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Effects of digital Just-In-Time nudges on healthy food choice – A field experiment

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ABSTRACT

Novel digital applications enable intervening in health behavior at moments hitherto impossible. Handheld self-scanning solutions in supermarkets allow providing nudges immediately in response to the product choice. While a nudge presented at this moment, in the optimal state of vulnerability/opportunity and receptivity, may serve as a cue to action and trigger healthier choices, post-choice biases instead predict that changing decisions is challenging. We investigated whether visibility nudges (product suggestions) and descriptive and evaluative nutritional labeling nudges provided immediately in response to choice can stimulate healthier food choices. Experimental manipulations were integrated in the self-scanning function of a smartphone application that allowed scanning and purchasing products in the physical supermarket. We compared: 1) a control version without adaptations, 2) a visibility nudge version in which after scanning an unhealthy product a pop-up with a healthier alternative appeared, 3) a version similar to version 2 but with additionally a descriptive nutritional label nudge denoting the healthiness of the alternative, and 4) a version similar to version 2 but with additionally an evaluative nutritional label nudge denoting the healthiness of the alternative. Sales data were collected during a 5-week period. The percentage of healthier products purchased was significantly higher for the visibility nudge version in which the healthier alternative was suggested without any additional nudge (37.7% healthier) compared to the control condition (29.9%), and the versions with an additional descriptive (30.0%) or evaluative nutritional label nudge (28.2%). The findings imply that saliently suggesting a healthier alternative stimulates healthier purchasing behavior but that an additional nudge emphasizing health may cancel this effect out.

1. Introduction

A substantial proportion of the daily food intake of people living in Western countries can be regarded as unhealthy, as based on the definitions of healthy food of National Health Councils (e.g., Kromhout et al., 2016). For instance, in the Netherlands, approximately one third of the total daily food intake is from products not in line with the guidelines of the Dutch Nutrition Center (Schuurman et al., 2020), namely from products that are too high in energy and have a poor nutritional value (e.g., high in salt, sugar, or saturated fat)[2]. This is problematic, as unhealthy eating is one of the risk factors for chronic diseases like Diabetes Type 2 and some forms of cancer (Jayedi et al., 2020), which all have associated healthcare costs (Schlueter et al., 2020). In the past decade, nudge strategies for promoting healthier food choice have gained traction. Nudges are defined as “any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives” (Thaler & Sunstein, 2009). Several studies have shown the potential of nudges for healthier eating in the lab and in the field (Cadario & Chandon, 2020; Wilson et al., 2016), although effect sizes appear to be larger for restaurants/cafeterias settings than for supermarkets. The effects of nudging on food choice have been attributed to the notion that most of our daily (food) decisions are made in system 1 reasoning. System 1 “operates automatically and quickly, with little or no effort and no sense of voluntary control” (Kahneman, 2013) and it has been proposed that nudges exploit the biases and heuristics of this ‘fast’ system 1 (Gigerenzer, 2015; Kahneman, 2003). Here, we focus on a novel delivery approach for nudges, namely the just-in-time (JIT) nudge, and we assess its effect on healthier food choices in the supermarket.

The JIT nudge relies on the same assets of novel technologies as just-

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[2] Please note that the definition of what constitutes a healthy product or healthy diet is part of an ongoing debate

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in-time-adaptive-interventions (i.e., JITAI), which are defined as "interventions that adapt over time to an individual's changing status and circumstances with the goal to address the individual's need for support, whenever this need arises" (Goldstein et al., 2017; Nahum-Shani et al., 2015). Advancements in (smartphone) technology facilitate in-the-moment monitoring of health behavior and the predictors hereof (e.g., mood, attitudes) and the provision of interventions anywhere the user goes. A key concept that distinguishes JITAI from standard interventions is that they are provided just-in-time, by for instance providing health information via push messages on the mobile phone at the exact time of need (Nahum-Shani et al., 2015). There is a wealth of research dedicated to the effectiveness and the factors influencing engagement in JITAIs interventions and other smartphone-based interventions/apps for promoting healthier eating (Flaherty et al., 2018, 2019; Wang & Miller, 2020). However, to our knowledge, no earlier study has explored the potential of novel digital technologies for timely interventions in the supermarket yet.

Traditionally, nudges are placed at the physical point of purchase (POP), that is, in the supermarket decision-making context. For instance, previous studies on POP-nudges placed posters at the entrance of the supermarket, placed labels at the shelves, or made other adaptations to the physical in-store environment (Cadario & Chandon, 2020; Chandon et al., 2009; Hoefkens et al., 2011; Ogawa et al., 2011). This means that nudges are (unobtrusively) present in the choice-context during the complete decision process. A large meta-analysis showed that nudging effects are weaker in supermarkets than in restaurants or cafetarias and this might be caused the huge variety of options and competing influences/nudges which may mitigate nudge effects (Cadario & Chandon, 2020). This may mean that the traditional POP-nudge in the physical supermarket, even though present in the choice context during the choice, may not be attended to because they are not sufficiently visible at the most optimal moment in time.

The developments in mobile technology have led to the introduction of handheld scanners and smartphone self-scanning applications that people use to scan their groceries themselves in the supermarket. Consumers use these devices while they conduct their shopping in the supermarket: they scan the products prior to placing them in the physical basket or shopping cart. Mobile self-scanning techology enables delivering nudges (or other interventions) directly in response to the choice, that is, at the exact time of need. For instance, nudges can be delivered at the moment when someone scans the barcode of an unhealthy product, just-in-time to steer this choice towards a healthier alternative. Being able to intervene at the POP directly in response to the unhealthy food choice holds great potential.

The JITAI literature posits that intervening just-in-time fosters health behavior by targeting individuals in an optimal 'state of vulnerability/opportunity' and an optimal 'state of receptivity' (Nahum-Shani et al., 2015). With the state of vulnerability/opportunity the authors refer to the moment in which a person is most likely to engage in unhealthy behavior and therefore this is also the moment when there is still an opportunity to support the individual in making a healthier choice. By providing nudges on the screen of the self-scanning application, directly in response to the unhealthy choice, they are provided in an optimal state of vulnerability/opportunity since it is still possible to replace the product with a healthier one. With the state of receptivity, the authors refer to the "conditions in which the individual can receive, process and use the support provided" (Nahum-Shani et al., 2015) and the provided support should fit with this condition. As mentioned previously, it is asumed that the choices we make in the supermarket are mostly made under system 1 reasoning. As nudges are theorized to rely mostly on system 1 reasoning, providing nudges as JIT intervention may be an optimal approach.

More support for the potential of interventions that intervene at the POP directly in response to the unhealthy food choice, can be found in classical Health Behavior theories. Several Health behavior theories attribute failing to engage in healthy behavior to the lack of a direct trigger for the health behaviour in the (physical) choice environment. The Health Belief Model identifies 'cues to action' which are described as internal (developing disease-related symptoms) or external cues (e.g., (health) communication) that are necessary to initiate the healthy behavioral choice (Janz & Becker, 1984; Rosenstock, 1974). The Fogg Behaviour Model (Fogg, 2009) posits that the health behavior will occur only if the person is sufficiently motivated and able to perform the health behavior, and if a trigger or prompt for the behavior is present. By presenting the nudge directly in response to the choice digital JIT nudges can serve as such a cue or trigger for action and thereby stimulate healthier food choices. Further, based on findings in the field of self-monitoring and (system-initiated) feedback, providing information in response to choice may make someone aware of their decision, and the (potential) discrepancy between the chosen unhealthy product and someone's intention to eat healthy (Hermsen et al., 2016). This may trigger people to change their initial unhealthy to a healthier choice.

On the other hand, based on endowment theory and post choice biases it may be challenging to change decisions. Post choice biases predict that the act of choosing it increases the value of the product (Sharot et al., 2010). Further, based on endowment effects: people have the tendency to retain the products that they already own (Morewedge & Giblin, 2015). These effects may decrease the likelihood of someone switching to a healthier alternative. To summarize, though most theories would suggest that JIT nudges result in healthier food choices, post-choice and endowment theories suggest that these effects may be limited.

In the current study we investigated the effect of three cognitively-oriented nudge types which have been shown to facilitate healthier choices in previous research (Cadario & Chandon, 2020). The definition of cognitively-oriented nudges is that "they seek to influence what consumers know" (Cadario & Chandon, 2020). Here we assessed their merit if delivered via a JIT approach. More specifically, we investigated the effect of visibility nudges alone and in combination with descriptive and evaluative nutritional labeling nudges, on healthier food choices in the supermarket. To assess the effects of the nudges, the conditions with nudges were compared to a control condition without nudges. Visibility nudges are defined as changes in the decision-making context that inform consumers of the availability of healthier options by increasing their visibility (for instance, placing healthier options at eye-level in the shelf, or by using frames to let healthier products 'stand out') (Blom et al., 2021; Cadario & Chandon, 2020). Visibility nudges were implemented in the current study by presenting a pop-up with a healthier product suggestion on the screen of the self-scanning application in response to scanning an unhealthy food product. We expected that the JIT approach would particularly boost the effectiveness of visibility nudges as the pop-up is presented on the screen at a moment that the consumer is inevitably attending to it. Both descriptive and evaluative nutritional labeling directly provide health or nutrition information. Descriptive nutrition labeling nudges provide nutritional information about the product, for instance about the nutrients in it (e.g., "high in iron" (Cadario & Chandon, 2020)), which in the current study was implemented as a short textual description of the health advantage of the suggestion over the originally scanned product. Evaluative nutrition labeling nudges employ color coding or symbols to help consumers infer the healthiness of the product (e.g., traffic light logos, heart-healthy logos (Cadario & Chandon, 2020)) which in the current study was implemented as a heart-healthy logo displayed next to the suggested alternative product. We investigated the combination between visibility and descriptive or evaluative nutritional labeling because mixed nudge approaches are relatively understudied while in supermarkets there are often multiple nudges simultaneously present at the POP. Findings have suggested that the use of multiple cognitively-oriented nudges may result in slightly larger effect sizes than a single cognitively-oriented nudge (See web appendix C of Cadario & Chandon, 2020).

In sum, the current study aimed to provide an answer to the following research questions: First, can digital JIT-delivered visibility nudges stimulate healthier food choices? And second, does providing an additional descriptive or evaluative nutritional labeling nudge result in a stronger effect on healthier food choice than the visibility nudge alone?

2. Material and methods

2.1. Procedures and participants

In this field study the experimental manipulations were implemented in the 'live' version of an existing mobile application that supermarket customers used to scan and pay their purchased products.

The study had a between-participants design with four conditions to which participants were randomly allocated, namely a *visibility nudge* condition, a *visibility + descriptive nutrition labeling nudge* condition, a *visibility + evaluative nutritional labeling nudge* condition, and a *control* condition in which no nudges were applied.

The dependent variable was the percentage of healthier target products purchased, which was based on the number of times unhealthy and healthier target products sold during the data collection period.

The sales data collection took place between December 1st 2019 and January 6th 2020 (37 days). The data for this experiment were collected anonymously. Sales data were collected from the supermarket application, and for this reason no demographic or other information about the participants of this study is available. However, higher level aggregate data of the users of the mobile application were available. It should be noted that these are aggregated over all users of the mobile application during the data collection period, so not only those using the self-scanning function. Most of the users have a Dutch nationality (96.3%) and the majority were females (58.7%). Supplementary Table 1 presents the total number of app users allocated to each of four conditions.

The study was approved by the Ethical Review Board of the Tilburg School of Humanities & Digital Sciences (Tilburg University) under file number 2019.108. Participants consented by accepting the general policy of the application. In the general policy it was stated that data could be used for research. Participants were not informed about the specific purpose of this study.

2.2. Materials

The experimental manipulations were integrated into the hand scanning function of an existing smartphone supermarket application developed by Nakko BV, which could be used in-store across 45 stores in the west-north of The Netherlands. With the application people could scan and pay their groceries at the checkout in the physical supermarket with their mobile phone. Aside from the self-scanning function that was used for the present experiment, the application also had functions to browse the weekly promotions, to search for products, to order for home delivery, and to find the nearest store locations.

The experimental manipulations outlined below were applied to a subset of the products available in the supermarket. In total, 26[3] unhealthy target products were selected from the top-100 list of most sold products of the supermarket chain. For each unhealthy target product, a 'matched' healthier alternative, was selected as well, resulting in 26 healthier target products. The unhealthy and healthier target products were categorized as such based on the guidelines of the Dutch Nutrition Center, which are derived from the advices from the Dutch Health Council (Kromhout et al., 2016). For this categorization, the recommendations table of the Dutch Nutrition Center (Voedingscentrum, 2016) was used. This table enlists per product category which products are unhealthy, why they are regarded as unhealthy, and which products are healthier alternatives. For example, the table lists white bread as an unhealthy product in the category of 'Bread, grain products and potatoes'. The reported reason why it is regarded as unhealthy is that white bread is low in fibres. The table lists brown and wholemeal bread as healthier alternatives. A few examples of unhealthy target products in the study were white bread, regular cola and full fat yoghurt. Examples of the matched healthier target products were wholemeal bread, sugar-free cola and skimmed yoghurt. A complete list of the target unhealthy and healthier products can be found in Table 1.

To allow easy access of the healthier alternatives for the customer, so they can easily add the healthier target product to their basket, all alternatives were chosen within the same food category as the unhealthy product. In this way, the alternative should have been in arm's reach of

Table 1
List of unhealthy and healthier target products and descriptive nutrition labeling nudgesa,

Unhealthy target product	Healthier target product (alternative)	Descriptive nutrition labeling Nudge
Regular Cola, brand A	Sugar Free Cola, brand A	This alternative contains no sugar
White buns, 12 pieces	Brown pistolets	This alternative contains more fibres
White buns, 6 pieces	Wholemeal bread	This alternative contains more fibres
Ground beef	Poultry	This alternative contains less fat
White buns with Dutch crunch	Wholemeal bread	This alternative contains four times more fibres
Energy Drink with sugar, brand A	Energy drink sugar free, brand A	This alternative contains no sugar
White bread	Wholemeal bread	This alternative contains more fibres
Chocolate bun	A brown or wholemeal bread with nut paste/Fruit skewer./ Fruitspies	This alternative contains less sugar
Cola Regular, brand B	Sugar free Cola, brand B	This alternative contains no sugar
Slices of bacon	Hearty topping for bread	This alternative contains less fat
Cooking fat, solid	Cooking fat, liquid	This alternative contains less saturated fats
Full fat milk, brand A	Skimmed Milk, brand A	This alternative contains less calories and fat
Full fat yoghurt	Skimmed yogurt	This alternative contains less calories and fat
Regular Cola brand C	Sugar free cola, brand C	This alternative contains less sugar and calories.
Italian white bun	Muesli bread	This alternative contains four times more fibers
German white bun	Brown bread	This alternative contains two times more fibers
Creme Fraiche	Low-fat quark	This alternative contains half the amount of fat
Full fat Milk, brand B	Skimmed milk, brand B	This alternative contains half the amount of fat
Chocolate Cookies	A brown bread with nut paste	This alternative is a good source of antioxidants and proteins
French white bun	Wholemeal bread	This alternative contains three times more fibers.
Cheese 48+	Low fat cheese	This alternative contains less fat
Energydrink regular, brand B	Energy drink sugar free, brand B	This alternative contains no sugar
Spelt bread	Wholemeal bread	This alternative contains less calories and two times more fibers.
Energy Drink regular, brand C	Bottled water	This alternative contains no sugar
Full fat milk, brand C	Semi-skimmed milk, brand C	This alternative contains less calories and fat
White baguette	Brown pistolet	This alternative contains two times more fibers

[a]Brand names have been covered and are replaced for brand A, B, C.

[3] Initially, manipulations for one additional 27th unhealthy target product were implemented; however, during data analysis it became apparent that the name of the product had changed. For this reason, data for this product was not included in the analysis.

the customer. During the selection of the target unhealthy and healthier products the prices were taken into account. Though the prices of similar but healthier alternatives were generally higher in most product categories, we selected the healthier alternatives for which this price difference was small. This was done to ensure that the prices of the healthier alternatives were not significantly higher. During the period of data collection, no promotions for target products were introduced.

The experimental manipulations were included in the application by an automatic update of the application. During this update, the customer was randomized to one of the four conditions. In the *control condition* the regular way to use the application was preserved and no manipulation was introduced. The customer scanned the products with the self-scanning function of the app and products were added to the shopping basket in the app. The person could continue scanning desired products and proceed to a checkout to finalise the transaction.

In the *Visibility nudge* condition, a pop-up appeared on the screen after scanning one of the target unhealthy products (see Fig. 1). This pop-up suggested adding an alternative for the scanned unhealthy target product to the basket. The pop-up consisted of an overlay screen with the title "Alternative", to indicate that that the product could be regarded as an alternative to the scanned product. Further, the pop-up presented a picture of the suggested alternative product and its price. The suggested product was the matched target healthier product. Note that no reference to the healthiness of this alternative was made in the *Visibility nudge* condition. The customer could contemplate the choice of the alternative and accept or reject it. Customers could accept the alternative by pushing the button 'Good idea' (in Dutch 'Goed idee'). The text "Good idea" was placed on the button to present going for the alternative as a good idea. When the suggestion was accepted by pushing the 'Good idea'-button, the scanned unhealthy target product was removed from the shopping basket of the app. After that, the user received a next pop-up with the instruction to scan the alternative product and to place the initially scanned product back on the shelf. Next, the scan function started again, and the customer could locate and scan the suggested alternative target healthier product, which than is added to the shopping basket in the app. Customers could reject the alternative target healthier product by pushing the 'X'-button. When the suggested was rejected, the scanned unhealthy target product remained in the shopping basket of the app, the pop-up disappeared from the screen, the scan function started again, and the customer could continue shopping.

The *Visibility + descriptive nutrition labeling nudge* condition was equal to the *Visibility nudge* condition, except that in the first pop-up screen depicting the alternative (i.e., the visibility nudge) an additional field with a descriptive nutritional labeling nudge was present (see Fig. 1). In this descriptive nutrition labeling nudge, a textual justification why this product should be chosen over the initially scanned product was presented. The textual nudge was systematically formulated as "This alternative contains no/more/less sugar/salt/saturated fat.". The nutrient depicted in this textual nudge was derived from the recommendations table of the Dutch Nutrition Center (Voedingscentrum, 2016) which listed for each unhealthy product why it is unhealthy and which product would be a healthier alternative. Table 1 lists the descriptive nutritional labeling nudges that were employed.

The *Visibility + evaluative nutritional labeling nudge* condition is equal to the *Visibility nudge* condition, except that in the first pop-up screen depicting the alternative (i.e., the visibility nudge) an additional field with a *evaluative nutritional labeling* nudge was present (see Fig. 1). A heart accompanied by a plus icon (similar to the 'heart check logo' or 'heart-healthy logo' used by the American Heart Foundation) was used to signal the healthiness of the alternative. A small pilot study (n = 5) revealed that this sign was understood as a sign of positive health benefits. Further, earlier studies have shown that heart-shaped logos and other types of 'evaluative nutrition labeling'' stimulated sales of healthier products (Cadario & Chandon, 2020; Levin, 1996).

A link to a video of the scanning procedure can be found in the Supplementary Materials.

2.3. Measures

The outcome measure *Healthier food choice* was calculated on the condition level and operationalized as the percentage of healthier target products purchased. This was determined by the number of times healthier target products and the number of times unhealthy products were purchased over the whole period (37 days) of data collection for the four conditions in the experiment by all the participants. The percentage of healthier target products for each condition was calculated by dividing the number of times healthier target products were purchased by the total number of times (unhealthy and healthier) target products were purchased for the respective condition and multiplying by 100. The number of times purchased target unhealthy and healthier products were extracted from the raw log data created by the smartphone

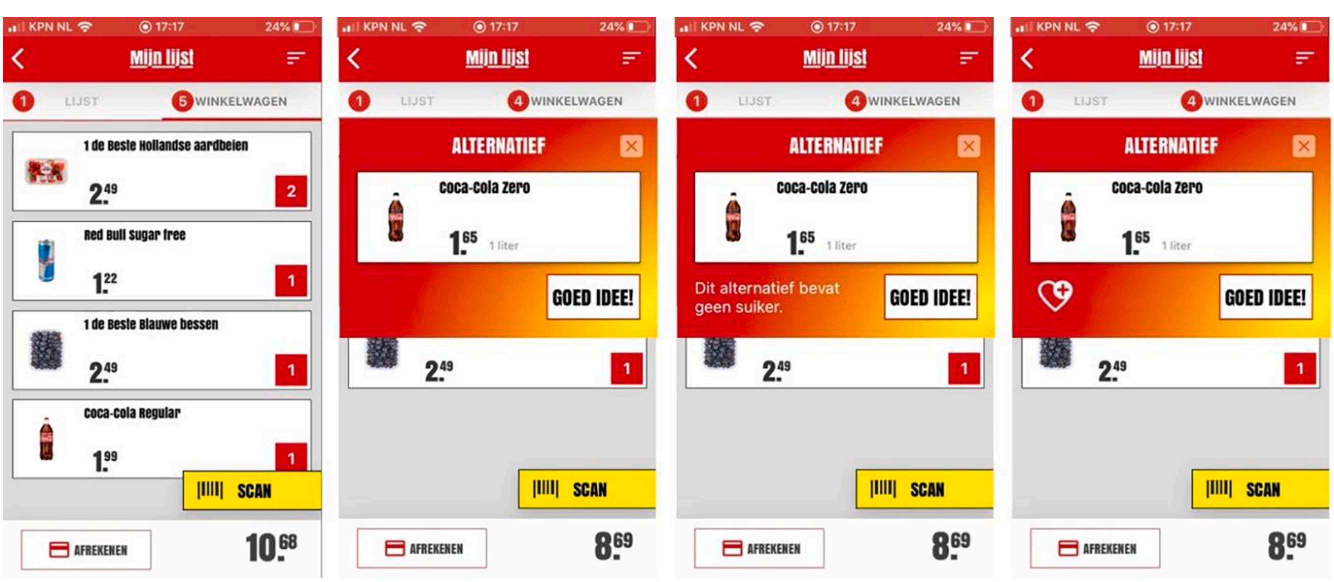

Fig. 1. Screenshots of the self-scanning function of the grocery shopping application. From left to right: *Control condition*, *Visibility nudge* condition, *Visibility + descriptive nutrition labeling nudge* condition and *Visibility + evaluative nutritional labeling nudge* condition.

application. The log data generated by the application was stored in a database (Firebase) and the relevant data was subtracted from the database with a customized query in the command line of BigQuery. The data logs include sales of all customers who scan the products in Table 1. Several meta-data was included in the logs, including the name of the experimental condition the customer was randomized to. The log data allowed to retrieve which healthier and/or unhealthy target products a user had in its basket at checkout. For this dependent variable, no distinction was made between product categories.

To avoid any biases arising from customers buying multiple of the same target products (e.g., five bottles of Cola Regular), if a customer purchased multiple the same healthier target products this was counted as one; the same was done for the unhealthy products. For this reason, we refer to the number of times a target product was purchased, instead of to the absolute number of products purchased.

3. Results

Table 2 shows the number of times unhealthy and healthier target products were purchased in the four conditions. To answer the first research question, whether a product suggestion provided after the product choice can encourage healthier food choices, we performed a chi square test to examine if the proportion of purchased healthier and unhealthy target product differed between the *Visibility nudge* and the *Control* condition. This analysis revealed that relatively more healthier target products were purchased in the *Visibility nudge* condition (289 unhealthy, 175 healthier; 37.7% healthier) compared to the *Control* condition (336 unhealthy, 143 healthier; 29.9% healthy) (X^2(1, N = 943) = 6.52, p = 0.011).

To answer the second research question, whether providing additional descriptive or evaluative nutrition labeling nudge with the suggestion results in a stronger effect of the suggestion on healthier food choice, we performed two additional chi square tests to examine if the proportion of purchased healthier and unhealthy target products differed between the *Visibility nudge* and respectively, the *Visibility + descriptive nutrition labeling nudge* and *Visibility + evaluative nutritional labeling nudge* conditions. The analysis revealed that significantly less healthier target products were purchased in the *Visibility + descriptive nutrition labeling nudge* condition (317 unhealthy, 136 healthier; 30.0% healthier) compared to the *Visibility nudge* condition (289 unhealthy, 175 healthier; 37.7% healthier; X^2(1, N = 917) = 6.05, p = 0.014). Also, significantly less healthier target products were purchased in the *Visibility + evaluative nutritional labeling nudge* condition (278 unhealthy, 109 healthier; 28.2% healthier) compared to the *Visibility nudge* condition (289 unhealthy, 175 healthier; 37.7% healthier; X^2(1, N = 851) = 8.66, p = 0.003).

For completeness, we also report the remaining chi square tests examining the pairwise differences in proportions healthier and unhealthy target product purchases between the *Visibility + descriptive nutrition labeling, Visibility + evaluative nutritional labeling, and the control condition.* There were no significant differences in proportion purchased healthier and unhealthy target products between the *Visibility + descriptive nutrition labeling nudge* and the *Control* condition (X^2(1, N = 932) < 0.01, p = 0.955); the same holds for the comparison between the *Visibility + evaluative nutritional labeling nudge* and the *Control* condition (X^2(1, N = 866) = 0.30, p = 0.587) and for the comparison between the *Visibility + descriptive nutrition labeling nudge* and *Visibility + evaluative nutritional labeling nudge condition* (X^2(1, N = 840) = 0.35, p = 0.555).

Table 2
Number of times and percentage of unhealthy and healthier target products purchased per condition.

Condition	Unhealthy target products Number (%)	Healthier target products Number (%)	Total
Control condition	336 (70.1%)	143 (29.9%)	479
Visibility nudge condition	289 (62.3%)	175 (37.7%)	464
Visibility + descriptive nutrition labeling nudge condition	317 (70.0%)	136 (30.0%)	453
Visibility + evaluative nutritional labeling nudge condition	278 (71.8%)	109 (28.2%)	387
Total	1220 (68.4%)	563 (31.6%)	1783

4. Discussion

Our first research question was whether digital JIT-delivered visibility nudges can stimulate healthier food choices. We found that saliently providing a healthier product suggestion on a pop-up after scanning an unhealthy product resulted in relatively more healthier food purchases than when no such suggestion was made. The finding is in line with nudge theory which suggests that by visibly presenting a product it is more likely to be considered, thereby exploiting the biases and heuristics of the 'fast' system 1 (Gigerenzer, 2015; Kahneman, 2003). The finding is also in line with JITAI literature that would suggests that the JIT nudge operates in the most optimal state of opportunity. That is, the suggestion is provided directly in response to choice, but before the actual transaction is made. The consumer still can replace the unhealthy product for the healthier alternative. The findings are also in line with health behavior theories in which a pop-up suggesting an alternative could be regarded as a cue to action (Rosenstock, 1974) or trigger (Fogg, 2009) to act in line with someone's health-related goals. The findings are also in line with the notion from theories explaining self-monitoring and feedback, that presenting a suggestion may make someone more aware of their behavior and the extent to which this deviates from their long-term goals (Hermsen et al., 2016). The effects of providing product suggestions have long been established in online retail (Senecal & Nantel, 2004) and the effects of visibility nudges for healthier food choice have been demonstrated before as well (Cadario & Chandon, 2020; Wilson et al., 2016). In recent years, studies have focused on digital nudges in online supermarkets and other ordering applications as well (Miller et al., 2016; Van der Laan et al., 2017). However, to our knowledge, no earlier study investigated the effects of nudges when provided in a just-in-time manner in the context of healthier food choices in the physical supermarket. Thereby, our study extends previous work by suggesting that intervening directly in response to choice with a visibility nudge could facilitate healthier food choice.

Our second research question second was whether providing an additional descriptive or evaluative nutritional labeling nudge results in a stronger effect on healthier food choice than the visibility nudge alone. Unexpectedly, additional descriptive or evaluative nutrition labeling nudges did not strengthen the effect of the suggestion. In fact, the finding that the percentage of purchased healthier products was lower when the suggestion was accompanied by a descriptive or evaluative nutrition labeling nudge than when the suggestion was presented alone, suggests that the other nudges cancelled out rather than amplified the beneficial effect of the suggestion. A possible explanation is that the additional nudge may have sparked user's awareness of the goal to steer their choices towards a healthier one. Previous studies showed that persuasion knowledge, being aware of the persuasive intention, can cause resistance (Friestad & Wright, 1994). More specifically, 'health resistance', a common resistance to health promotion may have triggered resistance strategies, cancelling out the beneficial effect of the suggestion (Crossley, 2002; Fransen et al., 2015). In a similar vein, reactance (Dillard & Shen, 2005) may be triggered by the additional descriptive or evaluative nutrition labeling nudge which reveals the persuasive intent. The perceived request to change one's choice may lead to a feeling of threat or autonomy and thereby to increases in anger and counterarguing which in turn may render the visibility nudge ineffective (Dillard & Shen, 2005). When a suggestion is shown without these additional nudges the persuasive health-promoting goal may be less apparent and trigger less resistance and reactance. An approach which may resolve the issues resulting from persuasion knowledge is making the nudges transparent, for instance by disclosing the purpose of the nudge or its effect. Several studies (Bruns et al., 2018; Loewenstein et al., 2015) amongst which one other field study on nudges for healthier food choice (Kroese et al., 2016) have shown that the active disclosure of nudges does not decrease the effectiveness of the nudge. An interesting direction for future research could be if this effect of disclosure is similar for JIT nudges.

Another explanation for why the additional descriptive and evaluative labeling nudge may cancel the positive effect of the visibility nudge out comes from the notion that the emphasis on the alternative product's healthiness may elicit negative feelings about the self (Hesse-Biber et al., 2006). For instance, feelings of guilt and negative emotions may result from the realization that someone is making "poor" nutritional choices, as the alternative is explicitly mentioned to be a "good choice". Negative emotions induced by these nudges may lead to increased food intake (and possibly unhealthy choices), though meta-analyses have shown that this effect may be limited to certain populations (e.g., individuals high in dietary restraint) (Cardi et al., 2015; Evers et al., 2018).

Researching in the real-life store environment with a population of regular supermarket customers has the advantage of a high external validity. However, the field setting and the anonymous data collection did not allow measuring process indicators of mechanisms. Future research studies could investigate if the beneficial effect of the visibility nudge is caused by the suggestion serving as a goal reminder or, alternatively, if the suggestion made people aware of the discrepancy between their choice and their long-term health goals. Also, future research could assess through which processes (persuasion knowledge, reactance) the additional nudges denoting the health of the suggested product may have exerted an adverse effect. Another interesting direction for future research is to investigate if the effects of the nudges differ by product category (e.g., bread versus snack foods) or by targeted nutrient (e.g., lower in sugar versus higher in fibres). A last suggestion for future research is to assess the long-term effects of the manipulations. A meta-analysis found that effect sizes of nudges were relatively unaffected by study duration, which may suggest that nudge effects remain as long as the nudge is still present (Cadario & Chandon, 2020). However, a recent study showed that the impact of a nudge for healthy eating faded out directly after removal (Van Rookhuijzen et al., 2021). A relevant topic for future research is to investigate the longer-term effects of JIT nudges and how long the impact food choice remains after the intervention stopped.

A limitation of the study is that we could not retrieve from the data logs if participants actually pushed the button to accept the suggestion in the pop-up, and thus to replace the unhealthy target product for the healthier alternative target product. We could only assess the total number of times target healthier and unhealthy product were purchased per condition. Though this level of data aggregation is similar to earlier field studies on effects of nudges on purchasing (Kroese et al., 2016) and it does allow us to assess effects on the proportion of healthier purchases, it is unknown if the suggestion resulted in a decrease in the purchasing of unhealthy products or in an increase of healthier products. We could also not retrieve from the data logs the moment at which the healthier product matches were added (before or after the exposure to nudges). It is likely that in each of the four conditions some of the healthier target products were already in the shopping cart prior to exposure to the experimental manipulations (i.e., shoppers that intentionally already purchased whole wheat bread). However, given that participants were randomized to conditions, it seems unlikely that this may have confounded differences between conditions. Future studies should employ more fine-grained data logs that could elucidate if people actually replaced their unhealthy for a healthier product.

The finding, that JIT nudges implemented in a retail application have a potential beneficial effect on healthier food choice is relevant for health promotion practice since effect sizes are generally smaller in supermarket environments (Cadario & Chandon, 2020) and the current findings do seem to suggest that JIT nudges may be effective in this setting. In several countries, supermarket chains have committed to improving citizens' health by promoting healthy eating (e.g., in the Netherlands the 'National Prevention Agreement') and JIT nudges may be a novel tool to establish this. Further, if implemented in a retail app, the potential reach of the intervention is wide as not only those particularly interested in health (i.e., users of m- and eHealth applications differ from the general user population in several dimensions (Elavsky et al., 2017)) but rather all users of the retail application are exposed. Nowadays, virtually all major supermarket chains and many moderately sized supermarket chains provide self-scanning (for some examples, see web appendix A of (Grewal et al., 2020)). The use of self-service in the supermarket, e.g., self-checkouts and self-scanning seems to be rapidly rising: usage triplet in some supermarket chains over the past year (Heijn, 2020).

5. Conclusion

To conclude, this study implies that saliently suggesting a healthier alternative directly in response to unhealthy choice stimulates healthier purchasing behavior but that an additional nudge emphasizing the healthiness of the alternative cancels this effect out. The current study is the first one that shows that visibility nudges presented in a just-in-time manner may be effective in changing food choices. These findings imply that visibility nudges implemented in self-scanning applications may be an effective a tool for retailers to facilitate healthier food choices in physical supermarket.

CRediT authorship contribution statement

L. Nynke van der Laan: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. **Oliwia Orcholska:** Conceptualization, Formal analysis, Investigation, Writing – review & editing.

Conflict of interest statement

We have no conflicts of interest to disclose. The study was conducted with the use of a smartphone application developed by Nakko BV. Nakko BV had no role in the design of this study and the analyses, interpretation, or decision to submit results.

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Appendix A. Supplementary data

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