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Investigating the conditions for the effectiveness of nudging: Cue-to-action nudging increases familiar vegetable choice[☆]

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ABSTRACT

Inulin-type fructans (ITF), which are fibres found in vegetables such as salsify, artichoke and Jerusalem artichoke, are known for their prebiotic capacities and may contribute to preventing obesity. The current study aimed to assess the differential effects of a type-2 and a combined type-1 and -2 nudge to increase the choice for "prebiotic" vegetables at a hot vegetable buffet of a university restaurant, using a nonrandomized intervention study design involving two interventions during five consecutive weeks. An intervention was implemented in which customers were exposed to type-2 nudging in the form of short "cue-to-action" messages placed on their trays and above the hot vegetable buffet, and an additional type-1 nudging intervention was implemented in the form of placing dishes with "prebiotic" vegetables in a more accessible place. On average, 28 servings of hot vegetables were registered on a total of 503 meals sold at the restaurant per day. The beta regression model showed that the "cue-to-action" intervention increased the proportion of customers who used the hot vegetable buffet ($p < .001$, OR: 1.24), but that the proportion of "prebiotic" vegetables chosen decreased during the "cue-to-action" intervention weeks ($p < .01$, OR: 0.73). The cue-to-action intervention increased familiar vegetable choice in general and decreased unfamiliar prebiotic vegetable choice. The additional intervention of increasing the accessibility did not change prebiotic vegetable choice. The effectiveness of nudging seems to depend on the specificity and/or the familiarity of the nudged products.

1. Introduction

Worldwide obesity has nearly tripled since 1980. In Europe, over 50% of the people are overweight or obese (WHO, 2008). Overweight and obesity are defined as abnormal or excessive fat accumulation that result in health problems (WHO, 2018). As an unhealthy diet is considered as one of the main determinants of overweight and obesity, it is recommended that individuals adopt a healthy diet, which includes a variety of fruit and vegetables. Research performed on both animals and humans has demonstrated that changes in the gut microbiota composition and/or activity may be related to the control of fat storage and altered glucose response in obese individuals (Delzenne & Cani, 2011). "Inulin-type fructans" (ITF) are a particular type of fibres, which are known for their prebiotic capacities: they can modulate gut microbiota and energy metabolism and improve glucose metabolism (Neyrinck et al., 2016). Two studies that used an ITF prebiotic-treatment (Dewulf et al., 2012; Salazar et al., 2015) found subtle changes in the composition of the gut microbiota of obese women. ITF are typically found in so-called "prebiotic" vegetables, such as artichoke, Jerusalem artichoke, and salsify (Kalala et al., 2018). Increasing the amount of prebiotic vegetables in diets could be a way to treat obese patients and to prevent overweight or obesity.

While the adoption of a healthy diet in the population is often promoted through nutrition education, the environment in which one lives also has an important influence on one's diet, and as such on the occurrence of obesity. The obesogenic nature of an environment has been defined as 'the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations' (Lake & Townshend, 2006). The environment can be related to health through socio-economic status, the socio-cultural rules

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that govern these environments, or its physical design (i.e., the built environment). For example, lower socio-economic neighbourhoods and greater perceived neighbourhood strain are related to poorer physical functioning (Feldman & Steptoe, 2004).

One way of making the physical design of the environment more health promoting is via *nudging*. The concept of nudging was first introduced in the behavioural economics field by Thaler and Sunstein (2010). Their definition of a 'nudge' is *'any aspect of the choice architecture that alters people's behaviour in a predictable way, without forbidding any options or significantly changing their economic incentives'* (p. 6). An example of a nudge that aims to increase food choice is placing healthy foods at a closer distance compared to unhealthy foods, so that it is easier to reach them (Hollands et al., 2013). A nudge usually aims to influence the behaviour of many people simultaneously, is implemented in the environment where the target behaviour is performed, and requires minimal conscious processing. Hollands et al. (2013) proposed a typology of three different types of nudging: altering properties (labelling, sizing and functional design), altering placement (availability and proximity), and altering both properties and placement (priming and combined nudges).

The theory behind nudging has its roots in Tversky and Kahneman (1974) theory on heuristics and biases, which highlights the interplay between the automatic and reflective system. Most theories of information processing distinguish between these two types of processing. Automatic processes are unconscious, automatic, rapid and high in capacity, whereas reflective processes are conscious, slow and deliberative. People often use heuristics and biases as shortcuts when making decisions, because consciously reflecting on every alternative would be too time-consuming. While heuristics can sometimes lead to choices that are disadvantageous because of biases, nudging uses heuristics that rely on the automatic system to the benefit of people, by directing them towards healthier behavioural options. Yet while nudging always affects automatic modes of information processing, it may also involve some level of reflective thinking. In this regard, Hansen and Jespersen (2013) distinguish between two types of nudges. Type-1 nudges aim at influencing the behaviour without involving reflective thinking. An example of a type-1 nudge would be to increase the selection of healthy food by placing healthy foods at a closer distance to the consumer or point of payment, compared to unhealthy foods. In this case there is no reflection or conscious choice required to perform the behaviour. In contrast, type-2 nudges aim to influence reflective thinking (i.e. making a choice) by influencing the automatic system. That is, an individual has to already have a goal that is consistent with the behaviour that is nudged. An example of a type-2 nudge would be to offer a "cue-to-action" whereby a cue, defined as an internal or external stimulus or instigating event, triggers the person to make a choice to perform the action (Conrad, Campbell, Edington, Faust, & Vilnius, 1996). Cues can have many forms, for instance they can transmit information in a media message or poster (Robertson, 2008).

Nudging has been applied to influence different types of behaviour, including health related behaviour. A review of the application of nudging in public health led Hansen, Skov, and Skov (2016) to conclude that '[it] offers evidence-based approaches to create behavioural changes in ways that may potentially supplement as well as substitute existing regulation in a comprehensive health strategy' (pp 248–249). However, systematic reviews regarding the effectiveness of nudging on food consumption point to the low quality of many studies and to inconsistent findings regarding the effectiveness of certain forms of nudging in particular settings (Skov, Lourenco, Hansen, Mikkelsen & Schofield, 2013; Frerichs et al., 2015; Nørnberg, Houlby, Skov, & Peréz-Cueto, 2016; Wilson, Buckley, Buckley, & Bogomolova, 2016). While some systematic reviews concluded that there is a positive effect of nudging on healthy food consumption (Thapa & Lyford, 2014; Bucher et al., 2016), Bucher et al. (2016) found this positive effect only for a specific type of nudge, i.e., positional changes of food placements. Wilson et al. (2016), on the other hand, found a positive effect of combined salience and priming nudges. One meta-analysis showed that nudges result in an increase of 15.3% healthier food choices (Arno & Thomas, 2016), yet another meta-analysis of interventions that used nudging to increase fruit and/or vegetable choice/sales/servings (Broers, De Breucker, Van den Broucke, & Luminet, 2017) showed that such interventions only have a moderately significant effect ($p < 0.001$, $d = 0.30$), with the largest effect for altering placement ($p < 0.001$, $d = 0.39$) and combined nudges ($d = 0.28$). As such, further research is needed to confirm whether nudging is indeed an effective means to change an obesogenic environment into a healthy one, and if so, under which conditions it is most effective.

The current study aimed to assess the differential effects of type-1 and type-2 nudges on increasing the selection of prebiotic vegetables and vegetables in general, using a nonrandomized intervention study design involving two interventions in a university self-service restaurant setting. For a type-1 nudge, we altered the placement of the prebiotic vegetables by placing them closer to the customer (i.e., at the front of the buffet display) to facilitate the behaviour, because increasing accessibility seems to be one of the nudges that show a positive effect (Bucher et al., 2016). For a type-2 nudge, we provided cues to action in the form of short messages on the location and benefits of prebiotic vegetables in order to elicit the intention and behaviour to eat more healthily. Our expectation was that the cues to action would attract more customers to the vegetable buffet and increase the choice for vegetables in general and for prebiotic vegetables in particular, by triggering the reflective process of customers. Our first hypothesis was therefore that the type-2 nudge would increase the frequency of overall vegetable choice, as well as of prebiotic vegetable choice. It is important to attract more customers to the vegetable buffet before implementing other nudges, because customers who do not visit the buffet cannot be influenced by the placement of the food. We also wanted to explore whether the quantity of prebiotic vegetables chosen would change as a consequence of the type-2 nudge. Our second hypothesis was that placing the prebiotic vegetables closer to the customer would further increase the frequency of prebiotic vegetable choice, since combined nudges have been found to be an effective type of nudge (Wilson et al., 2016; Broers et al., 2017). This nudge was only expected to increase the choice of prebiotic vegetables, and not the overall choice of vegetables, because only the prebiotic vegetables were placed closer to customers. We also wanted to explore whether the quantity of prebiotic vegetables in grams would change as a consequence of the nudge type-1 intervention.

2. Material and methods

2.1. Participants

Participants were customers of a Belgian university restaurant during lunchtime, and specifically customers of a self-service hot vegetable buffet within this restaurant. During five consecutive weeks in October and November 2016, an average of 503 meals were sold per day at the restaurant (*SD* = 59.67), of which 28 were sales of hot vegetables meals (*SD* = 6.22). Of the total number of hot vegetable meals sold, 53.12% were to students, 26.26% to university staff, and 20.62% to people who were not working or studying at the university.

2.2. Design

Two nudging interventions were implemented. The first intervention (*type-2 nudge*) consisted of short messages about the novelty and health benefits of (prebiotic) vegetables printed on paper tray liners placed on the customer's trays (Fig. 1). The messages provided general information about the location ("vegetables to discover at the hot vegetable buffet"), content ("rich in fibres") and health benefits ("beneficial health effects", "so, for your health, wouldn't you like to taste them?") of the vegetables. The health claim "rich in fibres" was pre-

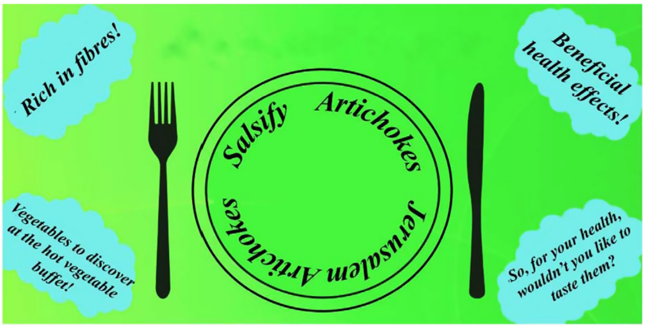

Fig. 1. Nudge type-2: cue-to-action tray liners encouraging prebiotic vegetable consumption (design: Mukaz-Museng, R. V.).

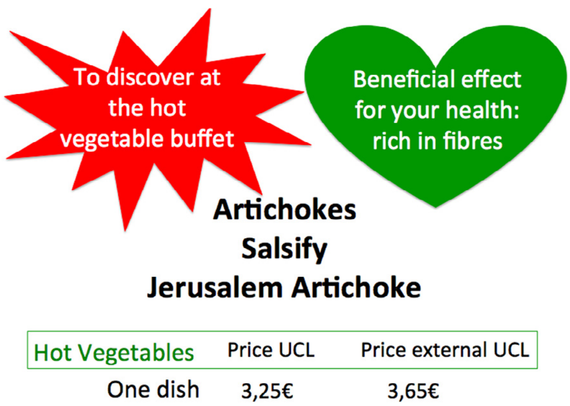

Fig. 2. Nudge type-2: cue-to-action pictograms about prebiotic vegetables.

tested among five other health claims (rich in colic nutriments, inulin, fructan, prebiotics, fructo-oligosaccarides) and considered by participants to be the most familiar, appropriate, natural and healthy claim for prebiotic vegetables (Mulders, Klein & Corneille, unpublished results). They were expected to activate the intention of eating healthy among people who already had the intention to do so. As customers are obliged to take a tray at the entrance of the restaurant, all customers were exposed to the cues. To increase visibility, pictograms repeating the messages of the tray liners were shown above the self-serve hot vegetable buffet, and information regarding the location, content and positive health effects of the vegetables was repeated on the price tag (Fig. 2).

The second intervention (*type-1 nudge*) consisted of increasing the accessibility of the prebiotic vegetables by placing them at the front row of the hot vegetable buffet, which contained a varying choice of 9 to 10 vegetable dishes (Fig. 3). This intervention was carried out in one week of the study only. During all other weeks the prebiotic vegetables were placed at the back row of the buffet. Only customers who went to the hot vegetable buffet could be influenced by this nudge.

Both interventions were implemented during five consecutive weeks in October and November 2016. The university restaurant where the study took place was open each weekday (Monday through Friday), except during week 5 on which Tuesday was a national holiday. The university restaurant provides a large variety of meals, including the meal of the day, a vegetarian meal, a “suggestion” meal, three varying types of pasta and/or a soup of the day, as well as other hot and cold meals and side dishes. The current experiment focused on one of the side dishes: the hot vegetable buffet. As the hot vegetable buffet was positioned on the other side of the room, not all customers passed the buffet. The hot vegetable buffet offering the prebiotic vegetables was only opened during lunchtime; therefore the experiment only took place during the lunch period. The hot vegetable buffet consisted of a varying choice of 9 or 10 vegetable dishes per day, of which 3 dishes were always prebiotic vegetables. One set of recipes (salsify puree, stuffed artichokes, and gratin of Jerusalem artichokes) was used from Monday through Wednesday, and another set (Jerusalem artichoke puree, “salsifis à la provençal”, baked artichokes) on Thursday and Friday. The recipes remained the same throughout the study period. Customers could add as many different vegetables as they wanted until their plate (see Fig. 3, left) was full. For all dishes, ingredients and calories were provided on labels above the buffet during all five weeks.

Week 1 served as a baseline. During this week no experimental intervention took place, but three new dishes prepared with prebiotic vegetables were introduced in the hot vegetable buffet. From week 2 through week 4, the type-2 nudge (the “cue-to-action” tray liner) was implemented. During week 3, the type-1 nudge (increased accessibility) was implemented in combination with the on-going “cue-to-action”. During week 5, no experimental interventions took place. This week (post-intervention) is comparable to week 1 in terms of the experimental design. Within each week, the experimental conditions were kept constant. Fig. 4 offers a visual representation of the experimental design.

2.3. Measures and statistical analyses

Effects of cue-to-action and nudging interventions on the choice of prebiotic vegetables in proportion and volume were assessed daily using 4 outcome measures: (1) The number of meals sold (checks), noted as n_i, measured by the number of passages via the cash register software; (2) The number of sales from the hot vegetable buffet, noted as v_i, also measured via the cash register software; (3) The number of servings containing prebiotic vegetables from the hot vegetable buffet, noted as c_i, measured via a manual counter operated by the researchers or their assistants; (4) the total daily weight of prebiotic vegetables (in grams) that were chosen was measured by weighing the service plates before and after the service. Each portion sold from the hot vegetable

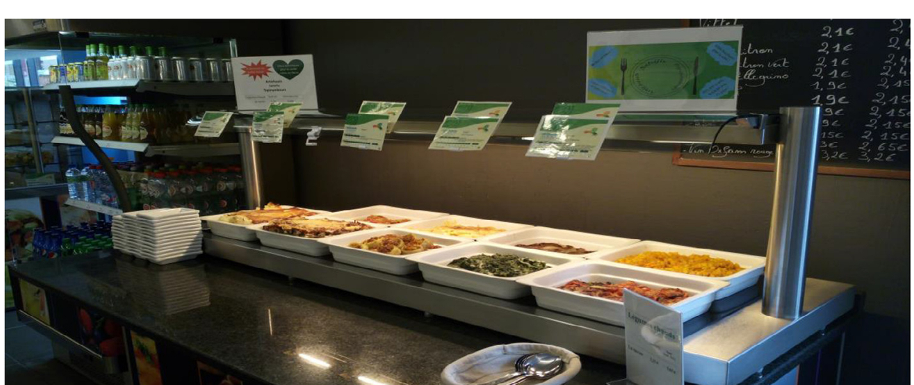

Fig. 3. Nudge type-1: increasing accessibility of prebiotic vegetables by placing them in the front of the self-service vegetable buffet.

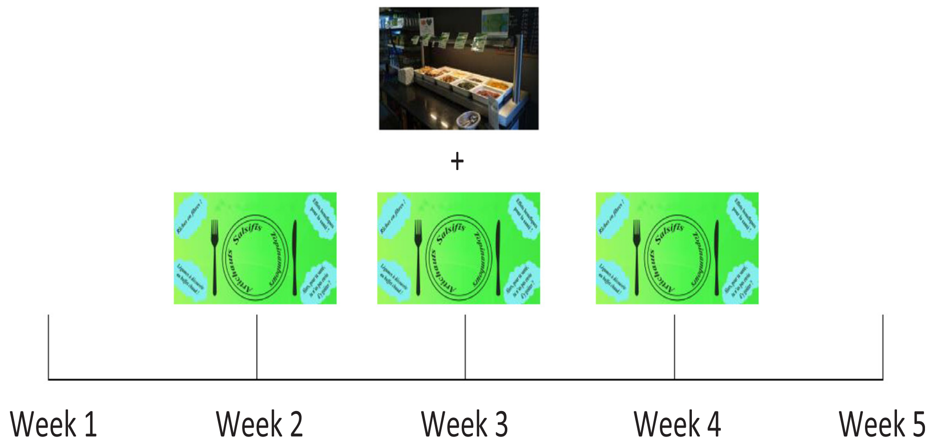

Fig. 4. Experimental design per week.

buffet could consist of a combination of vegetables. In case a serving was registered as containing prebiotic vegetables, it usually also contained non-prebiotic vegetables. The index i in mathematical notations refers to the collection day, with $i \in \{1, 2, \cdots, 24\}$. There are only 24 days instead of 25 because the last week contained only 4 days (one holiday).

As the values of the absolute counts and weights depend on external factors like restaurant size, transformed variables were preferred over crude measures to allow for extrapolation and comparison with other studies. As such, absolute counts were replaced by proportions and total weight by weight per sale from the vegetable buffet. Two proportions were calculated: (1) The proportion of prebiotic vegetable servings amongst all sales from the hot vegetable buffet, defined and noted as $p_{C,i} = c_i/v_i$; and (2) The proportion of sales from the hot vegetable buffet amongst all registered meals sold, defined and noted as $p_{V,i} = v_i/n_i$. The first proportion was expected to be affected by both types of intervention, the second proportion only by the cue-to-action intervention, since the nudging was not visible for people who did not come near to the hot vegetable buffet. The relative weight of prebiotic vegetable per sale from the vegetable buffet was defined and noted as $r_i = w_i/v_i$.

Aside from the classical descriptive statistics, the relationship between both types of interventions and outcome variables was modelled via generalized linear models. Potential predictors considered were (1) the binary experimental variable “cue-to-action” (type-2 nudge); (2) the binary experimental variable “accessibility” (type-1 nudge); (3) the multinomial variable “day of the week”; (4) the multinomial variable “week qualitative” to test the effect of the interventions; and (5) the quantitative variable “week quantitative” to test the effect of time. The multinomial variable “week qualitative” cannot be used in combination with accessibility, as this nudging intervention took place during only one week of the experiment. The quantitative variable “week quantitative” was added to detect if a trend can be observed over the weeks. The binary variable “recipe” was not included in the models since its effect would overlap with the “day of the week” effects, which were considered more important. For relative weights, the relationship between these predictors and the outcome variables was modelled via general linear regressions for relative weights, since this measure and the model residuals were normally distributed. For proportions, the beta regression model (Ferrari & Cribari-Neto, 2004; Simas, Barreto-Souza, & Rocha 2010) was favoured over a binomial logistic regression model since the latter assumes independent trials of the same Bernoulli experiment. Because in a restaurant interactions and reciprocal influences between customers cannot be excluded, the assumption of independence between trials that is a condition for binomial logistic regression cannot be maintained. Furthermore, it is not possible to control for these interactions, since only aggregated data were collected. In contrast, the location-scale model structure of the beta regression model allows the average proportion and its variance (or its precision) to be modelled simultaneously. The beta regression model can have two sub models: (1) a regression model for the mean – similar to a linear regression model – identifying covariates that increase/decrease the value of the average proportion; (2) a regression model for the precision parameter – which is the inverse of the variance – identifying covariates that influence the dispersion of the points around this average proportion. As the scale sub-model allows heteroskedasticity, this additional assumption was not required.

The models were built sequentially with a forward process based on the likelihood ratio test for nested models. When at least two main effects were introduced, interactions at the first level were also considered. Due to the small sample size (N = 24 days), higher interactions were not explored. Whereas day and week effects could also have been considered as random instead of fixed effects, exploring mixed models like these on a small sample size (N = 24) could lead to biased results. All analyses were performed using R software version 3.3.2 (R Core Team, 2016) and its Betareg package (version 3.1-0; Cribari-Neto & Zeileis, 2010).

3. Results

3.1. Descriptive findings

The mean percentage of meals sold from the hot vegetable buffet amongst all meals sold during week 1 (5 days) was 4.7% (SD = 1.1%, min = 3.2%; max = 5.7%), during week 2 (5 days) the mean was 6.1%, (SD = 1.5%, min = 3.6%; max = 7.7%), during week 3 (5 days) the mean was 6.1%, (SD = 1.3%, min = 4.4%; max = 7.5%), during week 4 (5 days) the mean was 6.0%, (SD = 1.2%, min = 4.5%; max = 7.9%) and during week 5 (4 days) the mean was 5.2%, (SD = 1.7%, min = 3.7%; max = 7.0%). See Fig. 5 for the mean percentage per week. The mean percentage of prebiotic vegetables servings amongst the total of hot vegetable buffet sales for week 1 (5 days) was 78.5%, (SD = 12.3%, min = 57.7%; max = 88.5%), for week 2 (5 days) the mean was 72.9%, (SD = 6.9%, min = 64.5%; max = 81.6%), for week 3 (5 days) the mean was 75.7%, (SD = 7.5%, min = 69.2%; max = 84.4%), for week 4 (5 days) the mean was 64.9%, (SD = 13.2%, min = 41.7%; max = 73.0%) and for week 5 (4 days) the mean was 75.4%, (SD = 5.3%, min = 68.2%; max = 80.7%). See Fig. 6 for the mean percentage per week. The daily mean relative weight of prebiotic vegetables per serving containing such vegetables as observed during the 24-day period was 182 g (median 179 g), (SD = 39 g, min = 123 g; max = 315 g). The mean relative weight of prebiotic vegetables per serving containing such vegetables for week 1 was 176 g, week 2 was 193 g, week 3 was 157 g, week 4 was 172 g and week 5 was 200 g.

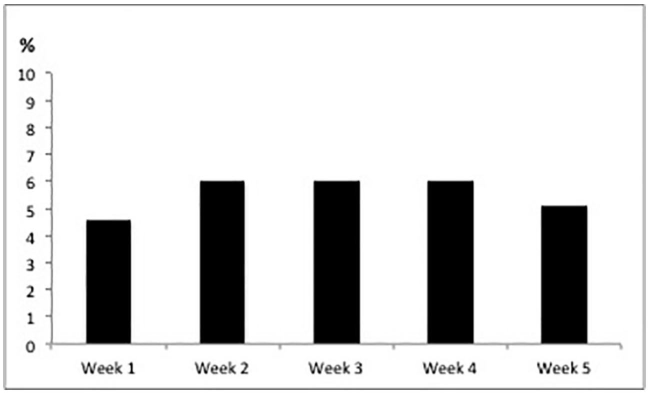

Fig. 5. The mean percentage of meals sold from the hot vegetable buffet amongst all meals sold per week.

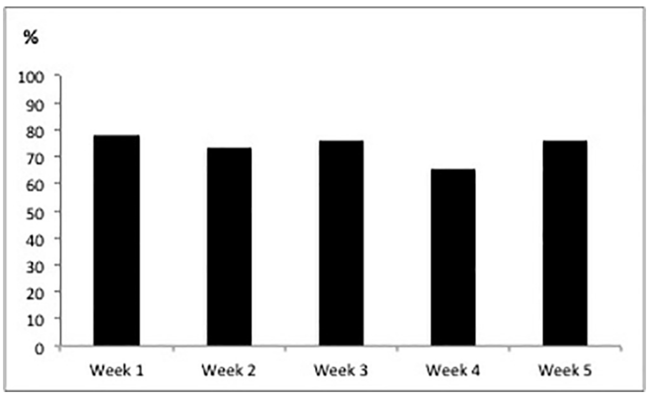

Fig. 6. The mean percentage of prebiotic vegetable servings amongst the total of hot vegetable buffet sales per week.

3.2. Regression analyses

The final beta regression model for the daily *proportion of meals sold from the hot vegetable buffet* amongst all registered meals sold shows two significant effects on the location sub-model. A first significant positive effect ($\hat{\beta} = 0.21$, $z = 3.44$, $p < 0.001$) on the average proportion of hot vegetable meals sold is observed for the *cue-to-action* intervention. The odds of choosing a hot vegetable dish from the buffet during cue-to-action days are 1.24 (95% CI [1.10; 1.40]) compared to days without the cue-to-action manipulation. A second significant overall effect is observed for the *day of the week* ($\chi^2_{(4)} = 37.55$, $p < 0.001$): The average proportion of hot vegetable meals sold significantly decreased on Thursdays compared to all other days, with Mondays being the second lowest ($\hat{\beta}_{ThursdayvsMonday} = -0.39$, $z = -3.91$, $p < 0.001$). The odds of selecting a hot vegetable dish on a Thursday was 0.68 times lower (95% CI [0.56; 0.82]) than on a Monday, and 0.57 lower than on a Tuesday, when the average proportion was at its highest. No significant effect was found on the precision sub-model. The pseudo R^2 of the location sub-model is 0.72, which indicates a good model fit. The pseudo R^2 evaluates the goodness-of-fit of logistic models and ranges from 0 to 1 with higher values indicating a better model fit. The expected means under various covariate levels with their corresponding confidence intervals are visualized in Fig. 7. The main model results are presented in Table 1.

The final linear regression model for the *absolute number* of hot vegetable buffet meals shows a significant positive effect ($\hat{\beta} = 5.82$, $t(22) = 2.38$, $p = 0.02$) of the cue to action, which matches the conclusions of the model on proportions.

The final beta regression model for the daily proportion of *prebiotic vegetables servings* amongst the total number of meals sold from the hot vegetable buffet gives two significant effects on the location sub-model, and one significant effect on the precision sub-model. A significant *negative* effect ($\hat{\beta} = -0.31$, $z = -2.81$, $p < 0.01$) on the average proportion of prebiotic vegetable meals sold is observed for the *cue to action* intervention: the odds of selecting a prebiotic vegetable dish from the buffet during the period when cue-to-action is applied are 0.73 times lower (95% CI [0.59; 0.91]) than on the weeks without action. A significant negative effect ($\hat{\beta} = -0.12$, $z = -3.07$, $p < 0.01$) on the proportion of prebiotic vegetable servings is also observed for the different *weeks* (considered as a quantitative variable), with the odds of selecting a prebiotic vegetable from the buffet during any week being 0.89 times lower (95% CI [0.59; 0.91]) than the previous one, and of selecting a prebiotic vegetable during the last week being 0.62 times smaller than during the first week. A significant overall effect is also observed for the *days of the week*. The variability of the proportion of prebiotic vegetables servings chosen is the highest on Fridays, which is significantly different from the variability observed on Mondays. The pseudo R^2 of the location sub-model is 0.16, which indicates a poor model fit. The expected means under various covariate levels with their corresponding confidence intervals are visualized in Fig. 8. The main model results are presented in Table 2.

The final linear regression model for the *absolute number* of prebiotic vegetable servings did not show any significant effects.

The final general linear regression model for the *relative weight of prebiotic vegetables* per serving containing prebiotic vegetable did not show any significant effects.

4. Discussion and conclusion

The aim of this study was to investigate the effectiveness of type-2 and combined type-1 and type-2 nudging interventions to increase the choice of prebiotic vegetables and vegetables in general. For testing these effects, a field trial was organised in a university restaurant in which customers were exposed to a type-2 nudging intervention in the form of short "cue-to-action" messages placed on their trays and above a hot vegetable buffet, and to an additional type-1 nudging intervention in the form of placing dishes with prebiotic vegetables in a more accessible place than non-prebiotic vegetable dishes.

The results show that the "cue-to-action" intervention increased the proportion of meals sold at the hot vegetable buffet. The odds of choosing a hot vegetable dish from the buffet during cue-to-action days are 1.24 bigger than during no cue-to-action days, which reflect an increase of 1.1% of the total meals sold on average per week. The pseudo R^2 indicated a good model fit so it is not likely that many other covariates are relevant to model the outcome. This confirms the hypothesis that type-2 nudges are an effective way to encourage vegetable choice. These findings are in line with the systematic review that showed a general positive effect of nudging on food choice (Thapa & Lyford, 2014), and with the two meta-analyses that showed an increase of healthier food choices (Arno & Thomas, 2016) and a moderately significant effect of nudging on fruit and/or vegetable choice/sales/servings (Broers et al., 2017). Moreover, when the cue-to-action was removed, the proportion of customers who purchased vegetables from the buffet fell back to the baseline level. This implies that there is no carry-over effect, and that the cue-to-action needs to be sustained in order to remain effective. The effectiveness of type-2 nudges has not yet been extensively documented in the literature, which seldom differentiates between type-1 and type-2 nudges. In practice, however, cues-to-action are commonly applied, for instance in the form of media messages and posters. One could also argue that food labels containing general and simple messages regarding the healthy nature of food products operate as type-2 nudges. The findings of the present study suggest that in addition to subgroup characteristics, the characteristics of the cue may also be important, and that other type-2 nudges, such as tray liners containing simple but straightforward messages, can also

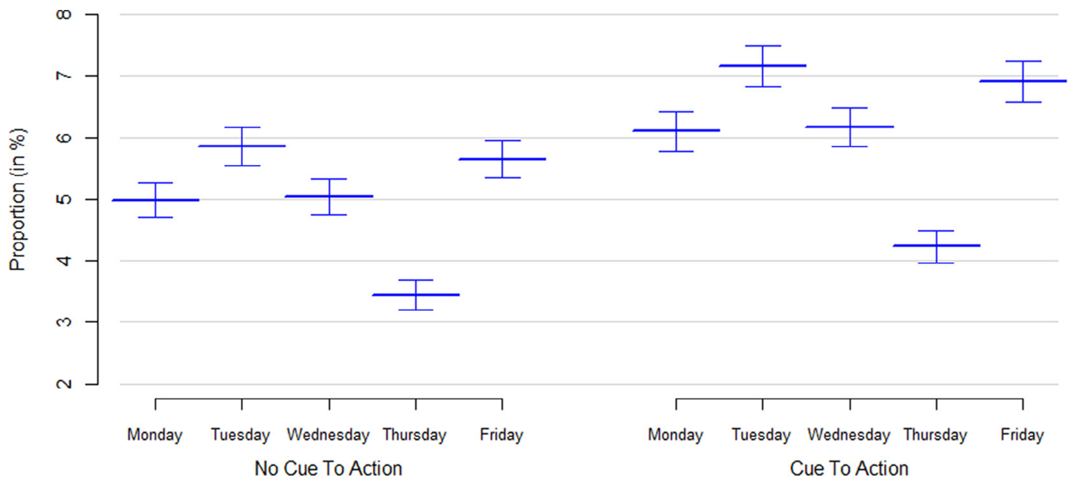

Fig. 7. Predicted means (bold bars) and quantile-based 95% confidence intervals for the predicted means for the daily proportion of meals sold from the hot vegetable buffet amongst all meals sold. No cue-to-action weeks are weeks 1 and 5, cue-to-action weeks are weeks 2, 3 and 4.

Table 1
Final beta regression model (location sub-model) including only the significant predictors for the daily proportion of plates from the warm vegetable buffet amongst registered plates.

Location Sub-Model	Estimate	Std. Error	Z	P-Value (2-tailed)	95% Conf. Int. Lower	Upper
Intervention weeks						
No Cue To Action	0.00	.	.	.	.	.
Cue To Action	0.21	0.06	3.44	< 0.001	0.09	0.34
Days of the week						
Monday	0.00	.	.	.	.	.
Tuesday	0.17	0.09	1.86	0.06	−0.01	0.35
Wednesday	0.01	0.09	0.13	0.90	−0.16	0.19
Thursday	−0.39	0.10	−3.91	< 0.001	−0.58	−0.19
Friday	0.13	0.09	1.50	0.13	−0.04	0.30

serve as cues to increase healthy food choice.

On the other hand, our results also indicated that while the cue-to-action intervention attracted more customers to the hot vegetable buffet, the proportion of prebiotic vegetables chosen actually *decreased*. The odds of selecting a prebiotic vegetable dish from the buffet during the period when cue-to-action is applied were 0.73 times lower than on

Table 2
Final beta regression model (location and precision sub-model) including only the significant predictors for the daily proportion of plates with prebiotic vegetables amongst warm vegetable buffet plates.

Location Sub-Model	Estimate	Std. Error	Z	P-Value (2-tailed)	95% Conf. Int. Lower	Upper
Week (effect over time)	−0.12	0.04	−3.07	0.002	−0.20	−0.04
Intervention weeks						
No Cue To Action	0.00	.	.	.	.	.
Cue To Action	−0.31	0.11	−2.81	0.005	−0.53	−0.09
Precision Sub-Model	**Estimate**	**Std. Error**	**Z**	**P-Value (2-tailed)**	**95% Conf. Int. Lower**	**Upper**
Days of the week						
Monday	0.00	.	.	.	.	.
Tuesday	0.53	0.94	0.56	0.58	−1.32	2.37
Wednesday	−0.85	0.88	−0.96	0.34	−2.58	0.88
Thursday	0.63	0.89	0.71	0.48	−1.11	2.37
Friday	−2.39	0.85	−2.79	0.005	−4.06	−0.71

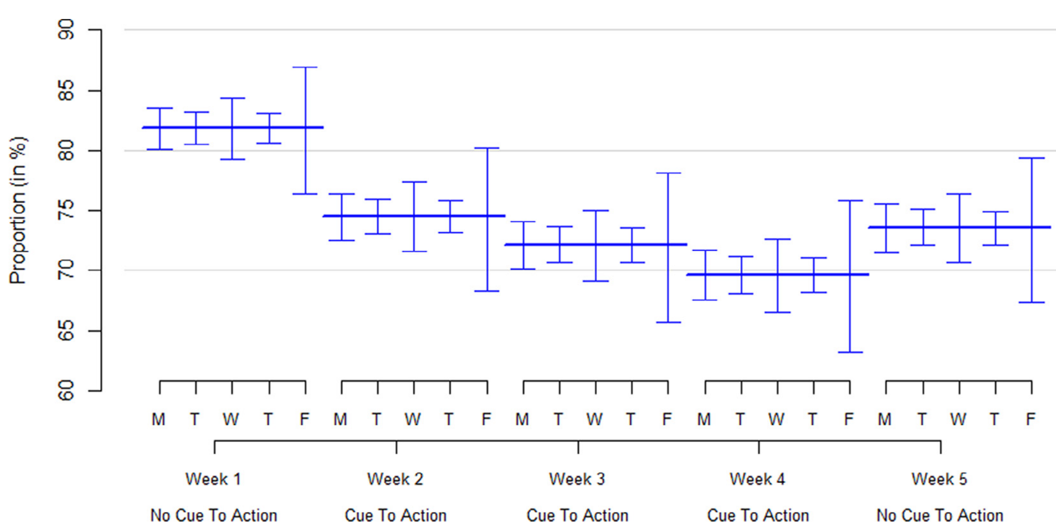

Fig. 8. Predicted means (bold bars) and quantile-based 95% confidence intervals for the predicted means based on the final beta regression model for the daily proportion of plates with prebiotic vegetables amongst warm vegetable buffet plates.

the weeks without cue-to-action, which reflect a decrease of 5.8% of the hot vegetable customers on average per week. So, despite the positive effect on general vegetable choice, the type-2 intervention was not successful in triggering people to select the target vegetables. The pseudo R^2 indicated a poor model fit however so it is likely that other covariates, not observed here, might be relevant to model the outcome. These results contradict those of the systematic reviews and meta-analyses showing positive increases in healthy food consumption by nudges (Thapa & Lyford, 2014; Bucher et al., 2016; Arno & Thomas, 2016; Broers et al., 2017), but are in line with the inconsistent findings of other reviews (Skov, et al., 2013; Frerichs et al., 2015; Nørnberg et al., 2016; Wilson et al., 2016), suggesting that nudges may only be effective in certain conditions. There are several possible explanations for this finding. Firstly, as the number of customers who visited the hot vegetable buffet increased in weeks 2, 3 and 4 compared to week 1 and 5, the samples are not the same for all weeks, which makes it difficult to compare the results across the weeks. Moreover, customers who normally do not make use of the hot vegetable buffet but who were "nudged" to visit the buffet through the cue-to-action may not be habitual vegetable consumers. If eating vegetables is already an achievement for them, choosing an unfamiliar vegetable may have been a step too far. This hypothesis is strengthened by the finding that the absolute number of prebiotic servings does not change significantly over the weeks. This absolute number could reflect the habitual vegetable customers, but this finding should be interpreted with some caution because we do not possess individual information of the customers per week. This finding would concur with the literature on food neophobia, or the reluctance to eat and/or avoidance of novel foods (Pliner & Hobden, 1992). Prebiotic vegetables are unfamiliar and not regularly consumed as part of the modern diet, as has been demonstrated in a representative sample of 1260 inhabitants of the Walloon region in Belgium (Broers, Van den Broucke & Luminet, unpublished results). The latter study revealed that 10% of the sample did not recognize salsify, and that there was only a weak intention to consume more salsify and Jerusalem artichoke in the future. These numbers are even higher among students (Broers, Van den Broucke & Luminet, unpublished results), 35% of whom do not recognize salsify or Jerusalem artichoke, and a large majority show a weak or non-existent intention to consume more salsify and Jerusalem artichoke in the future. Finally, the type 2 nudge may have been too obvious, which may have induced a reactance effect to the prebiotic vegetables. A reactance effect is activated when a person experiences a threat of their freedom and tries to restore it by opposing or resisting the pressure to conform (Brehm, 1966). On the other hand, Marchiori, Adriaanse, and De Ridder (2017) have reviewed evidence regarding the effect of transparency of nudges, and concluded that making individuals aware of a nudging intervention probably does not affect its effectiveness.

To our knowledge, no previous research has investigated the effectiveness of nudging on unfamiliar foods. As type-2 nudging requires a partially conscious choice to perform the behaviour of interest, this type of nudge may well be ineffective for inducing new behaviour or selecting novel products. Secondly, nudging is generally aimed at increasing broader categories of behaviour, such as consuming healthy foods in general, or eating more vegetables and fruit. Since most vegetables are considered as healthy, it may be difficult for costumers to distinguish between specific food products in terms of healthiness. It may be, then, that nudging is less effective in increasing the choice for a specific product, especially when it is presented amongst other products of its category. Thirdly, it is possible that many customers do not recognize prebiotic vegetables among the vegetables offered at a buffet. Although the names of the vegetables were shown above the dishes, it is not certain that they were recognized as such, on account of their unfamiliarity. A replication of this study should therefore verify if the prebiotic vegetable dishes stand out sufficiently.

A third important finding of this study is that the combined type-1 (enhancing the accessibility of the prebiotic vegetables) and type-2 nudge (cue-to-action) did not change the proportion of prebiotic vegetables chosen from amongst the vegetables offered. It thus seems that, like the more "conscious" type-2 nudge, a combination of two types of nudges does not increase the choice of unfamiliar vegetables either. Furthermore, no effects were observed for either type-2 or combined nudges with regard to the portion sizes of the prebiotic vegetables. This suggests that neither more conscious nudges nor a combination of conscious and automatic nudges is effective in increasing the choice of prebiotic vegetables. This contradicts findings of studies showing that combined nudges are more effective (Wilson et al., 2016; Broers et al., 2017). Again, this may partly be attributed to the potential counteracting effect of food neophobia or to the possibility that the prebiotic vegetables may not have been recognized. Alternatively, it may also indicate that nudging requires a certain familiarity with the product to which one is "nudged", or that it is less effective in increasing the choice for specific products as opposed to broader categories. However, as there was no "wash-out" period between the two interventions, there may have been a spillover effect of the intervention of the previous week. While the effect of the type-2 intervention disappears immediately when it is removed for hot vegetables in general, it may have influenced the prebiotic vegetable selection.

Finally, the study also showed some significant effects over time and by day of the week, which were included as control variables. For vegetables in general, fewer hot vegetable dishes were sold on Thursdays than on Mondays. This may be due to the fact that on Thursdays the restaurant in which the experiment took place promotes a vegetarian dish as "meal of the day". Customers may have chosen this option instead of purchasing a dish from the hot vegetable buffet. For prebiotic vegetables, there was more variability on the sales of hot vegetables from the buffet on Fridays than on Mondays, as well as an overall decrease over the five weeks of the study. The change in variability could be due to the fact that on Fridays there are fewer customers overall, as many students leave early to go home for the weekend and do not have lunch at the restaurant. On the other hand, the difference in the uptake of prebiotic vegetables over the weeks may reflect the novelty or variety drive (Faison, 1977). This phenomenon, which is the opposite of food neophobia, implies that under certain conditions people have a need for variety in their daily lives. During the first week of the study, the percentage of customers who chose prebiotic vegetables was the highest, suggests that the novelty of unfamiliar vegetables may have played a role, especially amongst habitual hot vegetable buffet customers. However, as time passed, the novelty of the prebiotic vegetables diminished, hence the uptake of these vegetables also decreased over time.

4.1. Limitations

This study is not without limitations. A first limitation is that the study design did not include a real reference week. For practical reasons, week 1 was considered as a reference, as no experimental intervention took place. However, since that week the prebiotic vegetables were introduced to the hot vegetable buffet, a novelty effect may have been induced, resulting in increased sales of vegetables that week. This may explain the decreasing prebiotic vegetable choice over time. It would be preferable to allow some adjustment time to let the novelty effect weaken before the baseline measure in future studies.

A second limitation is that the study only included one week for the accessibility intervention (i.e., type-1 nudging), which was offered simultaneously with the cue-to-action (type-2 nudge). As a result, the direct effect of the type-1 nudge could not be distinguished from its combination with the type-2 nudge. Moreover, only the direct effects of each intervention type could be considered in the analyses, while there may have been an interaction effect. As such, the absence of a significant effect of the combined type-1 and type-2 nudge on prebiotic vegetable choice may be the result of the influence of negative influence the type-2 nudge. However, we considered it important to attract more customers to the vegetable buffet before implementing other nudges because customers who do not visit the buffet cannot be influenced by the placement of the food. Moreover, as a type 2 nudge requires a more conscious choice at some point (Hansen & Jespersen, 2013), it can be expected to work only for customers who have an intention to eat healthy, so there could have been a selection bias for customers who were exposed to the type-1 nudge. The intention to eat healthy was not measured in the current study because the aim was to measure natural behaviour and questionnaires could have interfered with this design. However, this assumption could be measured in a future study.

A potential effect of the type-1 nudge may also have been undermined by the "week" effect (i.e., the decrease of prebiotic vegetable choice over the weeks of the experiment). Moreover, the variation of the non-prebiotic vegetable dishes over the days may have influenced sales due to their different taste, colour or visual texture, but it was not possible to control for these variables because of the policy of the restaurant to provide a variation of dishes to regular customers. To control for all these effects experimentally would have required a randomized design that would have been impossible to organize in a realistic restaurant setting. However, adding a week with the type-1 nudging but without the cue-to-action could have given some information to estimate the interaction effects. External constraints that are impossible to avoid, such as daily variations (e.g., having a vegetarian meal of the day on a given day) or differences between weeks (e.g., a holiday during one of the weeks) should be taken into account in statistical models as potential fixed or random effects, depending on the context.

Another limitation is that, for practical reasons, food sales and observed food choice were used to operationalize the dependent variables. It should be kept in mind that these are only proxy measures of actual food consumption. In addition, the presence of observers to measure the choice of prebiotic vegetables may have had an effect on the customer's behaviour. Although the observers positioned themselves in an unobtrusive place, it cannot be ruled out that they were noticed by some customers who adapted their behaviour accordingly because they knew they were participating in an experiment (Hawthorne effect). On the other hand, this observer effect does not interfere with the comparability of the conditions, as the measures were kept constant during the five weeks of the study.

Finally, as the clientele of the restaurant varied, the composition of the sample was not constant over the weeks. Some customers may also have been included in the sample several times, if they were "regulars". However, the latter is accounted for by the fact that the beta regression model that was used for the statistical analysis allows observations to be dependent on each other.

4.2. Conclusion

This study demonstrated that nudging can be an effective strategy to influence vegetable choice. However, the effectiveness depends on the specificity and the familiarity of the vegetables. On the one hand, a "conscious" type-2 nudge (cue-to-action) appears to increase vegetable choice in general, but to decrease the choice for unfamiliar prebiotic vegetables. On the other hand, a combination of a type-1 nudge (increasing the accessibility) and type-2 nudge (cue-to-action), does not increase the choice or portion size of prebiotic vegetables. To further interpret these findings, future studies should investigate the effects of different types of nudges both in combination and separately, and to examine the importance of the specificity and familiarity of the nudged products for the effectiveness of nudging.

5. Conflict of interest

None.

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