the participants' shopping decisions in terms of nutritional quality.

First, we assessed the overall impact of the intervention by comparing the selected food items purchased by the control and treatment group respectively (RQ1). The data analysis shows that on average, the treat-

All users	**CG (N=67)**	**TG (N=59)**	*p*
Energy[2]	623.553±91.944	637.383±76.093	.38
Saturated fat[1]	1.874±0.237	**1.799**±0.227	.070 *
Sugar[1]	6.162±0.774	**6.022**±0.7245	.100 *
Unhealthy sugar[1,3]	3.843±0.788	**3.521**±0.714	.100 *
Protein[1]	5.138±0.814	**5.493**±0.660	.78
Dietary fiber[1]	1.842±0.262	**2.124**±0.259	.47
Sodium[1]	0.393±0.245	**0.317**±0.124	.34
Low food literacy users	**CG_{LFL} (N=27)**	**TG_{LFL} (N=21)**	*p*
Energy[2]	637.812±131.629	623.211±124.895	.37
Saturated fat[1]	2.091±0.424	**1.976**±0.382	.23
Sugar[1]	7.052±1.429	**6.310**±1.280	.097 *
Unhealthy sugar[1,3]	4.738±1.506	**3.707**±1.240	.072 *
Protein[1]	5.168±1.275	**5.192**±1.021	.55
Dietary fiber[1]	1.818±0.381	**1.957**±0.402	.96
Sodium[1]	0.307±0.143	**0.256**±0.172	.41
Conscious perception	**$CG_{not\text{-}perceived}$ (N=66)**	**$TG_{perceived}$ (N=42)**	*p*
Energy[2]	622.299±92.924	628.532±92.298	.59
Saturated fat[1]	1.884±0.239	**1.712**±0.262	.055*
Sugar[1]	6.165±0.77	**5.853**±0.862	.16
Unhealthy sugar[1,3]	3.863±0.795	**3.439**±0.857	.18
Protein[1]	5.140±0.822	**5.400**±0.800	.95
Dietary fiber[1]	1.832±0.264	**2.108**±0.318	.31
Sodium[1]	0.386±0.263	**0.293**±0.139	.28

[1]mean + SD (in g), per 100g of purchased food, [2]mean + SD (in KJ), per 100g of purchased food
[3] all sugar except fruits and vegetables, * significant at $\alpha = .1$
bold marks healthier values in direct comparison of group G_1 and G_2, if: $|n_{G_1} - n_{G_2}| / |n_{G_1}| \geq 2\%$.

Table 3. Detailed analysis of average nutrients per 100g in shopping baskets in control (CG) and treatment group (TG)

ment group that was exposed to the digital Nutri-Score food label purchased healthier shopping baskets, as indicated by the significantly higher mean HETI (Table 2) and significantly lower quantities of saturated fat, sugar and unhealthy sugar (sugar quantities in purchased food items except for fruit and vegetables) (Table 3). Meanwhile, there exist further promising, albeit non-significant tendencies that suggest healthier food choices in the treatment group, such as a higher share of healthy products (Nutri-Score A and B) and a lower share of unhealthy products (Nutri-Score D and E). In addition, also in terms of dietary fiber, protein and sodium, the products selected by the treatment group feature healthier nutritional compositions than in the control group. We also conducted an exploratory analysis of selected health-relevant food categories to explain which food groups contributed to the improvement in nutritional quality of the purchased items. On a weighted average, participants in the treatment group chose over 11% more fruits (14.6% in CG, 16.3% in TG), over 11% more vegetables (17.3% in CG, 19.3% in TG), over 24% more salad (1.9% in CG, 2.4% in TG), over 22% less processed meat (1.1% in CG, 0.8% in TG), over 16% less chocolate and almost 27% less convenience food (1.4% in CG, 1.1% in TG). Counter-intuitively, members of the treatment group purchased over 22% more sweets (3.0% in CG, 3.7% in TG), which also include chocolates that were purchased less frequently by them. We hence assessed the purchased sweets which also includes cookies, cakes, desserts, puddings, cereal bars, ice-cream in detail, to shed light on what kind of products were purchased more by viewers of the digital Nutri-Score. We found that the differences in the composition of the sweets were similar in terms of sugar (42.0g per 100g in CG, 40.0g 100g in TG) and saturated fat (10.6g in

CG, 12.0g in TG, per 100g). This is particularly interesting, as the uptake in sweets was significantly higher among consumers with high food literacy (CG_{HFL}: 1.4±1.7, TG_{HFL}: 5.1±6.6, % of food items,p = 0.024), as compared to their low-literate counterparts (CG_{LFL}: 3.9±5.1, TG_{LFL}: 3.1±3.6, % of food items). Given the exploratory nature of the assessment of the food categories, we suggest to conduct further research to assess potential self-licensing behavior when digital Nutri-Score labels are displayed. Still, given the significant improvements in the healthiness of the overall distribution of food items baskets, we conclude that the display of the product-specific Nutri-Scores in the e-commerce environment during the shopping process leads to immediate healthier shopping decisions.

Second, we assessed the impact of digital food labels on the shopping behavior of consumers with low food literacy as they represent an at-risk population for diet-related diseases (RQ2). Low food literacy users in the treatment group selected food items that feature significantly lower amounts of sugar and unhealthy sugar (Table 3). In addition, albeit not statistically significant, they have made healthier food choices with regard to all other measures that we have proposed, such as HETI and the share of healthy and unhealthy food items. Also in terms of the other nutrients, namely saturated fat, protein, dietary fiber and sodium, consumers with low food literacy made healthier food choices than their counterparts in the control group in our study. In conclusion, even though our study shows significant differences in sugar and unhealthy sugar, the overall shopping basket effects (HETI, healthy food, average NS) are not significant. To assess whether consumers with low food literacy make healthier food choices when using our Nutri-Score IS, we require studies with larger numbers of participants.

Third, we assessed the effect of conscious perception of the Nutri-Score during the shopping journey (RQ3). Conscious perception of digital food labels should amplify the effects of such an intervention, as the desired increase in salience and reduction in search costs for healthy food choices is only possible if a consumer actually acknowledges the digital food label. To assess the importance of conscious perception, we hence compared the shopping behavior of consumers who stated in the post-hoc survey that they have consciously perceived the digital food label in the treatment group with users who have not perceived the Nutri-Score in the control group, respectively. Due to the non-invasive design of the empirical study, N=17 users (ca. 29%) responded not to have consciously perceived the Nutri-Score during the shopping task. Surprisingly, also one user within the control group mentioned that he has seen the Nutri-Score, which was technically not possible, but hence was excluded from this analysis. Again, users in the treatment group make healthier food choices, as they purchase significantly higher shares of healthy (Nutri-Score A and B, % of food items) and significantly smaller quantities of unhealthy food items (Nutri-Score D and E, % of food items), and since their baskets have a marginally (non-)significantly healthier HETI score (Table 2). Also in terms of nutrients, significant improvements (i.e. saturated fat), as well as descriptive improvements (i.e. sugar, unhealthy sugar, protein, dietary fiber, sodium) were observed among the users who perceived the Nutri-Score consciously. We conclude that the display of product-specific Nutri-Scores has a significant health-beneficial impact on food choices of individuals who consciously perceive the Nutri-Score label during shopping in an online store. When comparing members of the treatment group, users who consciously perceived the Nutri-Score labels ($TG_{perceived}$: N=42) purchased significantly healthier weight-averaged Nutri-Scores (p=0.035) as users in the treatment group who did not actively perceive the label ($TG_{not-perceived}$: N=17). The other nutrients and indicators (HETI, share of healthy and unhealthy products) suggest that both groups, i.e. $TG_{perceived}$ and $TG_{not-perceived}$ made similarly healthy purchase decisions. More research is needed to understand its impact among members in the treatment group better, as also users who did not consciously perceive the Nutri-Score shopped healthily. Hence, the conscious perception of the label does not seem to correlate with negative effects. As the Nutri-Score is still a relatively new concept, users might not be fully aware of its purpose yet, which might explain them not consciously noticing the digital label. We suggest that users of such an intervention should receive an introductory tutorial on the purpose of the digital Nutri-Score label to ensure it is well-understood.

Finally, we assessed the participants' perception of the Nutri-Score and of their shopping experience. Members of our control and treatment groups did not differ in their overall ratings of the online shopping experience, nor of the Nutri-Score's intrusiveness or trustworthiness. In addition, the digital food label was perceived as slightly positive by the treatment group, with their rating being significantly different from neutral. Hence, we conclude that the introduction of such Web-based information systems, for example by food producers as suggested by the treatment group members, can be expected not to lead to negative emotional reactions or resistance. When asked about a future mandatory introduction of the Nutri-Score label, users in the treatment group were more favorable to its introduction than their counterparts in the control group. Hence, to facilitate the ongoing political debate and process of the Nutri-Score introduction (e.g. current Nutri-Score petition in Europe), information systems such as the proposed browser extension can be a helpful tool for citizens and political decision-makers to understand the potential of the label prior to its introduction.

Contribution

This study contributes to research on IS, as this empirical field study confirms the health-beneficial impact of the IS on food choices. More specifically, our findings suggest that members of the treatment group who were exposed to the IS-mediated digital food label made healthier purchase decisions suggests that Nutri-Score labels indeed increase users' attention to the healthiness of food when selecting products. Second, our findings show that Web-based IS which enrich online grocery stores with Nutri-Score labels are a promising approach to improving shoppers' food choices. This is especially promising, as such IS does not rely on active user input, but can display relevant just-in-time interventions during the online grocery shopping journey automatically. Besides contributing to the literature, this study has also important implications for practice. First, providers of online grocery websites and food producers need to understand that such IS can be installed by consumers themselves on their own deceives with little possibility of intervention: as healthy food choices are a goal that most consumers aspire to follow, there exists the possibility to a mass-adoption of such IS in the future, even if distributors and producers do not agree. Thereby such IS could induce a shift in consumer behavior towards healthier food choices with consequential negative commercial implications for producers of primarily unhealthy food items. This also includes the potential adoption of Nutri-Score by consumers in regions where food labels such as Nutri-Score have not (yet) been mandated by regulators, potentially due to resistance from industry or regulators. Further, health-care professionals such as physicians and dietitians could recommend such IS to their patients. As the Nutri-Score IS is triggered automatically during making purchase decisions in online grocery shopping, the systems does not require active user input such as permanent logging of diets. Since manual diet-logging applications are often discontinued by a majority of users, automatic IS-based interventions such as our Nutri-Score IS thus offer a promising complementary approach to current dietary mobile health applications.

Limitations

Certain limitations exist in regard to the conduction of this empirical field study. First, the number of participants ought to be increased to further confirm the promising potential of digital food labels in online grocery shopping. Also, as the participants were university students, their shopping behavior and reaction to the digital food labels might not be representative of the entire population. Second, the research was performed in a laboratory setting with clear shopping guides as well as environmental controls, and while excluding incentives such as discounts. Therefore, it is difficult to precisely simulate participants' daily shopping behaviour in the real world, where such distractions might moderate the impact of digital food labels. Third, our extension is designed only to track participants' shopping behavior during a single session, while improvements in dietary behavior usually require long-term interventions and monitoring of food choices. Such long-term shopping assessments across multiple purchasing sessions could be supported in a future version of the browser-based extension. Last, while the average protein values in the treatment group are higher compared to the control group, the post-experimental questionnaire shows a prevalence of higher daily protein intakes within the treatment group compared with the control group. Thus, it is not clear that the increase of protein intake was caused by the display of Nutri-Score labels.

Future work

Information systems that support transparency for individual consumers and thereby allow for a reduction of search costs for healthy food choices in online grocery shopping have a lot of potential for future research. First, our initial prototype and this study point to the possibility of integrating digital food labels on online grocery stores world-wide. Second, the personalization of digital food labels in terms of food allergies, recommended target energy intake, and diet-related diseases could deliver tailored, potentially just-in-time adaptive recommendations rather than generic interventions. Another avenue for research is the potential long-term effects of widely accessible IS that improve transparency on online grocery stores on product reformulations. There exists consistent evidence that mandatory or widely adopted food labels can have an additional, indirect positive effect of food suppliers improving the nutritional composition of food products through recipe reformulation (Ni Mhurchu et al. 2017). The adoption of such IS could therefore yield additional improvements in the nutrient profile of food products on the market, especially as they can be adopted by consumers even in absence of corresponding food label regulation. Finally, such scalable, passively triggered information systems also allow for other interventions beyond dietary health behavior interventions: for instance, sustainability-related digital food labels could bring transparency towards the impact of an individual consumer's food choices onto climate change. Finally, the potential effect of self-licensing, especially among users with high levels of food literacy, requires further investigation.

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