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Reducing meat consumption using a diet-related written prompt and the Swiss food pyramid: A field study

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ABSTRACT

Current levels of meat consumption in developed countries exceed nutritional recommendations and harm the environment. A promising intervention to reduce meat consumption is prompts, that is, reminders to perform a specific behavior in a particular situation. The present study tested a written prompt combined with an adapted version of the visualized Swiss dietary recommendations 'Swiss Food Pyramid' in the field. The study was conducted simultaneously in two staff restaurants with a two-week baseline period followed by a two-week intervention period. Participants ($n = 131$) photographed their food choices in the staff restaurants using a depth camera provided. The amount of meat on their plates was estimated using the automatic volume estimation module by goFOOD™, an artificial intelligence-based automatic dietary assessment system. The results showed that participants in one staff restaurant preferred the vegetarian menu over the meat menu when exposed to the intervention, consequently reducing their meat consumption. The intervention was particularly successful among participants with a positive attitude toward environmental protection and high health consciousness. Participants who enjoyed meat for hedonistic reasons and who ate meat the most frequently were less influenced by the intervention. In the other staff restaurant, the intervention had no effect. Potential reasons are discussed in light of the different clientele of the two staff restaurants.

1. Introduction

The estimated average meat consumption in developed countries is about 57 kg per capita per year (Organisation for Economic Cooperation and Development, 2023). Depending on the dietary guidelines of different European countries, this exceeds the recommendations for a balanced and thus healthy diet by a factor of two to three (Cocking et al., 2020). High levels of meat consumption are also a major contributor to climate change and environmental pollution (Godfray et al., 2018). This raises the question of how to effectively reduce meat consumption.

In contrast to regulatory instruments or significant changes in economic incentives, interventions that do not restrict freedom of choice may be better accepted by consumers (Ammann et al., 2023; Mertens et al., 2022a). Therefore, they are of interest when trying to reduce meat consumption. A recent meta-analysis found them to have a small to medium effect size. These interventions can be categorized as (1) decision structure-related (e.g., changing default options), (2) decision information-related (increasing the availability, comprehensibility, and/or personal relevance of information), and (3) decision assistance-related (e.g., providing reminders). A comparison showed the best results for decision structure-related interventions, although decision information-related and decision assistance-related interventions were also found to be effective (Mertens et al., 2022a). However, other analyses that correct for publication bias more rigorously do not confirm the effectiveness of such interventions (Bakdash & Marusich, 2022; Maier et al., 2022; Szaszi et al., 2022). A further issue is the high heterogeneity in the effect sizes of various of those interventions (Hummel & Maedche, 2019; Mertens et al., 2022b). Therefore, it is considered important to examine, for example, contextual factors and individual characteristics, such as intentions, that may explain differences in the effectiveness of an intervention (Mertens et al., 2022b; Szaszi et al., 2017; Szaszi et al., 2022).

An intervention that strengthens behavioral intentions or positive attitudes is prompts (Abrahamse & Matthies, 2018). Prompts are

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reminders in the form of a written message and/or a visual cue about how to best behave in a particular situation. To successfully support behavioral change, prompts should be integrated into the decision context as closely as possible to when a decision is made and when an intended behavior can be performed (Papies, 2017). A meta-analysis of pro-environmental behavior research found prompts to be effective in influencing people's behavior (Osbaldiston & Schott, 2012). More recently, in a study of 680,000 persons, prompts in the form of text messages increased vaccination rates in pharmacies by 6.8 % (Milkman et al., 2022).

1.1. Prompts to change dietary behavior

Prompts have been found to be effective in reducing food waste in restaurants (Stöckli et al., 2018), increasing fruit and vegetable intake in university cafeterias (Yi et al., 2022), and reducing red meat consumption among undergraduate students (Carfora et al., 2017). Overall, however, prompts have rarely been tested in the field for their potential to reduce meat consumption. Promisingly, an online choice experiment recently showed that individuals who encountered a written prompt to choose a meatless option combined with an adapted version of the visualized Swiss dietary recommendations 'Swiss Food Pyramid' (see Fig. 1) preferred meatless options over meat menu options (Zumthurm & Stämpfli, 2024). To confirm the results of this online study, specifically to address the external validity of the intervention, it should be tested in real-world settings.

Various drivers, such as positive attitudes, intentions, and other individual characteristics, could help reduce meat consumption by using a prompt (i.e., increasing a prompt's effectiveness). However, there are potential barriers to a prompt's effectiveness. Generally, more research is needed to elucidate the psychological constructs that interact with prompts (Stöckli et al., 2018). The present study, therefore, tests a set of individual characteristics that could strengthen or attenuate a prompt's effectiveness.

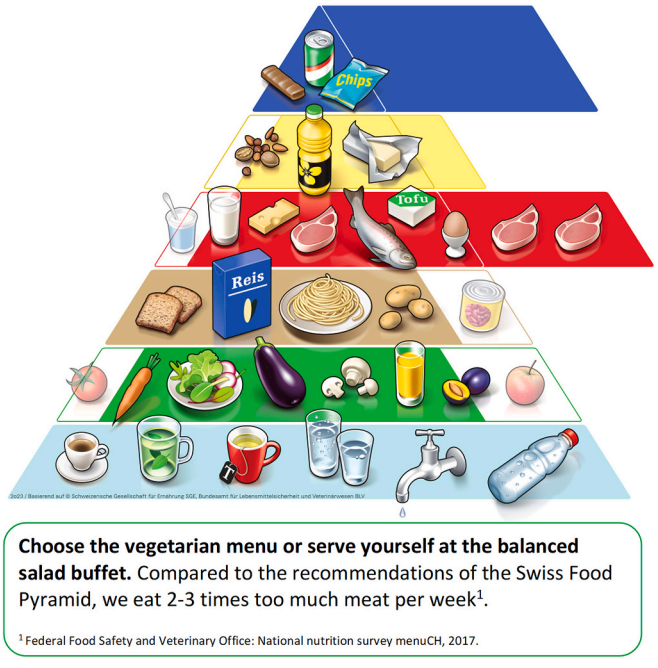

Fig. 1. The intervention consisted of a written prompt and a visual element (the 'Unbalanced Swiss Food Pyramid'). The pyramid reveals the gap between the recommended and actual consumption of different food categories. The overconsumption of meat was emphasized by adding two additional meat icons to the red protein bar. The intervention design was obtained from an online study (Zumthurm & Stämpfli, 2024). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

1.2. Potential drivers of the prompt's effectiveness

Individuals with positive attitudes and intentions toward reducing meat consumption could respond better to prompts regarding meat consumption than those with negative attitudes and weak or no intentions. For instance, when study participants had to formulate if–then plans, those with strong existing intentions to reduce meat consumption reduced their meat consumption more than those with weak intentions to reduce meat consumption (Loy et al., 2016).

Furthermore, individuals high in health consciousness might respond better to a diet-related prompt than those low in health consciousness. Health messages targeted at decreasing the intention to eat red meat were more effective among individuals who were concerned about eating healthily to prevent diseases than among individuals who were less concerned about it (Bertolotti et al., 2019). Similarly, preexisting beliefs about the negative effects of red meat consumption on health and the environment facilitated the effect of persuasive messages on decreasing the intention to consume red meat and increasing the intention to consume plant-based alternatives (Vainio et al., 2018).

Regarding the environment, communicating a message about the environmental and health benefits of reducing meat consumption increased the intention to reduce meat consumption the most among individuals who placed importance on environmental sustainability (Verain et al., 2017). Therefore, individuals with pro-environmental attitudes might also be more easily triggered by a prompt to reduce meat consumption than individuals without pro-environmental attitudes.

1.3. Potential barriers to the prompt's effectiveness

Meat consumption is a highly habituated process (Rees et al., 2018). The stronger a habit is, the more difficult it is to change it (Wood & Neal, 2009). Therefore, strong eating habits could be a barrier to convincing individuals to reduce their meat consumption. Similarly, high meat consumption frequencies are negatively associated with willingness to reduce meat consumption (Sanchez-Sabate & Sabate, 2019). Therefore, the effectiveness of a diet-related prompt to reduce meat consumption may be hindered among individuals with a high frequency of meat consumption.

Some individuals enjoy eating meat simply for hedonistic reasons and have a strong meat attachment (Graça et al., 2015). Consumers with strong meat attachment are typically unwilling to reduce meat consumption and are often skeptical toward meat alternatives (Götze & Brunner, 2021). Therefore, it could be challenging to persuade meat enthusiasts to eat less meat.

Furthermore, individuals could behave contrary to a prompt's recommendations regarding a behavioral change because they feel a threat to their freedom of choice, a phenomenon known as psychological reactance (Reynolds-Tylus, 2019). For example, daily reminders highlighting the negative consequences of meat consumption for the environment, human health, and animal welfare had the unintended effect of increasing meat consumption among the participants of a recent study (Ottersen et al., 2022).

1.4. Automatic dietary assessment

Measuring the effect of an intervention on meat consumption requires a dietary assessment. Traditional dietary assessment methods include long-term approaches, such as food frequency questionnaires (Pannen et al., 2023; Steinemann et al., 2017; Willett et al., 1985) and short-term approaches, such as 24-h recalls and dietary records (Poslusna et al., 2009; Yuan et al., 2017). However, these approaches are time consuming, labor intensive, costly, and error prone. For example, they rely on manual processes in which individuals record their food

intake, which can introduce inaccuracies due to subjectivity and recall bias (Stumbo, 2013). Recent advances in artificial intelligence (AI) offer a promising solution for more efficient, real-time, and accurate dietary assessments.

The process within an AI-based automatic dietary assessment system, such as goFOOD™, which has demonstrated accuracy comparable to that of dietitians (Lu et al., 2020; Papathanail et al., 2023), typically follows a structured workflow. It starts by capturing images, which are subsequently subjected to food segmentation and recognition tasks by AI-based algorithms. These algorithms, usually neural networks, distinguish and categorize individual food items within the image, such as identifying whether an item is a meat or a vegetable. The volume of each food item can then be estimated using various techniques, usually by estimating the depth of each pixel of the image. Two approaches can be adopted to generate depth information: utilizing a single image through depth cameras or AI-based approaches, or employing multi-view images using geometry to infer depth. Depth camera-based food volume estimation has been found to provide a balance between accuracy and user-friendliness (Abdur Rahman et al., 2023). Lastly, the volume computed for each individual food item is multiplied by its respective energy and nutrient content, utilizing publicly accessible food composition databases, such as the USDA's FoodData Central (U.S. Department of Agriculture, 2024) and the Swiss Food Composition Database (Federal Food Safety and Veterinary Office, 2023). Adding the values for all food items results in the energy and macro-nutritional content of the entire meal.

1.5. The present study and its research questions

The aim of the present study was to test an intervention to reduce meat consumption in the field that had proven successful in promoting the choice of meatless menu options online (Zumthurm & Stämpfli, 2024). Specifically, in the present study, the intervention was conducted simultaneously in two staff restaurants. The intervention was a combination of a written prompt to choose a vegetarian option or the salad buffet and an adapted version of the visualized Swiss dietary recommendations 'Swiss Food Pyramid,' which emphasizes the over-consumption of meat (Fig. 1). To measure meat consumption objectively, participants photographed their meals with a depth camera provided for four weeks. The automatic volume estimation module from goFOOD™, an AI-based automatic dietary assessment system (Lu et al., 2020; Papathanail et al., 2023), was used to estimate the amount of meat in the images. Ideally, a study combines objectively measured data with the individual characteristics of the participants (Baumeister et al., 2007). Therefore, individual characteristics were captured using a survey and linked to data on the amount of meat. Furthermore, there is a lack of studies that measure meat consumption objectively, and potential moderators of intervention effectiveness are underexplored (Kwasny et al., 2022). Thus, the present study addresses several research gaps.

The following key research question (RQ) and hypothesis (H) were formulated and preregistered (https://osf.io/qytd8):

RQ1: What is the effect of an intervention combining a written prompt and a visual element to reduce meat consumption in two different staff restaurants on the **amount of meat (g)** chosen by the study participants?

H1: The intervention decreases the amount of meat chosen by the study participants in both staff restaurants.

The following secondary research questions address the mechanism driving the observed effect (e.g., do participants reduce their meat consumption by choosing the vegetarian menu more often, or do they serve themselves less meat from the buffet?):

RQ2: What is the effect of the intervention in two different staff restaurants on the type of meal selected (meat menu, vegetarian menu, or buffet)?

RQ3: What is the effect of the intervention in two different staff restaurants on the **amount of meat (g) chosen at the buffet** by the study participants?

Based on the literature review on potential drivers and barriers to the prompt's effectiveness (Sections 1.2 and 1.3), a set of individual characteristics was further tested for their potential influence on the effectiveness of the diet-related prompt.

RQ4: Which individual characteristics facilitate or attenuate the effect of the intervention on menu choice and/or the amount of chosen meat?

Three individual characteristics that could facilitate the prompt's effect were assessed: intention to reduce meat consumption, health consciousness, and pro-environmental attitude. Four individual characteristics with the potential to attenuate the prompt's effect were also investigated: meat eating habits, frequency of meat consumption in main dishes, eating meat for reasons of personal pleasure, and reactance.

Other than being preregistered, the data on the total amount of meat consumed during the study by all the staff restaurant visitors, independent of study participation, could not be used for analysis because the weighing of the buffet meat containers was too imprecise in one of the staff restaurants.

2. Methods

2.1. Participants

The study was conducted in two staff restaurants in Swiss federal offices. Participants were recruited via e-mail and the internal communication channels of the federal offices in May 2023. The required sample size was calculated based on the data of a previous online study (Zumthurm & Stämpfli, 2023). In the online study, half of the vegetarian options were meat substitutes (Zumthurm & Stämpfli, 2024). As the proportion of meat substitutes was assumed to be considerably smaller in real-world staff restaurants, the effect size of the intervention in the online study was recalculated based only on the choice situations without meat substitutes. This resulted in a Cohen's d of 0.23, which was used to calculate the required sample size for the field study in G*Power version 3.1.9.7, with an alpha error probability of 0.05 and a power of 0.80, for a repeated measures design with within-between interactions. The required sample size also depended on how often the study participants visited the staff restaurant during the study. The calculation of the sample size in the preregistration was based on a conservative assumption that participants visited the staff restaurant only twice during the baseline and twice during the intervention period. According to this assumption, 52 people would have had to participate in each location. In total, 202 individuals completed the initial questionnaire and registered for the study. Participants who never recorded their menu choices during the study period ($n = 38$), those who recorded their menu choices in only one of the two study periods ($n = 17$), and vegetarians ($n = 16$) were excluded. After the exclusions, the sample consisted of 131 participants ($n_{\text{Restaurant 1}} = 91$, $n_{\text{Restaurant 2}} = 40$). Since participants in Staff Restaurant 2 photographed their menu choices on average 8 times during the study, according to G*Power, 34 participants would have already been a sufficient sample size.

The first staff restaurant (Staff Restaurant 1) was located on the campus of three federal offices (the Federal Office for Agriculture, the Federal Office of Public Health, and the Federal Food Safety and Veterinary Office) and a research institution (Agroscope) (age range participants 18–66 years, $M = 43.77$ years, $SD = 10.47$, 61.5 % female, 96.7 % education higher than vocational education). The staff restaurant was operated by a canteen operator and served lunch Monday through Friday to a daily clientele of approximately 300–400 people. The second staff restaurant (Staff Restaurant 2) belonged to the Federal Office for Building and Logistics (age range participants 25–60 years, $M = 46.83$ years, $SD = 7.94$, 40.0 % female, 85.0 % education higher than vocational education), was operated by the same canteen operator, and had a daily clientele of approximately 100–200 people per day.

The participants in both locations were similar in terms of intention

to reduce meat consumption ($t(1, 129) = -0.29$, $p = 0.771$), health consciousness ($t(1, 129) = 0.12$, $p = 0.903$), attitude toward environmental protection ($t(1, 129) = -0.92$, $p = 0.360$), eating habits ($t(1, 129) = 0.17$, $p = 0.862$), and reactance ($t(1, 129) = -0.43$, $p = 0.666$). However, the participants in Staff Restaurant 2 placed more importance on hedonic meat-eating ($M = 4.56$, $SD = 1.55$) than those in Staff Restaurant 1 ($M = 3.87$, $SD = 1.60$), $t(1, 129) = 2.32$, $p = 0.022$. In addition, the participants in Staff Restaurant 2 had a higher self-reported meat-eating frequency ($M = 3.80$, $SD = 1.80$) than those in Staff Restaurant 1 ($M = 3.07$, $SD = 1.55$), $t(1, 129) = 2.38$, $p = 0.019$.

2.2. Study design and procedure

A 2 × 2 mixed design was applied, with the location as a between-subjects factor and the periods baseline versus intervention (prompt) as a within-subjects factor. Participants were asked via e-mail if they would like to participate in a four-week study about dietary behavior in June 2023. The participants gave their informed consent before participating. They were asked to complete a questionnaire to assess their individual characteristics and to photograph their meals at the staff restaurant during the coming study period. The participants created their own participation number to participate anonymously. As an incentive, the participants received a voucher worth 20 Swiss francs for their staff restaurant if they participated until the end of the study. In addition, a voucher worth 200 Swiss francs was raffled at the end of the study in each location. There were no criteria for a minimum number of staff restaurant visits per week due to part-time work and the use of remote work options. One week before the start of the field study, the participants received a reminder that the study would begin the following week.

In both staff restaurants every day, the participants had the choice between a meat menu, a vegetarian menu, and a buffet with hot dishes and a variety of salads. The buffet was mostly vegetarian but also contained meat options. In addition, Staff Restaurant 2 daily offered a "surprise" menu, which most of the time contained meat. During the entire field study, the study participants photographed their food choices at the exit of the staff restaurant, where a camera was installed. They placed their tray with the full plate on it under the camera, together with their participation number, and took a picture. During the first two weeks, a person from the study team stood next to the camera in case the participants needed assistance in taking the picture. After the two-week baseline period, the intervention material was installed for two weeks.

2.3. Materials and measures

2.3.1. Intervention

During the intervention period, the participants were exposed to the text "Choose the vegetarian menu or serve yourself at the balanced salad buffet. Compared to the recommendations of the Swiss Food Pyramid, we eat 2–3 times too much meat per week." In addition, the participants were exposed to an adapted version of the visualized Swiss dietary recommendations, which emphasizes the overconsumption of meat; that is, the 'unbalanced Swiss Food Pyramid' (Fig. 1). The intervention content was pretested in an online experiment (Zumthurm & Stämpfli, 2024) and was based on a representative Swiss nutrition survey (Federal Food Safety and Veterinary Office, 2017).

The participants were exposed to the intervention in several places and forms in the staff restaurant (illustrations in the supplementary information). The intervention was printed on a canvas and displayed at the entrance of the staff restaurant. The intervention was also printed on a transparent foil that was laid on top of the menu list. In addition, posters were placed next to the menu list. The unbalanced Swiss Food Pyramid was further installed on a triangle chipboard next to the cutlery and trays in one location and in the other location on the salad buffet. The protein section of the Swiss Food Pyramid was highlighted with a red light. The written prompt was presented next to the unbalanced Swiss Food Pyramid. The intervention was also placed on the counters of the menus. In addition, in both staff restaurants, a monitor alternately displayed the official Swiss Food Pyramid, the unbalanced Swiss Food Pyramid, and the written prompt.

2.3.2. Estimating the amount of meat chosen using the goFOOD™ system

An Intel RealSense Depth Camera D455i[1] was utilized to capture color and depth images of the participants' meals to measure the amount of meat on their plates. Only images that could contain meat were analyzed: 142 and 126 meat menu images and 245 and 124 buffet images from Staff Restaurants 1 and 2, respectively. To estimate the amount of meat chosen based on the images, the first step was to detect where meat appeared in the image. This can be achieved either semi-automatically, involving human-led image annotation, or fully automatically, using the predictions of an AI-based segmentation network. In the present study, meal images were segmented both semi-automatically and automatically. After this step, the volume of the meat was computed using the depth information provided by the depth camera, along with the (semi-automatic and automatic) segmented areas.

For the semi-automatic segmentation, the researchers annotated meat menu and buffet images with a tool (Fig. 2). The tool allowed the annotators to select food segments and plate segments with clicks and amend segments using a painting brush. Each item in the segmented area was labeled as one of six food categories (soup, meat, sauce, side dish, vegetables/salad, dessert) or one of four plate types (round plate, soup bowl, square bowl, glass). For the automatic segmentation, a pre-trained segmentation network analyzed the color images and automatically segmented the various foods (Lu et al., 2020; Papathanail et al., 2021). To improve the network's accuracy, 80 % of the researcher-annotated data were used to fine-tun the network, while the remaining 20 % were used to test its performance. Compared with the annotated data, the network's predicted segmented areas achieved a 72.41 % intersection over union, a standard metric that demonstrates strong alignment with the researchers' semi-automatic annotations. This performance is consistent with previous studies on food image segmentation (Papathanail et al., 2021).

The next step was the automatic volume estimation process, during which the depth information captured by the depth camera was used along with the segmented areas (both from the semi-automatic process and the automatic process) to compute the volume of the segmented food item in milliliters. This volumetric output was then converted into grams, leveraging a compiled food database equipped with density conversion factors. It is noteworthy that different meat types possess distinct densities, thus necessitating a tailored conversion from milliliters to grams for each meal.

To compare the performance of the volume estimation module using either the automatically predicted segmented areas or the human-annotated data, both sets of data were compared to the information from the kitchen about the weight of the meat component from the meat menu. This comparison showed that the mean absolute percentage error was 22.8 % for the human-annotated data and 24.1 % for the segmentation network, with only a small difference of 1.3 % between them. Given this small difference and considering that the AI-based approach could only use 20 % of the data (since the other 80 % was used for fine-tuning), the researchers decided to use the human-annotated data to measure meat chosen from the buffet during both the baseline and intervention periods. It is important to mention that the uncertainty in these measurements was consistent for both periods, so it did not affect the results observed.

2.3.3. Measures

The amount of meat chosen per study participant in grams was the

[1] https://www.intelrealsense.com/depth-camera-d455/

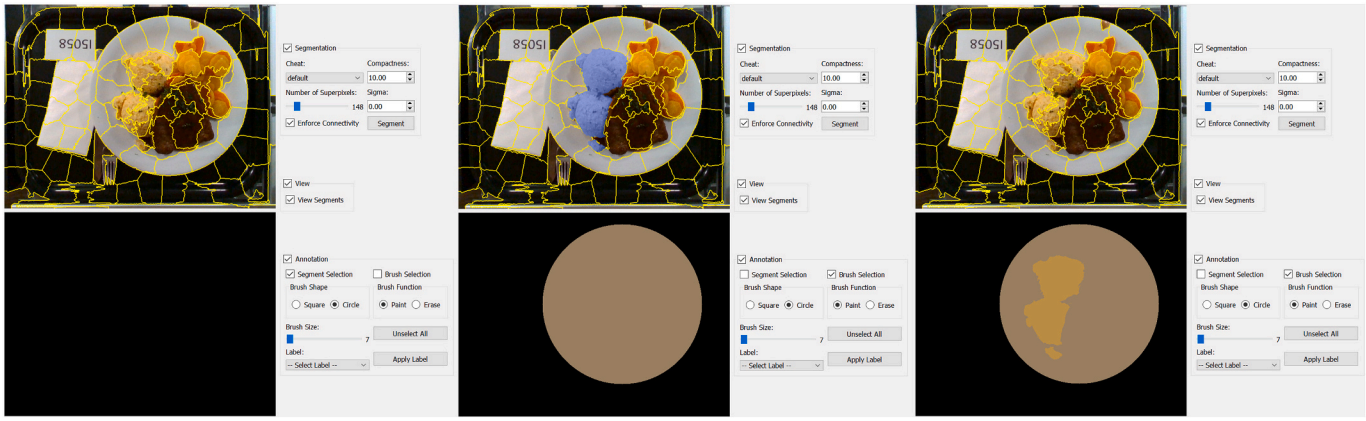

Fig. 2. The in-house developed annotation tool. The image is split into regions and the users can select the pixels to segment the image into the different food items.

main dependent variable. For the meat menus, the amount of meat in grams was obtained from the staff restaurants' recipes. For the amount of meat chosen from the buffet, the automatic volume estimation module of the goFOOD™ system was used, which relied on data from the researchers' annotations using the food annotation tool and the information provided by the depth cameras (see Section 2.3.2). The ***participants' menu choice (meat, vegetarian, or buffet)*** was the second dependent variable. The classification into the different menu categories was performed manually based on the pictures.

Additionally, the participants' individual characteristics were obtained from the questionnaire. The construct variables were all measured on a 7-point Likert scale ranging from 1 ("strongly disagree"/"does not apply to me at all") to 7 ("strongly agree"/"applies to me totally"). The *intention to reduce meat consumption* was measured as a binary variable (1 = yes—I have the intention to reduce meat consumption; 0 = no; 26.7 % yes). *Health consciousness* ($\alpha = 0.69$; $M = 5.50$, $SD = 0.78$) was assessed using the scale of Dohle et al. (2014), which was adapted from Schifferstein and Ophuis (1998) and included four items. An example item reads, "My health is dependent on how and what I eat." *Attitude toward environmental protection* ($\alpha = 0.80$; $M = 6.34$, $SD = 0.64$) was assessed using the scale of Chen and Chai (2010) and contained five items. An example item reads, "If all of us, individually, made a contribution to environmental protection, it would have a significant effect." *Habit* ($\alpha = 0.84$; $M = 4.82$, $SD = 0.86$) was assessed using the scale developed by Renner et al. (2012) and contained three items. An example item reads, "I eat what I eat because I am familiar with it." *Meat and/or fish-eating frequency* ($M = 3.29$, $SD = 1.66$) was assessed using the single-item question of how often meat and/or fish is eaten as a main course per week (0–7 times per week). *Hedonism related to meat*, that is, eating meat for reasons of personal pleasure ($\alpha = 0.94$; $M = 4.08$, $SD = 1.61$), was assessed using the scale developed by Graça et al. (2015) and contained four items. An example item reads, "To eat meat is one of the good pleasures in life." *Reactance* ($\alpha = 0.82$; $M = 3.54$, $SD = 0.94$) was assessed with the short version by Dillard and Shen (2005) consisting of eight items of the original scale (Hong & Faedda, 1996). The factor 'emotional response toward restricted choice' was not assessed, as no choices were restricted in the present study. An example item reads, "I resist the attempts of others to influence me."

3. Results

3.1. The effect of the intervention on the amount of meat chosen (RQ1)

To analyze the effect of the intervention on the amount of meat chosen, a mixed-effects regression was executed in R version 4.2.2, with the amount of meat chosen as the dependent variable and the intervention and the location as fixed factors. A model containing a conditional model part and a zero-inflated model part with a gamma distribution was used to account for the many zero values (vegetarian menus and meatless buffet menus) and to inform the model of the absence of negative values (package: glmmTMB). The random structure of the regression was specified by including random intercepts for participants to account for within-participant variance. No random slopes were included. The conditional part of the model indicates, given that participants chose meat, whether they chose less meat during the intervention. The zero-inflated part of the model transformed the data into a binary form (meat yes/no) and deciphered whether the intervention changed the share of meatless options (vegetarian menus and meatless buffet choices) compared to options with meat (meat menus and buffet choices with meat).

There was no main effect of the intervention on the amount of meat chosen or the share of meatless options. However, the success of the intervention depended on the location and can be observed in the zero-inflated model ($\beta = 0.730$, $p = 0.021$; Cohen's $d = 0.40$, which is a small effect size) (Table 1). In Staff Restaurant 2, the odds of study participants preferring a meatless option over an option with meat increased by 2.076 during the intervention. The conditional model revealed that when participants chose meat, they did not choose less during the intervention compared to the baseline period in either of the two locations ($\beta = 0.0002$, $p = 0.998$). This suggests that the reduction in the amount of meat chosen did not come from a reduction of meat chosen from the buffet but rather from a complete switch from meals with meat toward meals without meat. Other than as formulated in H1, the intervention only reduced the amount of meat chosen among study participants in Staff Restaurant 2 ($\beta = 0.652$, $p = 0.012$) but not among study participants in Staff Restaurant 1 (β = -0.083, $p = 0.654$), when comparing the baseline period to the period with the prompt (Fig. 3).

3.2. Effect of the intervention on menu choice (RQ2)

To analyze the effect of the intervention on menu choice (meat menu, vegetarian menu, or buffet), a multinomial logit mixed-effects model was executed (package: mclogit), with the meat menu as the reference category. The random structure of the regression was specified by including random intercepts for participants to account for within-participant variance. No random slopes were included.

There was no main effect of the intervention on menu choice. However, the success of the intervention depended on the location ($\beta = 1.044$, $p = 0.005$; Cohen's $d = 0.58$, which is a medium effect size) (Table 2). In Staff Restaurant 2, the odds of study participants choosing a vegetarian menu instead of a meat menu increased by 2.840 during the intervention. The participants in Staff Restaurant 2 chose the vegetarian menu more often than the meat menu ($\beta = 0.839$, $p = 0.006$), whereas the participants in Staff Restaurant 1 did not ($\beta = -0.209$, $p = 0.345$).

Table 1
Parameter estimates and odds ratios for the conditional and the zero-inflated mixed-effects model.

RQ1: Effect of intervention on the amount of meat chosen (gram)					
Fixed effects: conditional model	***B***	***SE (B)***	***z-value***	***OR***	***95 % CI***
(Intercept)	4.708***	0.051	91.571	110.790	100.183, 122.486
Intervention	-0.051	0.070	-0.727	0.950	0.828, 1.091
Location (Staff Restaurant 2)	0.014	0.073	0.193	1.014	0.880, 1.169
Intervention × Location (Staff Restaurant 2)	0.0002	0.101	0.000	1.000	0.821, 1.219
Random effect: conditional model	***SD***				
Participants (intercept)	0.059				
Fixed effects: zero-inflation model	***B***	***SE (B)***	***z-value***	***OR***	***95 % CI***
(Intercept)	0.650***	0.175	3.708	1.916	1.358, 2.702
Intervention	-0.083	0.186	-0.446	0.920	0.640, 1.326
Location (Staff Restaurant 2)	-1.693***	0.317	-5.333	0.184	0.099, 0.343
Intervention × Location (Staff Restaurant 2)	0.730*	0.317	2.306	2.076	1.116, 3.861
Random effect: zero-inflation model	***SD***				
Participants (intercept)	1.049				
Observations (number of images)	984				
Log-likelihood	-3149.0				
Deviance statistic	6298.1				
AIC	6320.1				
BIC	6373.9				

Note. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

The intervention did not influence the choice of a buffet menu compared to the meat menu, regardless of location ($\beta = 0.640$, $p = 0.088$; Table 2).

Fig. 4 descriptively illustrates that there was a reduction in the share of meat menus in Staff Restaurant 2, which is mainly due to the higher share of vegetarian menus selected during the intervention period compared to the baseline period.

3.3. Effect of the intervention on the amount of meat chosen from the buffet (RQ3)

To calculate the effect of the intervention on the amount of meat chosen from the buffet, the meat consumption data were filtered for buffet choices, and the model with the conditional and zero-inflated part was executed again for Staff Restaurant 2, as the intervention proved effective only in this restaurant (see Section 3.1). The intervention had no effect on the amount of meat chosen from the buffet ($\beta = -0.279$, $p = 0.106$) and no effect on the choice of a meatless option from the buffet ($\beta = 0.071$, $p = 0.878$). This indicates that the reduction in meat consumption in Staff Restaurant 2 was mainly due to an increased choice of vegetarian menus (replace meat) and not to smaller portions of meat from the buffet (reduce meat).

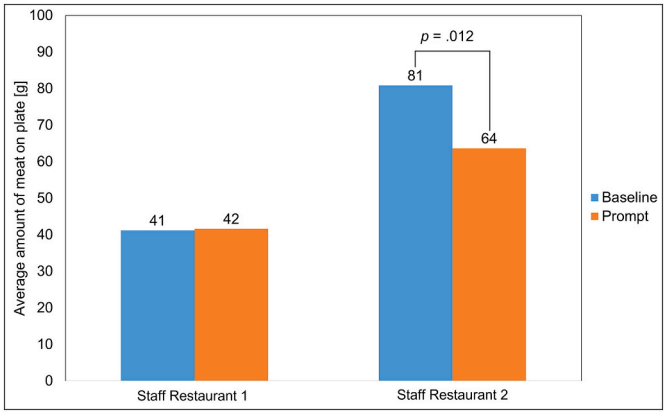

Fig. 3. The average amount of meat chosen by study participants during the baseline (blue) and the intervention period with the prompt (red) in both staff restaurants. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.4. Variables influencing prompt's effectiveness (RQ4)

Thus far, the analyses have shown that the reduction in meat consumption was due to the more frequent choice of a vegetarian menu. To test whether individuals with certain characteristics were more strongly influenced by the intervention to choose a vegetarian menu, the intervention's effect on the choice of the vegetarian menu was analyzed for interactions with individual characteristics using multinomial logistic regression. There was no interaction between the intervention and individual characteristics when the variable location was not included. As the intervention only proved successful in Staff Restaurant 2, three-way interactions between location, intervention, and individual characteristics were calculated. A positive attitude toward environmental protection ($\beta = 1.394$, $p = 0.030$; Cohen's $d = 0.77$) and a high health consciousness ($\beta = 1.042$, $p = 0.028$; Cohen's $d = 0.57$) each positively influenced the effect of the intervention to promote vegetarian menu choices in Staff Restaurant 2. Furthermore, participants who scored high in hedonism related to meat—that is, eating meat for reasons of personal pleasure—(β = -0.712, $p = 0.011$; Cohen's d = -0.39) and those with higher meat and/or fish-eating frequency for main dishes per week (β = -0.516, $p = 0.032$; Cohen's d = -0.28) were less influenced by the intervention to prefer a vegetarian menu over a meat menu in Staff Restaurant 2.

4. Discussion

4.1. Summary and discussion of key results

The present field study tested whether a diet-related intervention can reduce meat consumption in two different staff restaurants. The intervention consisted of a written prompt that read, "Choose the vegetarian menu or serve yourself at the balanced salad buffet. Compared to the recommendations of the Swiss Food Pyramid, we eat 2–3 times too much meat per week." An adapted version of the visualized Swiss dietary recommendations 'Swiss Food Pyramid,' which emphasizes the overconsumption of meat (the 'unbalanced Swiss Food Pyramid'), complemented the written prompt.

Table 2
Parameter estimates and odds ratios for the multinomial logit mixed-effects model.

RQ2: Effect of intervention on food choice					
Fixed effects: vegetarian vs. meat	***B***	***SE (B)***	***z-value***	***OR***	***95 % CI***
(Intercept)	0.679***	0.202	3.361	1.971	1.327, 2.928
Intervention	-0.209	0.221	-0.942	0.812	0.526, 1.253
Location (Staff Restaurant 2)	-1.872***	0.362	-5.164	0.154	0.076, 0.313
Intervention × Location (Staff Restaurant 2)	1.044**	0.375	2.785	2.840	1.362, 5.920
Random effect: vegetarian vs. meat	***SD***				
Participants (intercept)	1.110				
Fixed effects: buffet vs. meat	***B***	***SE (B)***	***z-value***	***OR***	***95 % CI***
(Intercept)	0.466*	0.225	2.069	1.593	1.025, 2.478
Intervention	-0.292	0.235	-1.240	0.747	0.471, 1.185
Location (Staff Restaurant 2)	-1.207**	0.382	-3.160	0.299	0.141, 0.632
Intervention × Location (Staff Restaurant 2)	0.640	0.375	1.708	1.896	0.910, 3.951
Random effect: buffet vs. meat	***SD***				
Participants (intercept)	1.352				
Observations (number of images)	984				
Pseudo R^2 (Nagelkerke)	0.28				

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

This intervention successfully reduced meat consumption among participants in one of the staff restaurants (Staff Restaurant 2). The participants reduced their meat consumption by choosing a vegetarian menu more often (replacing) and not by eating less meat from the buffet (reducing). The intervention was most effective among participants with a positive attitude toward environmental protection and with a high health consciousness and the least effective among participants who reported the highest meat consumption levels and scored highest in eating meat for hedonistic reasons. In Staff Restaurant 1, the intervention did not reduce meat consumption.

In Staff Restaurant 2, where the intervention proved effective, participants did not work with topics related to nutrition and health issues, in contrast to the participants who visited Staff Restaurant 1. Participants in Staff Restaurant 1 were probably already familiar with diet-related health issues by profession and may have already made up their minds about their meat consumption. This does not mean they were more health conscious (there was no difference in health consciousness between the participants at the two locations; see Section 2.1), but it suggests that they were likely to be more knowledgeable about health issues and that the diet-related prompt did not provide them with new knowledge. It is therefore possible that the participants in Staff Restaurant 1 either resisted changing their meat consumption or had already reduced their meat consumption in the past. The lower average meat consumption during the baseline period among the study participants in Staff Restaurant 1 (average of 41 g of meat per plate versus average of 81 g of meat per plate in Staff Restaurant 2, Fig. 3) reflects the possibility that many participants in Staff Restaurant 1 had already reduced their meat consumption before the start of the present study. Thus, the behavior change potential in Staff Restaurant 1 may have been exhausted before the intervention. The field study should be repeated in staff restaurants where the customers are not too knowledgeable about diet-related issues to test whether the use of the diet-related prompt is scalable.

4.2. Drivers and barriers to the prompt's effectiveness

The prompt was effective in promoting vegetarian menu choices in Staff Restaurant 2, especially among participants with a positive attitude toward environmental protection and high health consciousness. The results regarding health consciousness are in line with previous studies that identified health motives as an important driver in reducing meat consumption (Malek et al., 2019; Neff et al., 2018). Interestingly, the influence of attitude toward environmental protection on the diet-related prompt's effect was stronger than that of health consciousness, although the prompt referred to dietary guidelines and, therefore, indirectly to health and not to the environment. It is plausible that the prompt also triggered participants' existing environmental motives, which can be a reason to reduce meat consumption among meat reducers (Sanchez-Sabate & Sabate, 2019).

In Staff Restaurant 2, individuals with high self-reported meat and/or fish-eating frequencies and who enjoyed eating meat (hedonism) were less influenced by the intervention. This is consistent with existing literature that a strong meat attachment is a barrier for individuals to reduce meat consumption (Lacroix & Gifford, 2019; Pohjolainen et al., 2015) and that a high meat-eating frequency also imposes a barrier to reduce meat consumption (Sanchez-Sabate & Sabate, 2019). Such individuals enjoy eating meat and probably do not consider reducing meat consumption beneficial to their well-being or health. Interestingly, the participants with the intention of reducing meat consumption did not reduce their meat consumption when exposed to the intervention. Possibly, the participants only expressed an intention to reduce meat consumption in the questionnaire due to social desirability.

4.3. Implications

Interventions containing changes in the food choice environment do not seem to differ in their effectiveness when they are implemented only for a short time period (one week) compared to a longer time period

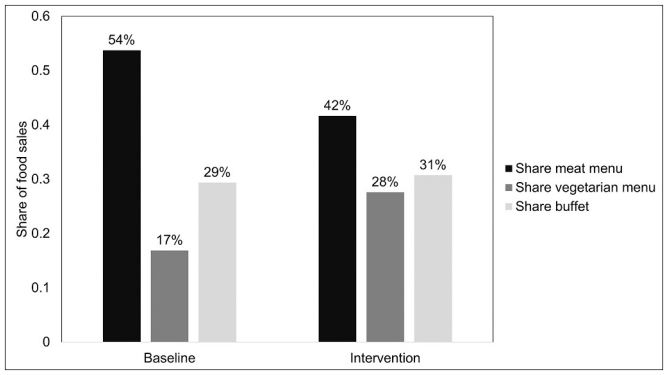

Fig. 4. Share of meat menu, vegetarian menu, and buffet choices in the two study periods in Staff Restaurant 2. (The percentages do not add up to 100 % due to rounding.)

(15 weeks) (Cadario & Chandon, 2020). This suggests that the prompt examined in this study could also be effective in reducing meat consumption for longer time periods than only two weeks. If the prompt could lead to automatic behaviors that are characterized by eating less meat, a new habit of reduced meat consumption could persist (Frey & Rogers, 2014). With regard to implementation in practice, public canteens are a suitable place to implement diet-related prompts, because public authorities can define rules for restaurant operators and thus can influence many aspects of the consumption situation (Lehner et al., 2016). Furthermore, prompts target the demand side without changing the supply. This means that prompts change only the environment in which the menus are presented, not the menus themselves. Therefore, they require less effort from restaurants, which lowers the threshold for practical implementation.

4.4. Strengths, limitations, and future research

The major strength of the present study is that the amount of meat chosen by the participants was objectively measured and matched with individual characteristics collected in a survey. To our knowledge, this has rarely been done in field studies (Kwasny et al., 2022), although this is important to better understand the observed behavior (Baumeister et al., 2007; Szaszi et al., 2017) and to tailor interventions to target groups. Furthermore, applying an intervention to reduce meat consumption in the field instead of online allowed us to capture actual behavior instead of intentions or hypothetical choices as the dependent variable. It was relevant to examine whether the intervention that had proven successful online would also be effective in a real-world setting, where it competed with many other stimuli (Rolschau et al., 2020). Therefore, the present study addresses the ecological validity of the intervention. Lastly, the intervention targeted employees and thus extended related empirical evidence, which is largely based on student samples (Kwasny et al., 2022), further addressing the external validity of the study.

The study also has its limitations, as there were many aspects beyond control. First, the staff restaurants did not offer the same menus in both locations and periods, and individual food choices were probably highly dependent on personal menu preferences. Further, the food pictures only allow the measurement of the meat chosen but not the meat actually consumed. In addition, what participants ate outside the staff restaurant was unknown (e.g., in the evenings or on remote workdays). Furthermore, in an AI-based automatic dietary assessment system like goFOOD™, the accuracy of food content estimation is frequently compromised by visual challenges, particularly occlusions. This occurs when food components are hidden by other items, such as when meat is covered by salad, making it difficult for the system to detect some items in images. Additionally, environmental factors, such as lighting conditions and reflections, also impact the accuracy of depth camera readings. Furthermore, it is worth noting that the recorded grams of meat provided by the kitchen were indirectly determined by following a specific recipe, rather than directly weighing individual food components, potentially resulting in inaccuracies. Although meals from the same menu theoretically had consistent meat portions, variations were observed among individual servings.

Regarding future research, providing consumers with real-time feedback on their meat consumption could help determine whether this influences their behavior. From the evaluation results of the AI-based goFOOD™ system, which were comparable to the results of the semi-automatic annotation tool, it is proposed that the results could be shared with users in real time so that they could receive ongoing feedback directly through an app. In addition, prompts could be implemented in such an app based on meat consumption levels; for example, if a consumer is approaching the recommended limit, the app could send a prompt to remind them of the recommendations and encourage healthier dietary choices.

5. Conclusion

The prompt to choose the vegetarian menu or the salad buffet instead of meat was successful in one of two staff restaurants. The intervention led participants to choose a vegetarian menu more often but not to reduce the amount of meat chosen at the buffet. The prompt could be tested in other staff restaurants where the clientele is not too knowledgeable about nutrition. The prompt could also be integrated into broader campaigns to reduce meat consumption, as it proved to be effective both online (Zumthurm & Stämpfli, 2024) and in the field (present study).

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CRediT authorship contribution statement

Samuel Zumthurm: Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ioannis Papathanail:** Writing – review & editing, Software, Resources, Methodology, Data curation. **Lubnaa Abdur Rahman:** Writing – review & editing, Software, Resources, Methodology, Data curation. **Lorenzo Brigato:** Writing – review & editing, Software, Resources, Methodology. **Stavroula Mougiakakou:** Writing – review & editing, Supervision, Software, Resources, Methodology. **Aline Stämpfli:** Writing – review & editing, Supervision, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2024.105416.

Data availability

Data will be made available on request.

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