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Are healthy diets also sustainable? Experimental study using a Fake Food Buffet

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ABSTRACT

Interventions to promote healthy and sustainable diets are urgently needed to curb growing obesity rates and greenhouse gas emissions. To date, little is known about consumers' awareness of the co-benefits of healthy and sustainable diets. Studies furthermore lack a global perspective. This study therefore aimed (1) to compare the composition of sustainable, healthy, and typical meals using an experimental Fake Food Buffet (FFB) study and (2) to compare sustainable diet knowledge and perceptions between individuals who grow up in Global North and Global South countries. The experiment used a 3 *Meal Type* x 2 *Region* mixed design. Participants ($N = 74$), of which half grew up in the Global North and South, respectively, were asked to self-serve three meals (typical, healthy, sustainable) from the FFB and to complete the Food Sustainability Knowledge Questionnaire (FSKQ). Sustainable meals contained more vegetables, grains, legumes, and plant-based protein ($Fs[2, 144] \geq 4.26$, $ps \leq .016$), and less red meat, animal-based protein, and sugar than healthy or typical meals ($Fs[2, 144] \geq 11.77$ $ps \leq .001$). FSKQ scores did not differ between regions ($W[71.82] = 0.58$, $p = .564$). However, participants from the Global North self-served more vegetables, grains, and plant-based protein from the FFB compared to participants from the Global South ($Fs[2, 72] \geq 4.89$ $ps \leq .003$). Many people are not fully aware of the substantial overlap of healthy and sustainable diets. Furthermore, culture influences food choices and thus needs to be considered when designing and implementing dietary interventions on a global scale.

1. Introduction

Promoting more sustainable food consumption patterns is becoming a priority since food production has a sizeable impact on the environment and climate (Alsaffar, 2016; Jones et al., 2016). Especially meat production is a major contributor to deforestation, water scarcity, and greenhouse gas emissions (Sievert, Lawrence, Parker, & Baker, 2021). In contrast, the production of plant-based foods requires significantly less energy, fewer natural resources such as land, and leads to less greenhouse gas emissions compared to the production of food from animal sources and is thus considered more eco-friendly (Carey et al., 2023). Additionally, a plant-based diet also has multiple health benefits, such as reducing the risk for overweight and obesity (Reger et al., 2024). Studies have shown that a diet rich in fruits, vegetables, and whole grains can reduce the risk of chronic diseases such as heart disease, diabetes, and certain cancers, due to reduced contents of saturated fat and cholesterol compared to animal products (EUFIC, 2021). Therefore, to promote both human and planetary health, diets need to shift from heavy meat consumption to consuming mostly plant-based foods (Garnett et al., 2014). This idea is reflected, amongst others, in the Planetary Health Diet proposed by the EAT-Lancet Commission (Willett et al., 2019) (see also Nelson et al. (2016)). It is characterized by consuming mostly plant-based foods, such as fruits, vegetables, whole grains, legumes, nuts, and seeds, and little consumption of animal-based foods, such as meat, dairy, and eggs. However, to date, most people do not eat in line with these guidelines (Leme et al., 2021), indicating the need for the promotion of healthier and more sustainable diets globally.

Underlying psychological mechanisms of healthy eating have been studied substantially and identified a number of important predictors including knowledge and attitudes (Carfora et al., 2021; de Ridder et al., 2017), which are frequently harnessed in interventions to promote behaviour change. When designing interventions to promote healthier

Abbreviations: ANOVA, Analysis of Variance; FFB, Fake Food Buffet; FSKQ, Food Sustainability Knowledge Questionnaire.

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and more sustainable diets, the question arises whether consumers are aware of the substantial overlap of healthy and sustainable diet patterns (Hoek et al., 2017; Sánchez-Bravo et al., 2020; Van Bussel et al., 2022; Van Loo et al., 2017). A small number of studies showed that ratings of healthiness and sustainability of foods or meals are positively correlated, suggesting the existence of a "healthy = sustainable" heuristic (Lazzarini et al., 2016; Sproesser et al., 2023; Verain et al., 2016). At the same time, consumer ratings only partially reflect objectively determined healthiness or sustainability (Sproesser et al., 2023), thus questioning whether such a heuristic is indeed a suitable intervention strategy.

Furthermore, these prior studies asked participants to rate food products or meals regarding their healthiness and sustainability, which only provides limited information about their actual behaviour. To study food choices under naturalistic yet controlled conditions to gain insights into influencing factors, the Fake Food Buffet (FFB) method has been proposed (Bucher et al., 2011). The method has been frequently used to study intervention strategies for promoting healthier food choices (Bucher et al., 2011, 2013; König & Renner, 2019), and was also recently used to study sustainable diets (Wassmann et al., 2023). Correlations between choices from a fake and real buffet are typically high, so ensuring external validity of the findings (Bucher et al., 2012). The present studies thus used a Fake Food Buffet to compare the types and amounts of foods chosen for healthy and sustainable meals to gain further insights into how similar consumers perceive these meals to be.

To date, most studies investigating the underlying mechanisms of food choice focus on populations from individual (García-González et al., 2020), WEIRD (i.e., western, educated, industrialized, rich, and democratic) countries (Henrich et al., 2010). This is also true for the study of sustainable diets in general (Peano et al., 2019; Siegrist et al., 2015; Van Bussel et al., 2022) and the "healthy = sustainable" heuristic in particular, which was so far investigated in Switzerland (Lazzarini et al., 2016), the Netherlands (Verain et al., 2016) and Germany (Sproesser et al., 2023). It is thus unclear whether these findings translate to other regions and cultures. The Brandt Line divided the countries into "Global North" and "Global South" (Lees, 2021) to describe the geographical and economic divide between the wealthier and developed countries, typically located in North America, Europe, and Australia, and the developing countries, mainly located in Africa, Latin America, and Asia (Khan et al., 2022). In contrast to the Global South, the Global North is characterized by higher economic development, advanced technology, higher income and education levels, as well as political stability (Kowalski, 2020). These aspects can greatly impact eating behaviour since they may impact attitudes and beliefs toward food. For example, Global South countries suffer from greater gender disparities and language barriers and have lower education quality (United Nations Department of Economic Social Affairs, 2022), which may impact food, nutrition, and health literacy. This can lead to differences in food choices, preferences, and eating habits that affect overall health and well-being (Trieste et al., 2021). Furthermore, Global North and Global South differ regarding food security: Global North countries experience more accessibility, availability, and diversity in foods compared to Global South countries, which again translates to differences in food consumption patterns (Krishna Bahadur et al., 2016).

Indeed, it has been observed that eating habits vary between countries and cultures (Fanzo & Davis, 2019). Global North countries consume up to 500 % of the recommended intake levels of animal-based protein sources due to availability, affordability and cultural preferences (Willett et al., 2019). Global South countries, on the other hand, consume small amounts of fruits and vegetables, which is partly due to limited access to these food groups (Drewnowski, 2010). Instead, they often rely on refined grains and sugary foods (Popkin & Reardon, 2018). At the same time, dishes from the Global South traditionally include more legumes, which may also impact current eating practices in these regions (Sproesser et al., 2019). Since the majority of the world's population does not live in WEIRD countries, it is imperative to include them in efforts to improve the understanding the determinants of diets, including psychological determinants.

1.1. Present study

This study's overarching aim was to advance the understanding of consumers' knowledge about and perception of sustainable and healthy diets in a global context; specifically, it firstly aimed to compare the composition of sustainable, healthy, and typical meals using an experimental Fake Food Buffet (FFB) study and, secondly, to compare results between individuals who grow up in Global North and Global South countries. To achieve these aims, it investigated three preregistered research questions. Due to the relative scarcity of prior research, no hypotheses were preregistered, and two-sided statistical tests were conducted.

Regarding the first aim, the study addressed two research questions (RQ). First, the study asked whether consumers' understanding of a sustainable diet is similar to their understanding of a healthy diet, as indicated by the overlap of foods chosen for healthy and sustainable meals (RQ 1). Second, it investigated whether consumers already ate healthy and sustainable diets, as indicated by an overlap of their healthy and sustainable meals on the one hand and their typical meals on the other (RQ 2). Regarding the second aim, the study addressed the following research question: Is there a difference between people's understanding of a sustainable diet depending on whether they grew up in the Global North or the Global South (RQ 3)? Differences were assumed since differences in education, access, and impact of climate change on livelihoods may exert long-term impact on knowledge and food choice. If differences between regions exist, this would point toward underlying differences in cultural values and education regarding sustainable diets, which may explain continent-level differences in adhering to guidelines for sustainable nutrition (Willett et al., 2019).

To address these research questions, an experimental approach was used, where participants from both the Global North and the Global South were asked to self-serve a typical, a healthy and a sustainable meal from a buffet of realistic food replicas (Fake Food Buffet, Bucher et al., 2012) to compare the type and amount of foods chosen between the conditions. This method allows to gain insights into food choices in a standardised but realistic setting. In addition, broader knowledge about sustainable diets was assessed using a questionnaire.

2. Pilot study

To test the study procedure and generate effect size estimates, a pilot study was conducted during an open day at a German university campus in July 2022. Participants could drop in at any time and complete the task. Groups were asked to complete the task individually, although discussions between participants while completing the task could not be fully avoided. Data from two initially recruited participants were incomplete and thus the participant had to be removed. Data from 42 adult participants (11 men, 31 women; $M_{age} = 47.24$, $SD_{age} = 17.40$) were analysed who self-served a healthy and a sustainable meal from a FFB with 33 items (see Table S1 in the supplementary material for a full list and allocation to food groups) in fixed order. Research staff immediately weighted and/or counted the items and recorded the values into an Excel sheet before refilling the buffet; they were later converted into the weight of real foods using pre-determined conversion factors (Sproesser et al., 2015). Data are available from the project's Open Science Framework (OSF) page (https://osf.io/g8brz/).

The amount of vegetables, fruit, animal- and plant-based protein was compared using paired samples *t*-tests. Because of the small sample size, results are only interpreted based on effect sizes (Cohen, 1992). Small effects were detected for vegetables ($t(41) = -0.75$, $p = .456$, Cohen's $d = -0.12$; $M_{healthy} = 149.08$, $SD_{healthy} = 47.22$, $M_{sustainable} = 156.24$, $SD_{sustainable} = 67.68$) and plant-based protein ($t(41) = -1.23$, $p = .227$, Cohen's $d = -0.19$; $M_{healthy} = 71.65$, $SD_{healthy} = 52.29$, $M_{sustainable} = 87.77$, $SD_{sustainable} = 79.82$). A medium effect was detected for fruits (*t*

(41) = −3.08, p = .004, Cohen's d = −0.48; $M_{healthy}$ = 54.94, $SD_{healthy}$ = 66.54, $M_{sustainable}$ = 89.89, $SD_{sustainable}$ = 79.89). A large effect was detected for animal-based protein (t(41) = 6.04, p < .001 Cohen's d = 0.93; $M_{healthy}$ = 43.21, $SD_{healthy}$ = 36.55, $M_{sustainable}$ = 13.21, $SD_{sustainable}$ = 29.94). The number of participants who self-served each food is depicted in Fig. 1. A visual analysis indicates that largest differences between healthy and sustainable meals occurred for chicken, which was more frequently self-served when composing healthy meals, and for apples, which were more frequently chosen for sustainable meals.

3. Main study: Methods

The study was preregistered on the OSF (https://osf.io/6wj5v). The protocol was uploaded on 21 November 2022, but no formal preregistration was created before 1 February 2023, due to a technical error. The study was approved by the University of Bayreuth ethics committee before starting data collection. Data and materials are available from the OSF (https://osf.io/g8brz/).

3.1. Sample

Using GPower 3.1 (Faul et al., 2009), a target sample size of 74 participants was determined for 80 % power and α = 0.05, assuming Cohen's f = 0.15, for an interaction effect a mixed 2 *Region* × 3 *Meal Type* ANOVA. Due to a lack of similar studies, effect size estimates were based on the comparison of sustainable and healthy meals in the pilot study, and comparisons between typical and healthy meals as presented in König and Renner (2019). To achieve an even distribution of the quasi-experimental between-subjects factor Region, we aimed to recruit 37 participants from the Global South and 37 participants from the Global North. No participant dropped out of the study or was excluded after having been recruited.

3.2. Recruitment and data collection procedures

The study was advertised via posts on social media platforms, flyers distributed at the university, and word of mouth; the sample was thus a convenience sample. To take part in the study, participants had to be at least 18 years old and suffer from no eating disorders. Data were collected between November 2022 and April 2023 at a Faculty of Life Sciences at a small German university. Participants were asked about their country of origin to keep track of the number of study participants per group, but only the region (Global North or Global South) was noted to preserve anonymity and to avoid confusion caused by the diverging definitions or lay understandings of the two regions. For example, participants from Turkey or Mexico were listed as Global South.

After having provided informed consent, participants were asked to self-serve three meals from the FFB that represent a typical meal, a healthy meal, and a sustainable meal, respectively. Participants were always asked first to self-serve a typical meal that they would usually consume in order to familiarize them with the buffet; afterwards, they were asked to self-serve a healthy or sustainable meal in random order to counterbalance the conditions of interest; the order was determined by the experimenter using the next available participant code from a list that was created by a researcher not involved in the data collection procedure in Excel. Whenever asked about the buffet setting (especially when assembling the sustainable meal), participants were asked to consider themselves serving from the buffet here and now (in Germany, winter 2022/2023) and for themselves. Whenever participants asked for clarification on what is meant by "sustainable", the researcher replied

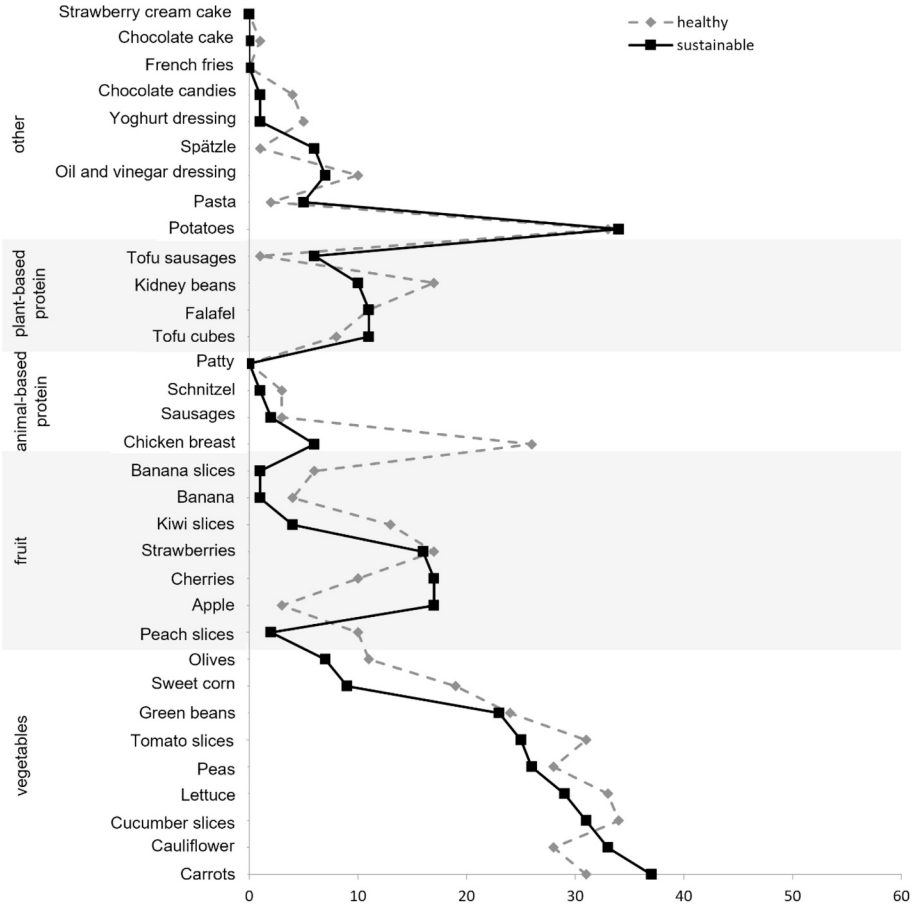

Fig. 1. Single food items chosen for healthy and sustainable meals.

that participants should follow their own understanding of the term. After each meal, participants were asked to fill in a short questionnaire assessing the typicality, healthiness, and sustainability of the meal, and task difficulty. The buffet was the same for all three prompts and refilled by the experimenter after each prompt. In the end, participants filled in an online questionnaire in Unipark (Tivian XI GmbH, 2021) to provide demographic information. In addition, participants were asked whether they intended to eat more sustainably in the future. Finally, their knowledge about sustainable diets was assessed.

3.3. Materials and measures

3.3.1. The Fake Food Buffet (FFB)

The primary outcome was participants' food choice from the FFB, which acted as a proxy for their understanding of a sustainable and healthy meal. The FFB was derived from König and Renner (2019) (see also Bucher et al. (2011)), with the addition of lentil patties, tofu cubes, red beans, yogurt, and eggs to provide more vegetarian/vegan protein sources. To ensure that the buffet was also appealing to an international audience, pre-tests were conducted with several individuals from African and Asian countries, who confirmed the suitability of the buffet to properly cater to their dietary preferences. The buffet included a total of 52 different food items which were placed in serving bowls and arranged on a table to look like an actual buffet (Fig. 2). Participants were provided with large and small plates (27 and 21 cm in diameter respectively) and small bowls (12 cm diameter). Participants were asked to put the assembled meals on three serving trays (55 cm × 35 cm) which were noted as T, H, and S based on the meal type. Fig. 3 depicts examples for meals self-served by the participants.

After the participants served each meal, the researcher took pictures of the meals, weighted, and counted the fake food items and refilled the buffet. The items of the self-served meals were either weighed (e.g., carrots) or counted (e.g., sausages) and converted into the weight of real foods using pre-determined conversion factors (e.g., from Sproesser et al. (2015)). The foods were divided into eight categories: vegetables, nuts, grains, legumes, red meat, animal-based protein, plant-based protein, and sugar (see Table S2 in the supplementary material for a full list of food groups and items).

3.3.2. Meal ratings and task difficulty

In between the FFB tasks, participants were asked to rate how typical, healthy, and sustainable their choice was and how difficult it was to complete the task on Likert scales from [1] not at all to [5] very much.

3.3.3. Food Sustainability Knowledge Questionnaire (FSKQ)

A modified version of the FSKQ (Funk, 2020) was used to assess participants' knowledge about sustainable diets. The questionnaire was validated in Switzerland and Germany to test the lay audience's knowledge about food production and choices and their impact on the environment (Funk, 2020). For some of the questions participants could respond with either "Right", "Wrong" or "I do not know" (e.g., "Production of meat and milk products leads to higher CO2 emissions per kg than production of vegetables."); other questions provided participants with three options to choose from in addition to the "I do not know" option (e.g., "Which of the following foods is associated with the lowest climate impact (per 100g)?", with response options "potato chips", "bread roll", and "salami stick"). For all questions, participants were encouraged to choose "I do not know" in case of doubts to increase the results' accuracy. Fourteen out of the original 16 questions were included; two questions were left out because one was focused on the steps of supply chain that has more environmental impact and the other was focused on harvesting in Switzerland. In addition, the foods were adapted to the German context to ensure familiarity (e.g., Swiss beef was adjusted to beef only without emphasize on the origin). A sum score was created according to the instructions in Funk (2020): right answers scored one point, and no points were added for "I do not know" or wrong answers.

3.4. Data analysis

3.4.1. Data handling and exclusion

Participants who were born in Germany did not provide a response on how many years they have lived in Germany; accordingly, for participants who indicated that they were born in Europe and did not report the number of years that they have been living in Germany, their age was used for this estimate, assuming that they lived in Germany since they were born. Since all questions in the questionnaire and the FFB task were mandatory, there was no missing data on the related variables, and no participant was excluded.

3.4.2. Descriptive statistics

Age of the total sample and years living in Germany were described based on the mean and standard deviation. Genders were reported as % men, % women, % other; level of education was described based on the median and interquartile range. In addition, characteristics were reported per group (Global North/ Global South) and compared between groups using an independent samples *t*-test (for age, years of living in Germany, and intention to eat sustainably in the near future) and chi-square tests (for gender and level of education). Because of deviations from normality for age, years in Germany, and intention to eat sustainably in the near future ($ps > 0.001$), Wilcoxon tests are reported instead for these variables.

3.4.3. Statistical models

JASP software version 0.16.4 was used to analyse the collected data. Mixed 3 × 2 ANOVAs were conducted to compare outcomes within (*Meal Type*: typical, sustainable, healthy) and between (*Region*: Global North, Global South) participants. Eight ANOVAs were conducted in total, i.e. per outcome: vegetables, grains, nuts, legumes, red meat, sugar, total animal-based protein, and total plant-based protein. For paired comparisons, post hoc tests with Holm correction were conducted. Effect sizes are interpreted based on Cohen (1992).

Furthermore, mixed 3 × 2 ANOVAs were conducted to compare the data within (*Meal Type*: typical, sustainable, healthy) and between (*Region*: Global North, Global South) participants for the outcomes task

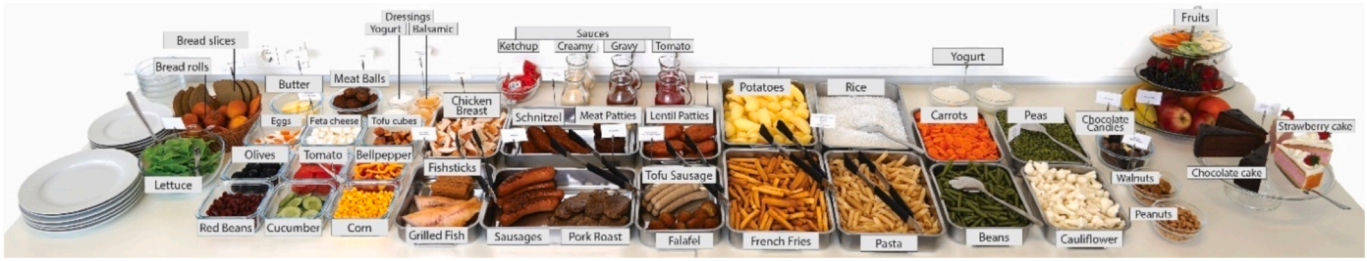

Fig. 2. Fake Food Buffet used in the main study.

Fig. 3. Example pictures for meals self-served by the participants. A) typical meal, Global North; B) healthy meal, Global North; C) sustainable meal, Global North; D) typical meal, Global South; E) healthy meal, Global South; F) sustainable meal, Global South.

difficulty and meat ratings (typical, healthy, sustainable) to serve as manipulation checks. Finally, we explored relationships between knowledge about sustainable diets and region; this was tested with an independent samples t-test.

3.4.4. Additional analyses

When inspecting the group means per food group, we noticed that means of the Global North group were consistently higher than means of the Global South group. We confirmed this with another mixed ANOVA, using the total amount self-served as the dependent variable (main effect *Region*: F (2, 72) = 4.34 p = .041, *partial* η^2 = 0.06). To account for this difference, all analyses were additionally conducted with the proportional amount of the respective food group of the total amount as dependent variables; they are reported in the supplementary material. In regard to the quality of food choices, the 52 food items included in the typical, health and sustainable meals were counted as single observations (Sproesser et al., 2015) (Fig. 4).

4. Results

4.1. Sample characteristics

Most of the 74 participants were women (73 %; 27 % men). Participants were aged from 18 to 57 years (M = 27.78, SD = 6.73). Concerning education, 51 % of participants had a bachelor's degree. Regarding years lived in Germany, 94.5 % participants of the participants from the Global North were born in Germany, and the remaining 5.5 % of participants from the Global North had been in the country for less than one year to 35 years. In comparison, participants from the Global South had been in Germany for an average of 2.71 (SD = 5.58) years, ranging from 0.08 to 35 years with a median of 1.4 years. Table 1 lists the descriptive statistics for the full sample and compares the two subsamples.

Due to a recording mistake, a participant from the Global South was recorded as being from the Global North, therefore, the sample was divided into 36 from the Global North and 38 from the Global South instead of 37 each as pre-registered. Results indicated no difference between Global North and Global South participants' age or in the gender distribution. There were significant group differences for education, and, as expected, in the number of years having lived in Germany (see Table 1). Participants from the Global South intended to eat more sustainably in the near future compared to participants from the Global North but did not differ in sustainability knowledge (see Table 1).

4.2. Manipulation check

A mixed ANOVAs was conducted to compare the three meals regarding *Typicality*, *Healthiness*, and *Sustainability* ratings (see Table 2

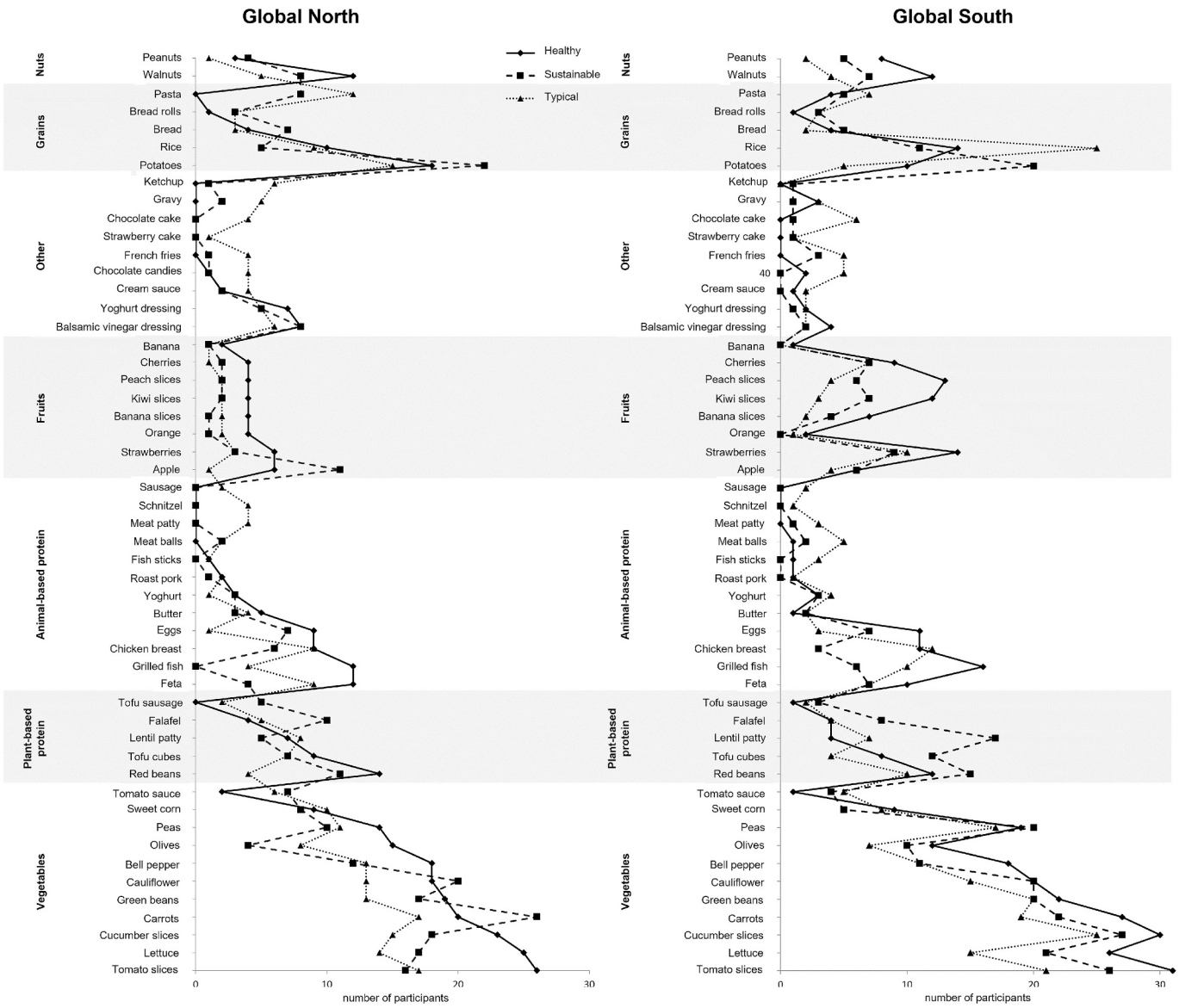

Fig. 4. Single food items chosen for healthy and sustainable meals by participants from the Global North (left) and the Global South (right).

for means and standard deviations and Table 3 for main effects and interactions), which were all assessed within-subjects. Participants agreed more strongly to have chosen a typical meal when putting together the typical compared to healthy ($p < .001$) and sustainable meals ($p = .001$). Participants agreed to have chosen a healthier meal when assembling the healthy meal compared to typical ($p < .001$) and sustainable meals ($p < .001$). Finally, participants agreed to have chosen a more sustainable meal when compiling the sustainable meal compared to typical ($p < .001$) and healthy meals ($p < .001$). Thus, the manipulations were successful.

4.3. Task difficulty

A mixed ANOVA was conducted to compare the *Task Difficulty* between the three meal types, yielding a significant main effect for the within-subjects factor. Participants found the task of putting together the sustainable meal to be more difficult than both the typical ($p < .001$) and healthy meals ($p < .001$), while there was no difference between healthy and typical meals ($p = .567$) (see Table 2 for means and standard deviations).

4.4. Comparison of food groups self-served between healthy, sustainable and typical meals (Aim 1)

To address RQs 1 and 2, mixed ANOVAs were conducted that compared the three different meals regarding the amount served per food group (see Table 4 for means and standard deviations and Table 5 for test statistics). There was a significant main effect for the within-subjects factor meal type regarding the amount of vegetables served. Sustainable ($p = .002$) and healthy ($p = .002$) meals contained more vegetables compared to typical meals.

A significant main effect regarding grains emerged. Sustainable meals contained more grains ($p < .001$) than typical meals. Furthermore, healthy meals contained less grains than typical meals ($p < .001$), and sustainable meals ($p < .001$).

Analyses also yielded a significant main effect for the meal type regarding the amount of nuts. Healthy meals contained more nuts than typical meals ($p = .001$).

Similarly, a significant main effect for the meal type regarding the amount of legumes emerged. Sustainable meals contained more legumes ($p = .022$) than typical meals.

There was a significant main effect for the meal type regarding the

Table 1
Sample characteristics.

Sample characteristic	Full sample	Global North	Global South	Statistical test
Number of participants	74	36	38	
Age in years (M, SD)	27.78, 6.73	27.36, 8.62	28.13, 4.32	$W^1(50.9) = -0.05$, $p = .632$
Gender (% male, female)	27 %, 73 %	36.11 %, 63.89 %	18.42 %, 81.58 %	$X^2(1) = 2.93$, $p = .087$
Continent (%)[2]	Asia 33.78 % Europe 47.3 % Africa 10.81 % North America 4.05 % South America 4.05 %	Europe 94.44 % North America 5.56 %	Asia 65.79 % Africa 21.05 % Europe 2.63 % South America 7.9 % North America 2.63 %	
Years in Germany (M, SD)	8.37, 10.40	14.35, 11.01	2.71, 5.58	$W^1(51.23) = 5.59$, $p < .001$
Education (%)	Some high school, no university entrance diploma 2.7 % High school graduate, university entrance diploma or equivalent 8.1 % Some college, no degree 4.05 % Trade/ technical/ vocational training 2.7 % Bachelor's degree 51.35 % Master's degree 26.67 % Doctoral degree 5.4 %	Some high school, no university entrance diploma 5.56 % High school graduate, university entrance diploma or equivalent 13.89 % Some college, no degree 8.33 % Trade/ technical/ vocational training 5.56 % Bachelor's degree 33.33 % Master's degree 25 % Doctoral degree 8.33 %	High school graduate, university entrance diploma or equivalent 2.63 % Bachelor's degree 68.42 % Master's degree 26.32 % Doctoral degree 2.63 %	$X^2(6) = 15.84$, $p < .001$, Cramer V = 0.46
Education (median, interquartile range [IQR])	Bachelor's degree, [Bachelor's degree; Master's degree]	Bachelor's degree, [Some college, no degree; Master's degree]	Bachelor's degree, [Bachelor's degree; Master's degree]	
Food allergy (no, yes)	85.14 %, 14.87 %	77.78 %, 22.22 %	92.1 %, 7.9 %	
Experienced the FFB before (% no, yes)	71.62 %, 28.38 %	77.78 %, 22.22 %	65.79 %, 34.2 %	
Representativeness of FFB (1 = not at all, 5 = very much) (M, SD)	3.53, 0.85	3.58, 0.94	3.47, 0.76	
Representativeness of FFB (1 = not at all, 5 = very much) (Median)	4	4	4	
Intention to eat sustainably in the near future (M, SD) (1 not at all, 5 very much)	4.03, 0.92	3.81, 0.98	4.24, 0.82	$W^1(68.36) = -2.05$, $p = .044$, Cohen's d = −0.48
Food Sustainability Knowledge Questionnaire (FSKQ) score (M, SD)	9.55, 2.02	9.69, 2.03	9.42, 2.04	$W^1(71.82) = 0.58$, $p = .564$, Cohen's d = 0.14

[1] Due to normality violation, W-tests were reported instead of *t*-tests.
[2] Two participants who were classified as Global South based on the country that they were born in selected continents selected continents typically associated with the Global North in the questionnaire. While there is substantial overlap between continents and the distinction between Global North and Global South, the distinction is not perfect.

Table 2
Meal ratings and task difficulty: Means and standard deviations by region and meal type.

Rating	Region	Typical meal		Healthy meal		Sustainable meal	
		M	SD	M	SD	M	SD
Typicality	North	4.03	1.03	3.58	0.99	3.56	0.94
	South	3.82	1.16	4.21	0.74	3.97	0.92
Healthiness	North	3.64	0.96	4.83	0.38	3.61	0.87
	South	3.24	1.05	4.74	0.5	4.08	0.82
Sustainability	North	3.28	1.14	4.33	0.59	4.56	0.56
	South	3.11	1.09	4.42	0.76	4.66	0.53
Task difficulty	North	4.03	1.03	3.58	0.99	3.56	0.94
	South	3.82	1.16	4.21	0.74	3.97	0.92

Table 3
ANOVA results for comparing the meal rating and task difficulty.

Rating	Test of main effect for within-subjects factor	Test of main effect for between-subjects factor	Test of interaction effect
Typicality	$F(2, 144) = 14.95$, $p < .001$, $\eta_p^2 = 0.17$	$F(1, 72) = 1.83$, $p = .181$, $\eta_p^2 = 0.03$	$F(2, 144) = 0.41$, $p = .666$, $\eta_p^2 = 0.01$
Healthiness	$F(2, 144) = 35.77$, $p < .001$, $\eta_p^2 = 0.33$	$F(1, 72) = 3.87$, $p = .053$, $\eta_p^2 = 0.05$	$F(2, 144) = 6.40$, $p = .002$, $\eta_p^2 = 0.08$
Sustainability	$F(2, 144) = 35.77$, $p < .001$, $\eta_p^2 = 0.33$	$F(1, 72) = 6.16$, $p = .015$, $\eta_p^2 = 0.08$	$F(2, 144) = 0.66$, $p = .519$, $\eta_p^2 = 0.01$
Task difficulty	$F(2, 144) = 21.76$, $p < .001$, $\eta_p^2 = 0.23$	$F(1, 72) = 0.12$, $p = .730$, $\eta_p^2 < 0.01$	$F(2, 144) = 1.19$, $p = .307$, $\eta_p^2 = 0.02$

amount of red meats served. Typical meals contained more red meats than healthy ($p < .001$), and sustainable meals ($p < .001$).

The analysis also showed a significant main effect for the meal type regarding animal-based protein sources. Sustainable meals contained fewer animal-based protein ($p < .001$) compared to both typical ($p < .001$) and healthy meals ($p < .001$).

Additionally, there was a significant main effect for the meal type regarding the amount of plant-based protein sources. Sustainable meals contained more plant-based protein sources than both healthy ($p < .001$) and typical meals ($p = .005$), whereas typical meals contained more plant-based proteins than healthy meals ($p = .032$).

Finally, a significant main effect for the meal type regarding the amount of sugar emerged. Typical meals contained more sugar than both healthy meals ($p < .001$), and sustainable meals ($p < .001$). All main effects represented medium to large effects.

To sum, regarding RQ 1, there were statistically significant differences between the healthy and sustainable meals for grains, animal-based and plant-based protein sources. Regarding RQ 2, there were

Table 4
Amount of food groups self-served in gram: Means and standard deviations by region and meal type.

Food groups	Region	Typical Meal		Healthy Meal		Sustainable Meal	
		M	SD	M	SD	M	SD
Vegetables	North	148.34	81.91	183.09	81.69	188.96	90.91
	South	123.8	63.11	153.61	82.89	148.72	87.06
Grains	North	135.94	67.81	87.08	55.6	128.14	69.92
	South	95.36	60	58.98	53.87	86.33	56.01
Nuts	North	1.4	3.54	4.88	7.33	3.37	6.13
	South	1.34	4.42	3.46	4.94	1.6	3.16
Legumes	North	57.95	72.78	68.83	53.29	71.96	65.61
	South	50.84	39.59	51.47	51.81	81.22	70.18
Red meats	North	32.89	60.42	2.39	9.99	6.06	23.09
	South	21	43.27	3.11	13.86	4.34	16.85
Animal-based proteins	North	76.12	69.77	92.53	80.72	49.43	87.23
	South	105.34	79.8	103.96	69.95	45.14	66.02
Plant-based proteins	North	161.13	123.83	192.29	114.72	251.84	131.39
	South	92.63	47.88	136.01	98.39	195.44	132.97
Sugar	North	17.67	36.73	0.28	1.67	0.83	5
	South	21.68	40.71	0.79	3.59	5.37	23.09

Table 5
ANOVA results for comparing the amounts per food group between meal types and regions.

Food group	Test of main effect for within-subjects factor	Test of main effect for between-subjects factor	Test of interaction effect
Vegetables	$F(2, 144) = 7.88$, $p < .001$, $\eta_p^2 = 0.09$	$F(1, 72) = 4.09$, $p = .047$, $\eta_p^2 = 0.05$	$F(2, 144) = 0.36$, $p = .698$, $\eta_p^2 = 0.01$
Grains	$F(2, 144) = 14.16$, $p < .001$, $\eta_p^2 = 0.16$	$(1.72) = 13.21$, $p < .001$, $\eta_p^2 = 0.16$	$F(2, 144) = 0.40$, $p = .671$, $\eta_p^2 = 0.01$
Nuts	$F(2, 144) = 6.45$, $p = .002$, $\eta_p^2 = 0.08$	$F(1.72) = 1.98$, $p = .164$, $\eta_p^2 = 0.03$	$F(2, 144) = 0.66$, $p = .519$, $\eta_p^2 = 0.01$
Legumes	$F(2, 144) = 3.93$, $p = .022$, $\eta_p^2 = 0.05$	$F(1.72) = 0.28$, $p = .600$, $\eta_p^2 < 0.01$	$F(2, 144) = 1.45$, $p = .024$, $\eta_p^2 = 0.02$
Red meats	$F(2, 144) = 11.77$, $p < .001$, $\eta_p^2 = 0.14$	$F(1.72) = 0.97$, $p = .329$, $\eta_p^2 = 0.01$	$F(2, 144) = 0.74$, $p = .478$, $\eta_p^2 = 0.01$
Animal-based proteins	$F(2, 144) = 12.12$, $p < .001$, $\eta_p^2 = 0.14$	$F(1.72) = 1.02$, $p = .317$, $\eta_p^2 = 0.01$	$F(2, 144) = 1.12$, $p = .328$, $\eta_p^2 = 0.02$
Plant-based proteins	$F(2, 144) = 23.5$, $p < .001$, $\eta_p^2 = 0.25$	$F(1.72) = 8.99$, $p = .004$, $\eta_p^2 = 0.11$	$F(2, 144) = 0.12$, $p = .886$, $\eta_p^2 = 0.002$
Sugar	$F(2, 144) = 14.74$, $p < .001$, $\eta_p^2 = 0.17$	$F(1.72) = 0.71$, $p = .404$, $\eta_p^2 = 0.01$	$F(2, 144) = 0.16$, $p = .849$, $\eta_p^2 < 0.01$

statistically significant differences between sustainable or healthy meals on the one hand and typical meals on the other for vegetables, grains, nuts, legumes, red meat, animal-based and plant-based protein sources, and sugar.

4.5. Comparison of food groups self-served between the Global North and the Global South (Aim 2)

Based on the same mixed ANOVAs, the two regions were compared regarding the amount of food groups self-served (see Tables 4 and 5 for details) to address the research question as to whether consumers from the Global North and the Global South differed in their perceptions of healthy and sustainable diets. There was a significant main effect for the between-subjects factor *Region* regarding the amount of vegetables, grains, and plant-based protein, with participants from the Global North self-serving more than the participants from the Global South. There were no significant difference for the remaining food groups (*ps* > 0.184). Across all food groups interactions were not significant (*ps* > 0.1), suggesting that the pattern of results for the meal types does not differ depending on the participants' region of origin (see Table 5 for the full test statistic for all interactions).

5. Discussion

This study compared the perception of sustainable and healthy diets in participants from the Global North and Global South using a Fake Food Buffet. Sustainable and healthy meals differed significantly from each other regarding the content of several relevant food groups: Sustainable meals included higher amounts of grains, legumes, and plant-based proteins, and had fewer animal-based proteins. Additionally, the study found that participants from the Global North tended to choose more vegetables, grains, and plant-based proteins, resulting in more sustainable meals compared to those chosen by participants from the Global South. The results underscore the relevance for designing culturally specific interventions to promote sustainable and healthy diets.

5.1. Are consumers aware of the similarities of healthy and sustainable diets?

Sustainable meals self-served from the FFB contained more grains, legumes, and plant-based proteins than healthy meals, and fewer animal-based proteins. It can thus be assumed that participants are generally aware of the benefits of consuming plant-based diets for planetary health (Wassmann et al., 2023). However, these findings also indicate that people's awareness of the co-benefits of a predominantly plant-based diet for human health is limited (Willett et al., 2019; World Health Organization, 2021), and that communication efforts, e.g. by the EAT Lancet commission, the World Health Organization or the Food and Agriculture Organization, were so far unsuccessful. It is important to note that most study participants held at least a bachelor's degree and were mainly students of food- and nutrition-related degree programmes and so should have acquired specialist knowledge about sustainability and health issues related to diet. Despite their high level of education and specialist knowledge, they did not fully recognize the overlap between sustainable and healthy diets. Effects in populations with lower levels of education thus might be even smaller. Indeed, is it to be expected that the general public still lacks a clear frame of reference for the meaning of a sustainable diet (Rust et al., 2020), and some individuals are still supporters of frequent meat consumption, ignoring its effects on health and the environment or animal welfare (Piazza et al., 2015). This may be because of an internalized social identity of masculinity linked to meat consumption or the ideology of carnism (Sievert et al., 2021) as well as the rationalization of meat consumption where people believe that eating meat is „Natural, Normal, Necessary, and Nice“ (Piazza et al., 2015). To promote diets low in meat and so planetary and human health, targeted information and education campaigns are necessary.

Additionally, participants displayed stereotypical patterns for both healthy and sustainable meals, that became apparent after taking a closer look at the individual meals composed. For instance, grilled fish, feta cheese, and walnuts seem to be stereotypically healthy foods, while

whole grain bread slices and plant-based meat alternatives such as lentil patties, falafel, potato, tofu cubes and sausages were often self-served for the sustainable meals. This is somewhat at odds with results of prior online studies that indicated that consumers do not see plant-based meat and dairy alternatives as more environmentally friendly than the corresponding animal-based products (Giacone et al., 2024; Hartmann et al., 2022). This could potentially be explained by sample differences (general population in Switzerland in the online surveys vs students of food-related subjects from various countries in the present study).

Research suggests that stereotypes about foods are prominent; some food items such as meats, fruits, and whole-grain breads are considered healthier or have lower fat content (Carels et al., 2006). Results of the present study mirror these findings. Moreover, participants substituted cakes and candies by fruits when composing the healthy meals similar to results reported in Bucher et al. (Bucher et al., 2013). However, these misconceptions are not necessarily in line with the actual nutritional value of the foods, especially when quantity and cooking methos are not taken into consideration. Therefore, it is essential to identify misconceptions regarding people's perception of healthy and sustainable diet based on stereotyping to strategically debunk them (König, 2023; Kotz et al., 2023).

Results furthermore suggest region-specific stereotypes, which are likely to reflect observations made in the respective food cultures (Sproesser et al., 2019). For instance, participants from the Global North often chose more carrots, cauliflower, tomato sauce, and apples when self-serving sustainable meals, which is in line with regional and seasonal availability of these products in Germany, where most Global North participants were from. This underlines the need for culturally sensitive interventions to counteract food-related stereotypes and myths.

5.2. Are there cultural differences in the perception of healthy and sustainable diets?

Even though the analysis of FSKQ scores showed no significant difference between the two regions regarding sustainability knowledge, they differed in the composition of meals self-served from the FFB. Specifically, participants from the Global North self-served more vegetables, grains, and plant-based protein for all meal types, which makes their meals overall more sustainable and healthier than meals self-served by participants from the Global South (Fresán & Sabaté, 2019). This supports the notion that knowledge and behaviour are correlated, but not necessarily fully aligned (de Ridder et al., 2017).

This difference between participants from the two regions seems to contrast with the fact that participants from the Global South intended to eat more sustainably and were better educated compared to the participants from the Global North, which is typically related to adhering to dietary recommendations (Fard et al., 2021). It is important to note, however, that education was confounded with region of origin due to the structure of the degree programmes offered at the university where this study was conducted; the study may thus not be able to speak to differences rooted in education, and both subsamples are not representative for their respective regions in terms of age or income.

Finally, the overall amount of food served was higher for participants from the Global North compared to participants from the Global South. This may be linked to participants' prior experiences regarding food security as well as their current financial status. Global North countries experience higher levels of food security compared to the Global South due to food availability, accessibility, and affordability (Bartelmeß et al., 2022). Migrants from the Global South may also experience higher levels of food insecurity after having relocated to high-income countries (Mansour et al., 2020). However, participants' income was not assessed, so we cannot disentangle food insecurity experienced in the country of origin vs in Germany in this study.

It is important to note that although we found significant main effects for both meal type and region of origin, interaction effects did not reach statistical significance. Thus, while there are general differences in food choices between Global North and Global South participants that mirror the available literature regarding food consumption patterns (World Health Organization & Food and Agriculture Organization, 2003), these are not specific to meal types. This again underlines the need for nutrition communication and dietary interventions to be culturally sensitive (Garnweidner et al., 2012; König et al., 2021). At the same time, deficits in knowledge and behaviour regarding specific diets seem to largely generalize across the globe, calling for global efforts to promote healthier and more sustainable diets.

5.3. Do people feel that they already eat healthy and sustainably?

Significant differences emerged for several food groups between typical meals on the one hand and healthy and sustainable meals on the other, indicating that participants perceive there to be a divergence between their habitual food consumption and healthy and sustainable diets. This became apparent for several stereotypically healthy food groups such as sugar and nuts (Oakes, 2005), as well as for food groups related to sustainability concerns such as plant-based vs animal-based protein. Comparing the foods self-served from the buffet to dietary recommendations such as the Planetary Health Diet (Willett et al., 2019) underlines that even in a relatively well-educated sample with prior education in nutrition and health, gaps in knowledge and behaviour persist. This gap was also reflected on the difference in task difficulty ratings, where participants rated composing the sustainable meal as more challenging compared to both typical and healthy meals. This could be explained by the knowledge-behaviour (Rimal, 2000) and intention-behaviour gaps (Conner & Norman, 2022), that indicate that knowledge and intention are not sufficient to change behaviour. In order to promote healthier and sustainable diets, these gaps need to be closed, for instance through addressing self-efficacy and planning (Schwarzer & Luszczynska, 2008).

Finally, in addition to education and awareness campaigns to promote healthier and more sustainable eating behaviours, a multidisciplinary approach should be followed; in addition to education, policy-based approaches are likely required to change people's eating habits (Hollands et al., 2017). For instance, in restaurants, school canteens, and university cafeterias as well as in supermarkets use choice architecture to focus on visibility and offer more variety of food alternatives to nudge plant-based consumption (Rekhy & McConchie, 2014).

5.4. Strengths and limitations

The study used a controlled experimental setup to study differences in actual healthy and sustainable food choices from the same set of choice options. By assessing the outcomes within subjects, the study was adequately powered to detect small to medium effects. It furthermore included a diverse sample of participants spanning all continents except Australia and Oceania. This was achieved through specifically targeting participants from both the Global North and the Global South. The buffet was adjusted to include a large variety of foods that are representative of international cuisine and also included a variety of plant-based protein sources, which led to relative high ratings of typicality without statistically significant differences between the two regions.

However, several limitations need to be acknowledged. Because recruitment focused on students of a life science faculty that, at the time of conducting the study, offered bachelor's programmes in German and master's programmes in English, the Global South subsample was even more highly educated than the Global North subsample. Nutrition, health, and sustainability knowledge of the sample is also likely to be above the national or global average. This may be further exacerbated by the high number of women in the sample, which tend to consume less meat, to be more conscious about their dietary choices also because of weight concerns (Modlinska et al., 2020), and to be more accepting of vegetarian diets than men (Judge & Wilson, 2019). Furthermore,

participants from the Global North were mainly from Germany, so results may not generalize to other Global North countries (e.g., USA). Most participants from the Global South migrated to Germany relatively recently, so this study was unable to include the time spent in the Global North as a moderator. Future studies should include samples that are more diverse in this regard to allow for studying the impact of food acculturation (Terragni et al., 2014). Finally, this study did not consider other factors that could influence the consumption of plant-based food such as nutrient content, price, seasonality, and perishability (Rekhy & McConchie, 2014), which should be taken into account in future research. The present study also did not provide concrete instructions to participants that they were supposed to focus on the environmental aspects of sustainability. While this allowed to test for general stereotypes regarding this term, we also cannot rule out that at least some participants might have rather thought about social or economic aspects or animal welfare (Wissenschaftlicher Beirat für Agrarpolitik, 2020). Explicitly addressing these indicators in future research would present a more holistic picture of sustainable diets and related stereotypes in lay populations.

6. Conclusions

The EAT Lancet Commission as well as the Intergovernmental Panel on Climate Change recommend reducing global meat consumption to reduce the environmental impact of the food production system (Sievert et al., 2022); consuming more plant-based diets have also been linked to promote human health (Vermeir et al., 2020). However, existing interventions to promote healthier and sustainable diets did not yet achieve the desired effects (Rekhy & McConchie, 2014). The present study suggests that culture is an important factor to be considered in these interventions since habitual food choices are heavily influenced by culture-specific eating traditions and stereotypes. Targeted information and education campaigns are needed to help people understand the co-benefits of healthy and sustainable diets to change dietary patterns on a global scale.

Declarations

Ethics approval and consent to participate

This study and all procedures involving research study participants were approved by the ethics committee of the University of Bayreuth. Participants provided written informed consent before taking part in the study.

Availability of data and materials

Study protocol, data and materials are provided on the Open Science Framework (https://osf.io/g8brz).

Declaration of generative AI in scientific writing

The authors declare that they did not use generative AI to write this manuscript.

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Mirna Al Masri: Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Laura M. König:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, 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.2024.105389.

Data availability

Study protocol, data and materials are provided on the Open Science Framework (https://osf.io/g8brz).

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