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RESEARCH ARTICLE

The "healthy = sustainable" heuristic: Do meal or individual characteristics affect the association between perceived sustainability and healthiness of meals?

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Abstract

Research has found an association between the perceived sustainability and healthiness of foods and meals between individual consumers. The current study aimed to investigate whether the association between perceived sustainability and healthiness on the individual level is rooted in reality. Moreover, we investigated whether meal or individual characteristics affect this association. In total, 5021 customers of a public canteen rated the sustainability and healthiness of 29 meal options. For determining the actual environmental sustainability and healthiness scores, exact recipes of each meal were analyzed using the NAHGAST algorithm. Results showed a substantial association between perceived sustainability and healthiness at the individual level. However, this perceived relation was unrelated to the overlap between the actual environmental sustainability and healthiness scores of the meals. Moreover, this "healthier = more sustainable" perception was unrelated to other meal characteristics (e.g., vegan content) or individual characteristics (i.e., gender, eating style). However, this association was slightly higher in older than in younger participants. The present study shows in a real-world setting that food consumers seem to evaluate the sustainability and healthiness of meals based on a simple "healthy = sustainable" heuristic which is largely independent of the actual overlap of these dimensions. Future research is needed to shed more light on the nature, sources, and consequences of this heuristic.

Author summary

Eating healthy and sustainable diets is a major challenge of our time; important but often not achieved. In the present study, we investigate the perceived sustainability and healthiness of foods, an important factor in choosing sustainable and healthy diets. In a real-world canteen setting, we asked consumers to rate the sustainability and healthiness of their consumed meals. Results show that respondents seem to rely on a "healthy = sustainable" heuristic. Specifically, if respondents perceived a meal as healthier, they also

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perceived it as more sustainable. This association was comparable between meals that had highly similar actual environmental sustainability and healthiness scores and meals that had very dissimilar actual scores. These results imply that it might be necessary to provide consumers with information regarding both the environmental sustainability and healthiness of foods to underline that these two dimensions can differ. Thus, one way forward might be the introduction of a sustainability label on foods, next to a healthiness label which already has been implemented in many countries.

1. Introduction

Eating healthy and sustainable diets is a major challenge of our time [1–5]. There are without doubt many factors, both on an individual and structural level, that influence whether people eat in a healthy and sustainable way (e.g., [6–10]). One of the individual factors is people's perception of what is healthy or sustainable [11,12]. That is, even if people are willing to choose healthy and sustainable foods, they will choose foods that they *perceive* to be healthy and sustainable. However, this does not necessarily mirror the *actual* healthiness and sustainability of foods (e.g. [13]). In addition, researchers have suggested that food sustainability is a multidimensional concept that includes environmental, health, and social dimensions, as well as animal welfare (e.g., [8]). Studies have shown, however, that the environmental dimension is most salient when people think of sustainable meals (e.g., [14]).

Previous research shows that there is a substantial association between perceived healthiness and sustainability of foods or meals (e.g., [12,15–17]). For instance, a study by Lazzarini et al. [16] found that the perceived environmental friendliness and healthiness of food items were highly correlated among individuals. These results hint towards the existence of a "healthy = sustainable" heuristic. Specifically, heuristics (or simple rules of thumb) are often used to make judgements under uncertainty or to reduce the time and effort to make decisions [18,19]. Importantly, heuristics are often useful given the numerous decisions that people need to make in everyday life [20]. However, in some contexts they can lead to systematic errors or "biases". For instance, research has shown that the larger the relationship between two variables, the more likely consumers assume that there is a causal relationship between these two variables, even when this is not true (magnitude heuristic [21]).

Regarding a potential "healthy = sustainable" heuristic, the question arises whether it accurately reflects an overlap in the actual healthiness and sustainability of foods and hence is rooted in reality. Indeed, there are many foods which are both relatively healthy and sustainable, such as many plant-based foods [22], and foods which are both relatively unhealthy and unsustainable, such as highly processed red meat [2,23]. Hence, associated perceptions of healthiness and sustainability can accurately reflect an actual overlap between the two characteristics. In contrast, the association between perceived healthiness and sustainability might operate largely independent from the actual similarity of the two characteristics. For example, there are also foods or meals such as air-transported fruits or vegetables which are relatively healthy but are associated with high greenhouse gases emissions (GHGs) and thus, are rather unsustainable [24]. Accordingly, for these types of foods a high association between perceived healthiness and sustainability would rather be inaccurate.

Until now, few studies have examined the question whether the observed association between perceived food healthiness and sustainability is rooted in reality. Results of Lazarini et al. [16] support the notion of a heuristic judgment process that does not reflect an actual overlap in sustainability and healthiness. Specifically, they presented 85 participants photographs of 30 pre-packed protein products (e.g., chicken breast, pork strips, chick peas) from two main grocery stores in Switzerland and asked them to rank the products first according to their perceived environmental friendliness and then according to their perceived healthiness. While perceived healthiness and environmental friendliness were positively related, the actual healthiness and sustainability scores of the examined foods were unrelated. These results suggest that consumers assume that healthiness and environmental friendliness are positively associated even when this is not true, suggesting that consumers might rely on a "healthy = sustainable" heuristic. This raises the question whether this judgment behavior can be generalized to everyday life choices. Specifically, there might be a lack of familiarity or motivational involvement as participants rated food pictures and did neither select nor consume the products themselves. Also, given the numerous decisions that individuals need to make in everyday life [20], they might invest less time and effort to make decisions than in a laboratory study and, thus, rely more on heuristics in everyday consumption situations.

Canteens or restaurants are, next to supermarkets, some of the most important places where people choose their foods (cf., [13]). Whereas producers and supermarkets provide various information regarding their products, such as nutrient labelling or country of origin (e.g., [16]), canteens or restaurants typically provide less information about their meals and products. In addition, meals provided in canteens or restaurants consist of various components and ingredients which contribute differently to the overall healthiness or sustainability of the meal. Hence, judging the healthiness or sustainability of meals is a more complex and uncertain task than judging a pre-packed single food item from a supermarket. This might create pre-conditions for the use of a "healthy = sustainable" heuristic.

Assuming people rely on a "healthy = sustainable" heuristic, the question arises which further characteristics impact this heuristic. Previous research on intuitions suggests that individual differences as well as food characteristics influence the decision-making process. For instance, the magnitude and valence of the "healthy = tasty" heuristic, that is associating food healthiness with food taste, varied with food characteristics and individual differences [25–27]. Specifically, Haasova and Florack [25] argued that one source of the "healthy = tasty" heuristic is the use of similar cues for both people's healthiness and tastiness judgements. With regard to a potential "healthy = sustainable" heuristic, people might use actual food healthiness, sustainability, and the degree of plant-based meal content as cues for judging both their sustainability and healthiness (see also [28]). Moreover, research showed that women have higher nutrition knowledge than men [29] and also people with certain eating styles, such as vegetarians or vegans have been found to have a fairly good nutrition-related knowledge [30]. In a similar vein, younger people have been reported to display more knowledge on the environmental friendliness of foods than older people [31]. Thus, given their higher knowledge, women, younger people, and people with certain eating styles might rely less on a potential "healthy = sustainable" heuristic than men, older people, and people without any special dietary regime. Still, to the best of authors' knowledge, studies so far have not directly investigated the role of individual and meal characteristics regarding a potential "healthy = sustainable" heuristic.

The present study aimed to investigate two research questions in a real-life context (university canteen) based on actual meal choices:

1. Do individuals who perceive a meal as healthier also perceive this meal as more sustainable; and does this association reflect an overlap in actual indicators of food healthiness and sustainability?
2. Which factors influence the strength of the association between perceived healthiness and sustainability? Specifically, do meal characteristics, such as actual healthiness, actual

environmental sustainability, or plant-based content, or individual characteristics, such as gender, age, or eating style, affect this association?

To answer these research questions, we assessed the perceived sustainability and healthiness of a number of canteen meals. Moreover, the actual environmental sustainability and healthiness scores of these meals were calculated. Specifically, the actual environmental sustainability score was calculated based on two indicators: greenhouse gases emissions and material consumption (cf., [32]). We chose these environmental indicators for the actual sustainability score as they generally align well with people's perceived sustainability, as previous research has shown that these environmental indicators are the most salient when people think of sustainable meals (e.g., [14]). The actual healthiness score was calculated based on the indicators energy content, dietary fiber, fat, carbohydrates, sugar, and salt content (see also [33]).

2. Materials and methods

2.1 Study site

The survey was conducted in the main area of a university canteen in Germany in February 2020. In 2020, the university recorded approximately 11,000 students and 2,400 employees. As the university is located at the outskirts of the city and alternative restaurants are at a distance, the canteen is frequented by most students and employees (see also Table 1 for the number of meals sold). During the time of the survey, the canteen offered four to five different hot meals for lunch with a preset serving size each day in up to five different menu lines. The student services (Studierendenwerk Seezeit), which operate the canteen, have the legal mandate to set prices for students in a socially responsible manner and the state of Baden-Württemberg subsidizes student meals. Therefore, prices for the meals differed by menu line and status group. The cheapest pricing was eligible for students and ranged from EUR 1.60 to EUR 6.90 per meal. Highest pricing applied to guests with a range from EUR 4.25 to EUR 6.90.

2.2 Data collection

The survey was conducted during the lunch hours of six days, resulting in 29 different meals investigated in the present study. When canteen customers chose one of preset hot meals, they received a brief paper-pencil questionnaire at the checkouts. Participants were asked to fill it in after eating and return it when returning their tray. To collect the questionnaires, questionnaire boxes were placed next to the tray returning points.

The brief paper-pencil questionnaire was self-administered (1 DIN A5 sheet). Participants were asked to indicate their meal choice and to rate the perceived healthiness and sustainability of the consumed meal. Specifically, participants were asked to rate the items "My meal of today was healthy." and "My meal of today was sustainable" using a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). Finally, respondents were asked to complete some demographic questions regarding their gender, age group, and eating style (e.g., being a vegetarian or vegan). Specifically, participants were asked whether they are female, male or diverse and in which age groups they fall ($<$ 18 years, 18–21 years, 22–25 years, 26–29 years, 30–39 years, 40–49 years, 50–59 years, $\geq$ 60 years).

Participants had the opportunity to win a voucher for the canteen as incentive for their participation. The number of people who rated each of the 29 meals ranged from 14 to 710, with M = 173 participants on average (SD = 171; see Table 1). The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the University of Konstanz (protocol code IRB20KN012-005/w). Informed consent was obtained from all

Table 1. Actual and perceived sustainability and healthiness of the 29 meals.

Meal	Animal or plant-based content	Actual environmental sustainability score	Actual healthiness score	Perceived sustainability		Perceived healthiness		*n*	Meals sold
				M	*SD*	*M*	*SD*		
1. Tomato basil pasta	Vegan	4.75	4.75	3.81	1.23	3.60	0.92	114	372
2. Penne with cheese sage sauce	Vegetarian	3.50	3.50	3.26	1.20	2.86	1.18	174	344
3. Swabian ravioli	Vegan	3.50	3.50	4.05	1.16	4.12	1.03	197	606
4. Chicken nuggets	Poultry	1.00	1.42	2.82	1.22	3.18	1.22	214	557
5. Vegetable pot	Vegan	6.00	5.17	3.38	1.40	3.83	1.24	24	152
6. Potato goulash	Pork	4.75	3.92	3.23	1.32	3.54	1.16	55	229
7. Fried swabian ravioli	Vegetarian	3.50	2.67	3.70	1.09	3.44	1.00	346	831
8. Poultry cordon bleu	Poultry	1.00	1.83	2.72	1.16	2.99	1.13	710	1055
9. Baked spring rolls	Vegetarian	6.00	4.75	3.32	1.24	3.31	1.17	357	578
10. Coucous tarts	Vegan	6.00	4.75	4.16	1.29	4.40	1.18	198	379
11. Oriental falafel	Vegan	6.00	4.75	4.13	1.26	4.25	1.18	406	609
12. Chili sin carne	Vegan	3.50	4.75	4.16	1.22	4.33	1.17	124	570
13. Kofta	Beef	1.00	2.25	2.73	1.16	3.17	0.98	126	385
14. Baked potatoes	Vegetarian	1.00	2.25	3.89	1.24	3.85	1.10	475	803
15. Spanish meatballs	Poultry	1.00	2.25	3.25	1.10	3.60	1.03	131	297
16. Tandoori soup	Vegan	6.00	4.33	4.53	1.13	4.89	0.99	19	210
17. Nuremberg bratwurst	Pork	2.25	3.92	2.77	1.38	2.85	1.17	107	557
18. Roast beef with onions	Beef	1.00	2.67	2.95	1.22	3.52	1.09	51	232
19. Mixed BBQ	Beef, pork, poultry	1.00	2.67	2.79	1.49	2.97	1.21	38	203
20. Tortelloni mediterraneo	Vegan	4.75	2.67	3.79	1.25	3.69	1.17	476	807
21. Cod fillet	Fish	3.50	5.58	3.74	1.24	4.56	1.11	51	176
22. Pork loin steak	Pork	1.00	3.50	3.19	1.30	3.74	1.23	62	228
23. Pork fillet medallions	Pork	1.00	3.92	3.21	1.33	3.87	1.02	136	268
24. Asian glass noodle stew	Beef	1.00	4.33	3.38	1.26	3.79	1.43	14	121
25. Chicken breast cutlet	Poultry	1.00	4.33	3.18	1.31	3.58	1.19	146	521
26. Curry Bombay	Pork	1.00	4.33	3.01	1.09	3.35	0.99	184	534
27. Turkey piccata	Poultry	1.00	4.33	2.98	1.24	3.42	1.40	44	231
28. Creamy mushroom soup	Vegan	1.00	5.17	3.53	1.46	2.75	1.61	17	131
29. Gyros and pepper stew	Pork	1.00	5.17	3.45	1.28	3.88	1.30	25	167

Note. n = number of participants rating each meal.

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participants by briefing them that by returning the questionnaire they agree to participate in the study.

2.3 Data analysis and power considerations

To visualize perceived sustainability and healthiness, v-plots were created for the different meals (see also [34–36]). The online tool to create v-plots is publicly available at https://v-plot.dbvis.de. Actual environmental sustainability and actual healthiness scores were determined for each meal based on the exact recipes provided by the canteen. These included information on ingredients, mass/volume per portion, whether it was frozen or fresh, country of origin, organic production, and preparation details (e.g. cooking duration). To calculate an actual environmental sustainability and healthiness score for all meals, the publicly available NAHGAST algorithm tool was used (https://www.nahgast.de/rechner; see e.g. [32–33,37]). The NAHGAST algorithm tool was tested and validated by a total of 120 recipes [38]. It can be used for the evaluation of single dishes as well as by practitioners in the out-of-home catering sector [28]. The NAHGAST algorithm tool was developed by a publicly funded research project (NAHGAST) in cooperation with five practice partners [38] and is able to calculate both actual environmental sustainability and actual healthiness scores for meals with indicators selected through a stakeholder process [32]. Included sustainability indicators were greenhouse gases (GHG) emissions and material consumption, each assessed as kg per meal. Regarding meal healthiness, included nutritional and hence health-related indicators were energy content (kcal per meal) as well as dietary fiber, fat, carbohydrates, of which total sugar, and salt content (g per meal). Based on these indicators, both an actual environmental sustainability score as well as an actual healthiness score was calculated by the NAHGAST tool with a scale from 1 (low) to 6 (high).

All statistical analyses were performed in IBM SPSS Statistics (version 28 for Windows). Mixed linear regressions were computed without imputing missing data in level 1 variables as suggested by Twisk et al. [39]. First-level units were individual participants ($N = 5021$), whereas second-level units were meals ($N = 29$). Restricted maximum likelihood (REML) was used as method of estimation, as suggested when there are small numbers of higher level groups in the study [40]. Tabachnick and Fidell [41] suggest that sufficient power for cross-level effects is obtained when sample sizes at the first level are not too small and the number of groups is 20 or larger. As we had 173 participants on average per meal (level 1) and 29 meals at level 2, sample size seemed sufficient to detect a cross-level interaction.

Before each analysis, assumptions were checked. Since independent variables did not correlate strongly (no correlation coefficient was above 0.70), no marked collinearity restrictions existed. Outliers with residuals greater than the third quartile plus 3 times the interquartile range were excluded from respective analyses; as were outliers with residuals smaller than the first quartile minus 3 times the interquartile range. Data was checked for linearity, normality, as well as homoscedasticity before analyses were performed. For analyses, all level-1 predictors were group-mean centered, and level-2 predictors were grand-mean centered, following recommendations of Enders and Tofighi [42].

First, a null model was defined with perceived healthiness (level 1) as dependent variable, meals as clustering variable, and no predictors. This analysis revealed an intraclass correlation (ICC) of 0.164, which indicates that the proportion of variance in perceived healthiness that lies between meals was 16%. This hints towards a non-ignorable multilevel structure of the data [40]. Second, a random slope and intercept model was defined to investigate the association between perceived sustainability and healthiness as well as whether meals differ in this association. Therefore, perceived sustainability (level 1) was added to the model as predictor with perceived healthiness (level 1) as dependent variable.

Third, to investigate whether the association between perceived healthiness and perceived sustainability is affected by the overlap in actual healthiness and environmental sustainability scores of foods, a discrepancy score was calculated by taking the absolute value of the difference between the actual healthiness and environmental sustainability scores. A model was defined with perceived sustainability (level 1), this discrepancy score (level 2), and a cross-level interaction between perceived sustainability (level 1) and the discrepancy score (level 2) as predictors and perceived healthiness (level 1) as dependent variable.

Fourth, to investigate whether the association between perceived healthiness and perceived sustainability is affected by further meal characteristics, similar models were defined as in the previous step, with the actual healthiness score, actual environmental sustainability score, single indicators of meal healthiness or meal sustainability, or plant- vs. animal-based meal content as level 2 variable instead of the discrepancy score analyzed in the previous step. As two single indicators of actual meal healthiness, that its sugar and salt content, were severely skewed, they were log-transformed before including them in the analysis. Regarding plant- vs. animal-based meal content, a dummy variable was computed with 1 for vegan meals and 0 for non-vegan meals.

Fifth, to investigate whether the association between perceived healthiness and perceived sustainability is affected by individual characteristics, models were defined with perceived sustainability (level 1) as predictor and perceived healthiness (level 1) as dependent variable. In addition, each of the following level 1 variables was included: gender, age, or eating style. Gender was dummy coded with 1 for females and 0 for males and gender-diverse people. Gender-diverse people had to be grouped with a different gender group because of the small group size. Also, eating styles were dummy coded. For instance, the value of 1 indicated a vegetarian eating style, whereas the value of 0 indicated that participants did not report a vegetarian eating style.

3. Results

3.1 Sample characteristics

In total, we received 6608 filled-out questionnaires. Of these, 1587 were removed from data analysis because participants (1) indicated that they had consumed more than one meal (n = 171), (2) did not indicate which meal they chose (n = 75), (3) indicated that they had chosen none of the hot meals with preset serving size (n = 1317), or (4) indicated that they had consumed a meal that was not provided this day (n = 24). The remaining 5021 participants comprised of 1992 women (39.7%), 2123 men (42.3%) and 71 gender-diverse people (1.4%); whereas 835 participants (16.6%) did not indicate their gender. Most participants were younger than 26 years (n = 3378, 67.3%), another 15.0% (n = 754) was between 26 and 29 years, and 14.9% (n = 748) was 30 years or older; whereas 2.8% (n = 141) did not indicate their age. Most participants indicated that they were students (n = 3640; 72.5%), whereas 1223 participants reported to be employees or Ph.D. students (24.3%). A total of 85 participants (1.7%) indicated that they had another role at the University and 157 (3.1%) indicated no role at all. As it was possible to indicate more than one role (e.g., being a student and Ph.D. student at the same time), these numbers exceed the total sample size of 5021. With regard to eating styles, 1271 participants indicated that they were vegetarians (25.3%), 348 that they were vegans (6.9%), 63 reported to avoid gluten (1.3%), 157 reported to avoid lactose (3.1%), 183 reported to limit consumed energy (3.6%), and 1197 participants indicated that they adhered to another eating style (23.8%).

The study sample (N = 5021) did not differ from the drop-out sample (N = 1587) in terms of gender (47.6% vs. 50.5% of those who responded to the item were women; $\chi^2(2) = 3.92$, p = .141), gluten-free, lactose-free, energy-limited, or another eating style (Gluten-free: 1.3% vs. 1.8%; $\chi^2(1) = 2.31$, p = .129. Lactose-free: 3.1% vs. 3.8%; $\chi^2(1) = 1.94$, p = .163. Energy-limited: 3.6% vs. 4.5%, $\chi^2(1) = 2.24$, p = .134. Other: both 23.8%; $\chi^2(1) = 0.00$, p = .986). However, the study sample was younger than the drop-out sample (69.2% vs. 60.3% of those who responded to the item were younger than 26 years; 15.3% vs. 23.2% 30 years or older; $\chi^2(7) = 87.11$, $p < .001$). In line with this, the study sample comprised of more students than the drop-out sample (72.5% vs. 61.7%, $\chi^2(1) = 66.93$, $p < .001$). Also, fewer vegans and vegetarians participated in the study than were in the drop-out sample (vegans: 6.9% vs. 8.9%; $\chi^2(1) = 7.14$, p = .008. Vegetarians: 25.3% vs. 30.7%; $\chi^2(1) = 17.83$, $p < .001$).

3.2 Descriptive statistics

Actual healthiness and environmental sustainability scores of the 29 different meals are displayed in Table 1. Out of the 29 meals, 9 were vegan, 4 were vegetarian, 1 included fish, 5 included poultry, 6 included pork, 3 included beef, and 1 included a mix of poultry, pork and beef. The actual environmental sustainability scores of meals ranged from 1.00 (lowest possible sustainability score) to 6.00 (highest possible sustainability score) with a mean of $M = 2.72$, $SD = 2.02$. In a similar vein, the actual healthiness scores of meals covered nearly the full range from 1.42 to 5.58, with $M = 3.77$, $SD = 1.15$. Energy content per meal varied from 217 kcal to 1552 kcal (see S1 Table for sustainability and healthiness indicators, Supplemental Material). As can be seen in Table 1, there were meals that received similar values regarding both actual environmental sustainability and healthiness scores. For instance, the meal "tomato basil pasta" was both relatively sustainable and healthy (values of 4.75 each), whereas the meal "chicken nuggets" was both relatively unsustainable and unhealthy (values of 1.00 and 1.42 respectively). At the same time, however, there were also meals for which actual environmental sustainability and healthiness scores diverged. This was, for example, the case for the meal "gyros and pepper stew", which was relatively unsustainable (value of 1.00) but at the same time relatively healthy (value of 5.17).

In addition, mean perceived healthiness and sustainability per meal as well as the number of participants who rated each meal are displayed in Table 1. Table 2 contains the correlations between the actual environmental sustainability and healthiness scores, and also between perceived sustainability and healthiness as well as aggregated means and standard deviations on the meal level ($N = 29$). Fig 1 depicts 29 v-plots, each displaying a histogram in light gray with the relative frequency of each response category for perceived sustainability and healthiness.

On average, 22 out of 29 meals had a higher mean perceived healthiness as compared to the mean perceived sustainability (please see Fig 1 and Table 1; across all participants: perceived healthiness $M = 3.57$, $SD = 1.22$ vs. perceived sustainability $M = 3.43$, $SD = 1.32$, $F(1, 4043) = 44.29$, $p < .001$, $\eta_p^2 = 0.01$). The meal "tandoori soup" was perceived both as the healthiest ($M = 4.89$, $SD = 0.99$) and as the most sustainable ($M = 4.53$, $SD = 1.13$) out of the 29 meals. The meal perceived as the least sustainable was "poultry cordon bleu" ($M = 2.72$, $SD = 1.16$); while the meal perceived as the least healthy was "creamy mushroom soup"($M = 2.75$, $SD = 1.61$). Thus, the level of the perceived healthiness of meals was generally higher than their level of perceived sustainability.

In addition to their mean level, also the distribution of perceived sustainability and healthiness varied across participants within meals (see Fig 1). For instance, regarding perceived sustainability, the lowest variability occurred for the meal "fried swabian ravioli" ($SD = 1.09$), indicating a relative agreement between perceptions of participants. Conversely, the highest variance in perceived sustainability was observed for the meal "mixed BBQ" with a rather flat distribution of responses ($SD = 1.49$). Regarding perceived healthiness, the smallest spread was observed for the meal "tomato basil pasta" ($SD = 0.92$), and the largest for the meal "creamy mushroom soup" ($SD = 1.61$).

Table 2. Correlations between actual and perceived sustainability and healthiness on the meal level (level 2; $N = 29$).

	M	*SD*	2 Actual healthiness score	3 Perceived sustainability	4 Perceived healthiness
1 Actual environmental sustainability score	2.72	2.02	.42*	.64***	.47**
2 Actual healthiness score	3.77	1.15		.45*	.41*
3 Perceived sustainability	3.42	0.50			.79***
4 Perceived healthiness	3.63	0.53			

Note. *** $p < .001$

** $p < .01$

* $p < .05$. Mean perceived sustainability and healthiness were first calculated for each meal; subsequently these means were correlated as well as averaged across the 29 meals.

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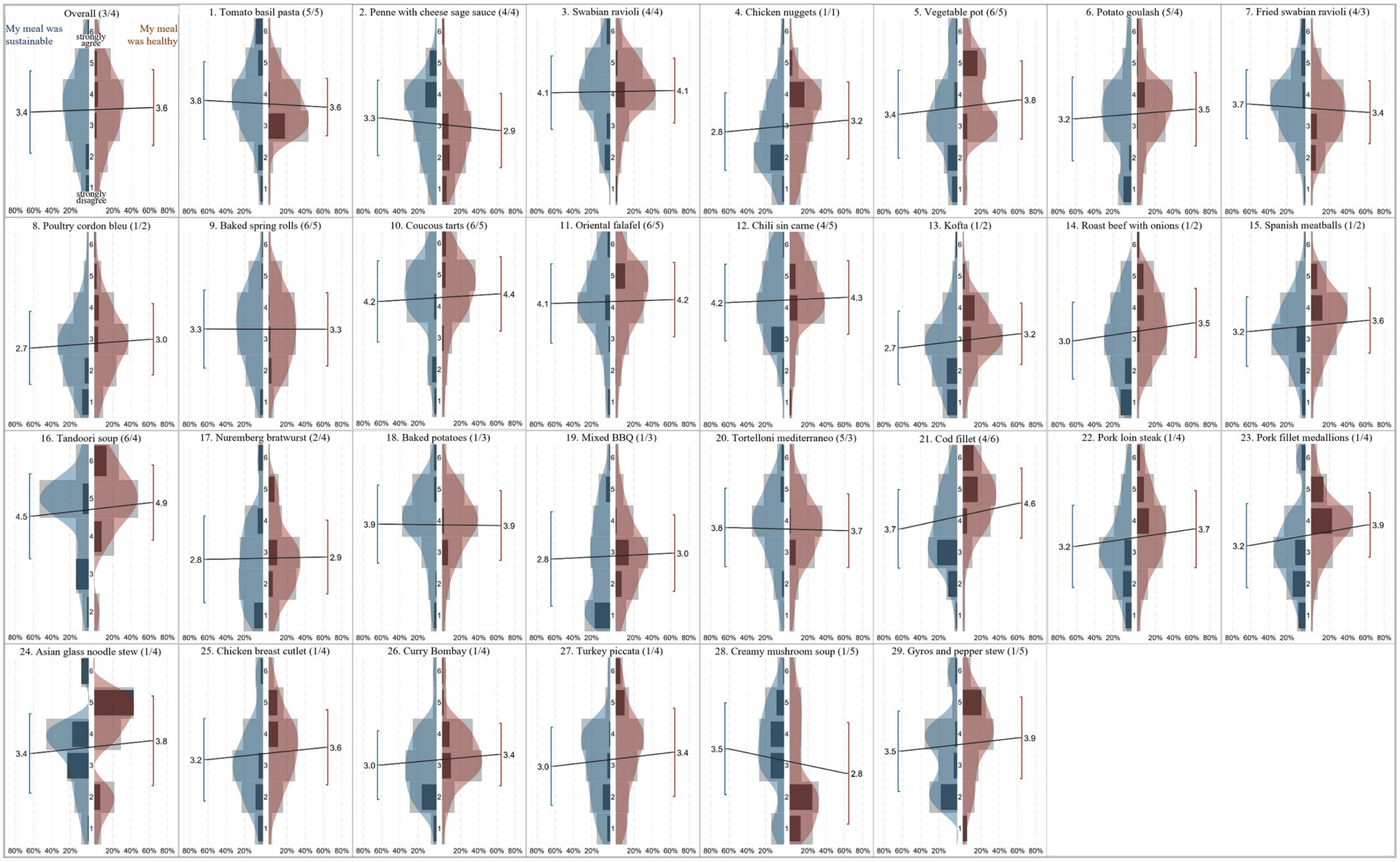

Fig 1. V-plots for perceived sustainability (blue) and healthiness (red) of the 29 meals. Smoothed density distributions (red/blue shape) show the type of distribution; histograms (light gray) depict the relative frequency of each response category; difference histograms (dark gray) highlight the differences in each response category; means and standard deviations are depicted as lines in red/blue above the distributions. Mean values are connected via a black line for comparison. Numbers in parentheses after the meal name refer to their actual environmental sustainability and healthiness scores.

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With regard to the relationship between perceived sustainability and healthiness, the random slope and intercept model (model 1) revealed a significant association between perceived sustainability and perceived healthiness (see Table 3). Moreover, this model revealed a significant variance of this association between meals ($\tau 11$ = .007, 95% CI [.003, .018], SE = .003, Wald Z = 1.981, p = .048). The bivariate Pearson correlations between perceived sustainability and perceived healthiness for the 29 meals are illustrated in Fig 2.

3.3 Actual overlap and association between perceived healthiness and sustainability

To investigate whether the association between perceived sustainability and healthiness reflects the overlap in actual healthiness and environmental sustainability scores of meals, we computed a mixed linear regression (model 2). We included perceived sustainability, the discrepancy score between actual meal healthiness and environmental sustainability scores, and a cross-level interaction between perceived sustainability and the discrepancy score as predictors as well as perceived healthiness as dependent variable. This analysis revealed again a significant association between perceived sustainability and perceived healthiness (see Table 3). However, neither the discrepancy between the actual healthiness and environmental sustainability scores

Table 3. Results of mixed linear regressions with perceived healthiness (level 1) as dependent variable (*N* = 5021).

Fixed effects	β [CI]	*SE*	*t*	*F*	*df*	*p*
Model 1: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.53 [.49, .58]	0.02	24.37	593.82	1, 21.87	< .001
Model 2: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.53 [.49, .58]	0.02	26.74	715.13	1, 20.03	< .001
Discrepancy score between actual healthiness and environmental sustainability scores (level 2)	.00 [-.13, .13]	0.06	0.01	0.00	1, 27.38	.989
Cross-level interaction between perceived sustainability (level 1) and discrepancy score (level 2)	.02 [-.01, .06]	0.02	1.42	2.01	1, 30.84	.166
Model 3: Pseudo R^2 (marginal) = .30						
Perceived sustainability (level 1)	.54 [.49, .58]	0.02	26.49	701.48	1, 17.25	< .001
Actual healthiness score (level 2)	.19 [.03, .35]	0.08	2.47	6.08	1, 25.29	.021
Cross-level interaction between perceived sustainability (level 1) and actual healthiness score (level 2)	.00 [-.04, .04]	0.02	0.05	0.00	1, 17.96	.959
Model 4: Pseudo R^2 (marginal) = .31						
Perceived sustainability (level 1)	.54 [.50, .58]	0.02	27.35	747.87	1, 19.08	< .001
Actual environmental sustainability score (level 2)	.21 [.05, .36]	0.08	2.73	7.42	1, 26.80	.011
Cross-level interaction between perceived sustainability (level 1) and actual environmental sustainability score (level 2)	-.02 [-.06, .02]	0.02	-0.92	0.84	1, 17.39	.373
Model 5: Pseudo R^2 (marginal) = .32						
Perceived sustainability (level 1)	.54 [.50, .58]	0.02	27.13	735.74	1, 19.29	< .001
Meal content (level 2)	.22 [.08, .37]	0.07	3.13	9.81	1, 24.52	.004
Cross-level interaction between perceived sustainability (level 1) and meal content (level 2)	.01 [-.03, .06]	0.02	0.64	0.42	1, 18.45	.527
Model 6: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.53 [.51, .56]	0.01	40.41	1633.27	1, 3371.92	< .001
Gender (level 1)	-.04 [-.06, -.01]	0.01	-2.90	8.42	1, 3371.48	.004
Interaction between perceived sustainability (level 1) and gender (level 1)	-.01 [-.04, .02]	0.01	-0.75	0.56	1, 3373.97	.455
Model 7: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.53 [.51, .55]	0.01	43.28	1873.02	1, 3930.40	< .001
Age (level 1)	-.01 [-.04, .01]	0.01	-1.07	1.14	1, 3931.20	.286
Interaction between perceived sustainability (level 1) and age (level 1)	.05 [.03, .08]	0.01	4.38	19.16	1, 3936.71	< .001
Model 8: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.54 [.51, .56]	0.01	44.14	1948.32	1, 4036.21	< .001
Vegan eating style (level 1)	.00 [-.02, .03]	0.01	0.22	0.05	1, 4036.68	.827
Interaction between perceived sustainability (level 1) and vegan eating style (level 1)	.00 [-.02, .02]	0.01	0.30	0.09	1, 4041.48	.767
Model 9: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.54 [.51, .56]	0.01	44.48	1978.85	1, 4036.21	< .001
Vegetarian eating style (level 1)	.02 [.00, .05]	0.01	1.98	3.92	1, 4036.97	.048
Interaction between perceived sustainability (level 1) and vegetarian eating style (level 1)	-.02 [-.04, .01]	0.01	-1.33	1.77	1, 4041.19	.184

(*Continued*)

Table 3. (Continued)

Fixed effects	β [CI]	*SE*	*t*	*F*	*df*	*p*
Model 10: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.54 [.51, .56]	0.01	44.38	1969.67	1, 4036.22	< .001
Gluten-free eating style (level 1)	-.00 [-.03, .02]	0.01	-0.12	0.01	1, 4037.96	.905
Interaction between perceived sustainability (level 1) and gluten-free eating style (level 1)	.00 [-.02, .02]	0.01	0.05	0.00	1, 4040.29	.963
Model 11: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.54 [.51, .56]	0.01	44.41	1972.15	1, 4036.23	< .001
Lactose-free eating style (level 1)	-.02 [-.04, .00]	0.01	-1.74	3.04	1, 4036.60	.081
Interaction between perceived sustainability (level 1) and lactose-free eating style (level 1)	-.02 [-.04, .01]	0.01	-1.38	1.90	1, 4039.67	.168
Model 12: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.54 [.51, .56]	0.01	44.30	1962.23	1, 4036.24	< .001
Energy-limited eating style (level 1)	-.01 [-.03, .02]	0.01	-0.64	0.41	1, 4036.69	.521
Interaction between perceived sustainability (level 1) and energy-limited eating style (level 1)	.02 [-.00, .04]	0.01	1.78	3.15	1, 4038.45	.076
Model 13: Pseudo R^2 (marginal) = .27						
Perceived sustainability (level 1)	.54 [.51, .56]	0.01	44.35	1966.55	1, 4036.22	< .001
Other eating style (level 1)	-.00 [-.03, .02]	0.01	-0.25	0.06	1, 4036.55	.805
Interaction between perceived sustainability (level 1) and other eating style (level 1)	.01 [-.01, .04]	0.01	1.15	1.33	1, 4038.24	.249

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nor the cross-level interaction had a significant effect on perceived healthiness. Thus, the association between perceived sustainability and healthiness does not reflect the overlap in actual healthiness and environmental sustainability scores of meals. Specifically, Fig 2 depicts Pearson correlations between perceived sustainability and perceived healthiness by meal on the Y-axis, whereas the discrepancy in actual meal environmental sustainability and healthiness scores is displayed on the X-axis. If the association between perceived sustainability and healthiness was affected by the overlap in actual healthiness and environmental sustainability scores of meals, then the Pearson correlations should be larger for meals with comparable actual environmental sustainability and healthiness scores (left side of Fig 2) and smaller for meals with diverging actual environmental sustainability and healthiness scores (right side of Fig 2). However, Pearson correlations do not follow this pattern. Hence, the association between perceived sustainability and healthiness did not appear to be rooted in reality, as indicated by the actual overlap in environmental sustainability and healthiness scores.

3.4 Influencing factors of the association between perceived healthiness and sustainability

3.4.1 Meal characteristics. To investigate whether the association between perceived sustainability and healthiness differs as a function of meal healthiness, a mixed linear regression was computed. The model contained perceived sustainability, the actual meal healthiness

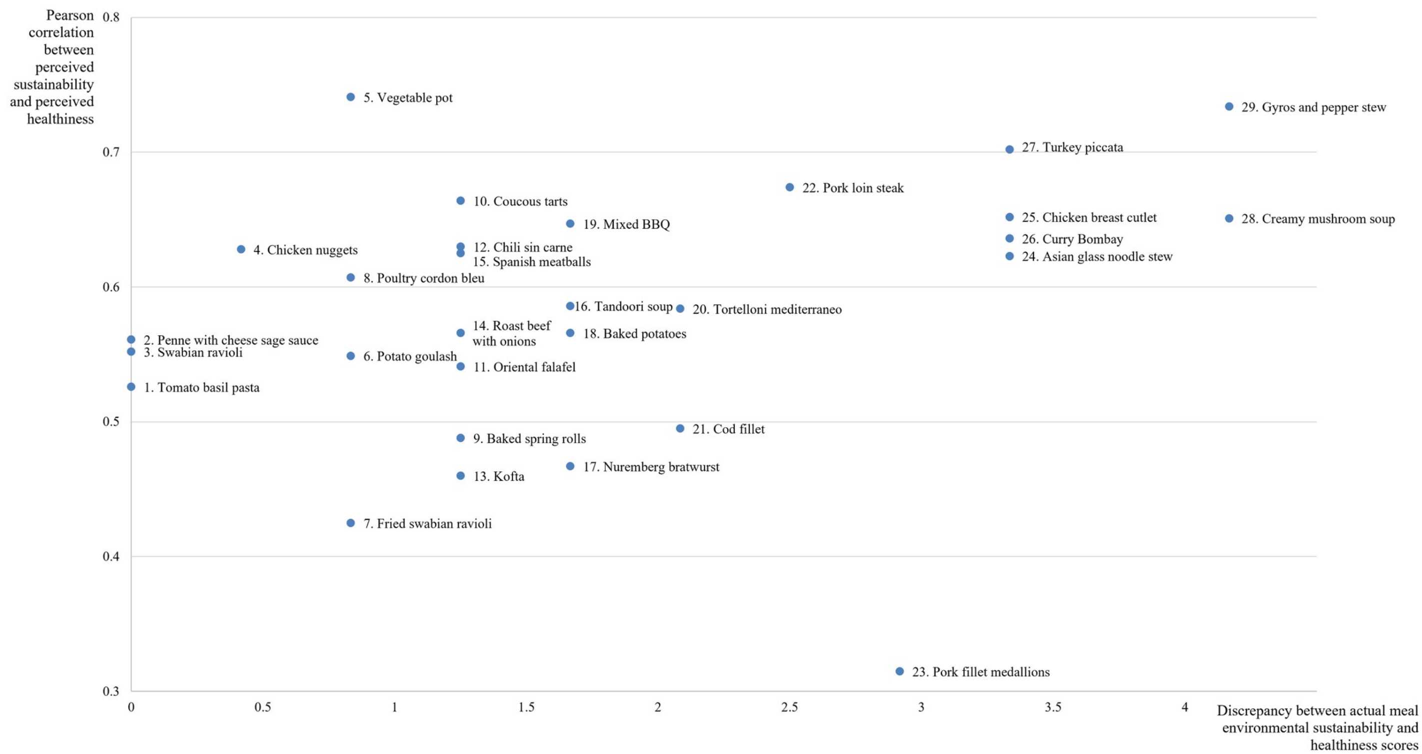

Fig 2. Pearson correlation between perceived sustainability and perceived healthiness by meal.

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score, and a cross-level interaction between perceived sustainability and actual meal healthiness score as predictors, as well as perceived healthiness as dependent variable (model 3). This analysis revealed again a significant association between perceived sustainability and perceived healthiness (see Table 3). Also, the actual meal healthiness score was a significant predictor of perceived healthiness. However, the cross-level interaction did not have a significant effect on perceived healthiness. To secure this pattern of results, the analysis was repeated with single indicators of meal healthiness instead of the overall meal healthiness score as level 2 predictors. Specifically, including energy content, dietary fiber, fat, carbohydrates, sugar, or salt content again revealed non-significant interactive effects with perceived sustainability on perceived healthiness ($\beta s \leq |.02|$, $ts \leq |1.18|$, $ps \geq .250$). Hence, the association between perceived healthiness and sustainability was not affected by actual meal healthiness indicators.

To investigate whether the association between perceived sustainability and healthiness differs as a function of the actual environmental sustainability score, a mixed linear regression was computed. The model included perceived sustainability, the actual environmental sustainability score, and a cross-level interaction between perceived sustainability and actual meal environmental sustainability score as predictors, as well as perceived healthiness as dependent variable (model 3). This analysis revealed again a significant association between perceived sustainability and perceived healthiness (see Table 3). Also, the actual environmental sustainability score was a significant predictor of perceived healthiness. However, the cross-level interaction did not have a significant effect on perceived healthiness. To secure this pattern of results, the analysis was repeated with single indicators of meal sustainability instead of the overall environmental sustainability score as level 2 predictors. Specifically, including material consumption or GHG emissions again revealed non-significant interactive effects with perceived sustainability on perceived healthiness (βs ≤ |.01|, *t*s ≤ |0.75|, *p*s ≥ .461). Hence, the association between perceived healthiness and sustainability was not affected by actual meal sustainability indicators.

To investigate whether the association between perceived sustainability and healthiness differs between plant-based meals and meals with animal-based content, a mixed linear regression was computed. The model contained perceived sustainability, meal content, and a cross-level interaction between perceived sustainability and meal content as predictors, as well as perceived healthiness as dependent variable (model 5). This analysis revealed again a significant association between perceived sustainability and perceived healthiness (see Table 3). Also, meal content was a significant predictor of perceived healthiness. Specifically, plant-based meals were perceived as healthier than meals with animal-based content. However, the cross-level interaction did not have a significant effect on perceived healthiness. Hence, the association between perceived healthiness and sustainability was not affected by the plant- or the animal-based content of the meal.

3.4.2 Individual characteristics. First, we investigated whether the association between perceived sustainability and healthiness depended on gender. Therefore, we computed a mixed linear regression with perceived sustainability, gender, and the interaction between perceived sustainability and gender as predictors as well as perceived healthiness as dependent variable (all variables at level 1; model 6). This analysis revealed again a significant association between perceived sustainability and perceived healthiness (see Table 3). Also, there was a significant main effect of gender on perceived healthiness. Specifically, female participants reported lower perceived healthiness than male and gender-diverse participants. The interaction between perceived sustainability and gender was not significant. Hence, the association between perceived healthiness and sustainability was not affected by gender.

Second, we investigated whether the association between perceived sustainability and healthiness depended on age. We calculated a mixed linear regression with perceived sustainability, age, and the interaction between perceived sustainability and age as predictors as well as perceived healthiness as dependent variable (all variables at level 1; model 7). This analysis revealed again a significant association between perceived sustainability and perceived healthiness (see Table 3). Also, there was a significant interaction between perceived sustainability and age on perceived healthiness. Specifically, the older the participants, the larger was the association between perceived sustainability and healthiness. The main effect of age on perceived healthiness was not significant. Hence, the association between perceived healthiness and sustainability was affected by age.

Third, we examined whether the association between perceived sustainability and healthiness depended on the following eating styles: vegan, vegetarian, gluten-free, lactose-free, energy-limited, or another eating style. We calculated mixed linear regressions with perceived sustainability, one of the eating styles, and the interaction between perceived sustainability and eating style as predictors as well as perceived healthiness as dependent variable (all variables at level 1; models 8–13). None of these analyses revealed a significant interaction between eating style and perceived sustainability on perceived healthiness (see Table 3) but again a significant main effect of perceived sustainability. Also, there was a significant main effect on perceived healthiness from the vegetarian eating style. Specifically, vegetarians perceived their meals as healthier than non-vegetarians. There were no significant main effects of a vegan, gluten-free, lactose-free, energy-limited, or another eating style. Altogether, results show that the association between perceived healthiness and sustainability is not affected by eating style.

4. Discussion

4.1 The "healthy = sustainable" heuristic and the impact of meal and individual characteristics

The current study aimed to investigate whether the association in perceived sustainability and healthiness is rooted in reality in a real-world setting. The results suggest that consumers seemed to evaluate the sustainability and healthiness of their purchased meals based on a simple "healthy = sustainable" heuristic. Importantly, the association in perceived sustainability and healthiness was largely independent of the overlap in the actual environmental sustainability and healthiness scores of the 29 examined meals. Further analyses showed that the "healthy = sustainable" association was also unrelated to other meal characteristics (e.g., environmental sustainability and healthiness indicators such as sugar or energy content; plant- or animal-based content). The observed pattern of results was also consistent across gender and personal eating style. However, older participants showed a slightly more pronounced "healthy = sustainable" association than younger participants. In conclusion, the finding that individuals who perceive a meal as healthier also perceive this meal as more sustainable appears to be largely independent from the actual overlap between the two characteristics. Future research needs to replicate and extend these findings with complementary research designs and different samples. For instance, experimental designs are needed to test whether perceived healthiness affects perceived sustainability or vice versa. Moreover, as the present sample consisted mainly of students, future research needs to examine whether findings can be generalized to other groups, for example, with lower education.

The results extend previous findings [12,15–17] and show that also within a context encompassing actual real-life food purchases and consumption, people seem to use heuristic information processing, which does not reflect the overlap in actual sustainability and healthiness scores. Moreover, as the sample in the present study was highly educated with an above average socioeconomic status, this points to the pervasiveness of the "healthy = sustainable" heuristic. Specifically, as education is positively related to nutrition-related knowledge [29], a relatively low reliance on a "healthy = sustainable" heuristic might be expected. Still, we found a strong association between perceived sustainability and healthiness in this highly educated sample.

An intriguing question is whether there is a "halo" effect from healthiness towards sustainability or vice versa. Halo effects refer to the phenomenon where an initial favorable impression promotes subsequent favorable evaluations on unrelated dimensions [43]. As perceived healthiness was on average higher than perceived sustainability and people might be generally more familiar with health-related indicators and diet quality (e.g., fat and sugar content) than sustainability indicators (GHG emissions and material consumption), it could be argued that there might be a halo effect from healthiness towards sustainability. In line with this assumption, the two meals with the highest discrepancy between actual environmental sustainability and healthiness scores ("Creamy mushroom soup" and "Gyros and pepper stew"), which nevertheless had very high correlations between perceived sustainability and healthiness, had very high actual healthiness scores of 5, but very low actual sustainability scores of 1 (see Fig 2 and Table 1). Moreover, Bschaden et al. [44] experimentally manipulated the perceived sustainability of a snack and found no effect on perceived healthiness. However, research from related domains found a halo effect for organic labels on perceived healthiness [45–47]. Also, the correlation between actual and perceived sustainability on the meal-level was higher than the correlation between actual and perceived healthiness, which might speak in favor of healthiness being inferred from sustainability. However, there might also be third factors which both influence perceived sustainability and healthiness. That is, from the data we can only infer that there is a "healthy = sustainable" heuristic, but other underlying variables might have contributed to the observed results, such as individual differences in the use of comparison standards for perceived sustainability and healthiness, differences in understanding the response scales or in response styles. Hence, future research needs to address this issue with alternative designs, such as experimentally testing whether manipulating healthiness (e.g., by using different health labels) affects perceived sustainability and vice versa.

In contrast to our assumption, the identified "healthy = sustainable" judgments were not modulated by the various actual meal characteristics. Hence, the actual meal healthiness and environmental sustainability scores or vegan meal content did not serve as joint cues for perceived sustainability and healthiness and, thus, a trigger for this association. Future research needs to study whether there are other cues than the ones investigated in the present study, such as green meal color, that act as source for a "healthy-sustainable" heuristic (cf., [25]).

With regard to individual characteristics, the results indicate that the association between perceived sustainability and healthiness was largely consistent across different groups. Only a small effect for age groups occurred. That younger participants seemed to rely slightly less on a "healthy = sustainable" heuristic than older participants might indicate greater interest and knowledge about sustainability topics, which might mitigate heuristic decision-making (cf., [31]). Still, future research needs to directly test the role of people's knowledge of what is healthy and sustainable regarding the association between perceived sustainability and healthiness (cf., [12,25,44,48]). Also, when considering that the present sample was relatively homogenous (e.g., high level of education), future research needs to investigate the role of individual characteristics in more heterogenous samples.

In the present manuscript, we investigated whether consumers who perceive a meal as healthier also perceive this meal as more sustainable, and whether individual and meal characteristics impact this association. We focused on this individual-level association because heuristics are assumed to act in individuals' decision processes [18,49]. However, it is important to note that this individual-level association differs from a meal-level perspective, in which the individual ratings are averaged per meal. Specifically, a meal-level question would be whether meals that are perceived as healthier, are also perceived as more sustainable, which was also the case in the present study (see Table 2). Still, Monin & Oppenheimer [49] argue that this correlation of averages falls short of investigating the process assumed to underlie a heuristic, which should be addressed at the level of the individual.

Another point for discussion is whether a "healthy = sustainable" heuristic is conceptualized as similar perceived healthiness and sustainability scores or as a covariation between perceived healthiness and sustainability. The first could be measured via the discrepancy between the level of perceived healthiness and sustainability, whereas the latter could be measured via a correlation and indicate a "healthier = more sustainable" perception, regardless of the absolute level of perceived healthiness and sustainability. In line with previous research on the "healthy = tasty" association (e.g., [25]), we chose the latter conceptualization. Still, investigating the similarity of perceived healthiness and sustainability scores would be an interesting topic for future research. Specifically, combining the meal-level perspective and the similarity-instead-of-association perspective, our data revealed a correlation of .45 between the discrepancy between aggregated perceived healthiness and sustainability and the discrepancy between actual healthiness and environmental sustainability scores. This result indicates that meals with higher discrepancies in their actual healthiness and environmental sustainability scores, have on average also higher discrepancies in their perceived healthiness and sustainability.

4.2 Strengths and limitations

Strengths of the present study include the real-world setting, the large sample size, and the combination of survey data with actual meal characteristics. However, there are also certain limitations. First, the real-world setting did not allow for a thorough control of possible confounding variables. For instance, it is possible that participants selected additional foods, such as desserts, which they also considered when reporting their perceived sustainability and healthiness. Second, due to time and brevity constraints, only the most important variables could be assessed. Third, it can be speculated that participants chose meals they like which might, thus, have resulted in reporting positive perceived sustainability and healthiness, due to halo effects (cf., [43]). Fourth, the sample consisted mainly of students and thus, findings might not generalize to other groups, for example, with lower education. Fifth, the study was conducted in Germany and it is possible that there exist cross-cultural differences (cf., [27,50]). Last, actual meal sustainability was assessed via the indicators material consumption and GHG emissions. However, researchers have suggested that food sustainability is a multidimensional concept, including not only environmental indicators, but also health, socio-economic, and fairness indicators (e.g., [8]). In addition, there are also further environmental sustainability indicators such as water consumption or land requirement (e.g., [33]). However, at the time of the study, the NAHGAST calculation tool only provided information about the indicators material consumption and GHG emissions. Thus, future research should explore whether the presented results for environmental sustainability scores replicate for other indicators such as water consumption (cf., [33]).

4.3 Implications

The current results imply that it might be necessary to provide information to food consumers regarding both the sustainability and healthiness of foods to underline that these two dimensions can differ. Specifically, if there is a causal relationship from perceived healthiness to perceived sustainability or vice versa, consumers might be misguided if only one dimension is labeled on foods and meals. The fact that many researchers have pointed towards the generally low level of knowledge among consumers about the sustainability of foods (e.g., [31,51]) speaks in favor of the introduction of a sustainability label on foods, not only in supermarkets but also in other food purchasing contexts, such as restaurants or canteens (e.g., [52]). In the domain of food healthiness, such labels for pre-packaged foods have been implemented already in many countries, such as the Nutri-Score in several EU member states (e.g., [53]). Such labels might have the potential to promote healthy eating also in canteen contexts [54]. With regard to the potential effectiveness of sustainability labels, a recent review revealed that ecolabels can promote the selection, purchase and consumption of more sustainable food and drinks [55]. Still, more high-quality research is needed on the effectiveness of sustainability labels in real world settings.

5. Conclusion

The current study investigated in a real-world setting whether the association between perceived healthiness and sustainability reflect an overlap in actual healthiness and environmental sustainability scores of foods, as well as which factors influence the strength of this association. The present study focused on a university canteen and included a sample of over 5000 consumers. We showed that consumers seem to evaluate the sustainability and healthiness of their purchased meals based on a simple "healthy = sustainable heuristic". Importantly, the association between perceived sustainability and healthiness was unrelated to the actual overlap in the sustainability and healthiness of the meals. Moreover, this "healthy = sustainable" association was unrelated to other meal characteristics (e.g., vegan meal content) or individual characteristics (i.e., gender, eating style). However, older participants showed a slightly more pronounced "healthy = sustainable" association than younger participants. Future research is needed to complement the present findings in studying the nature, sources, and consequences of heuristics in perceived sustainability and healthiness.

Supporting information

S1 Table. Actual environmental sustainability and healthiness indicators of the 29 meals. (DOCX)

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