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Abstract

Understanding which food attributes influence food decisions is a matter of public health and a lever for interventions promoting healthy diets. Research shows that food decisions are strongly influenced by taste, with health having a weaker and later influence in the food decision process. Yet, the influence of other food attributes and specifically ethical attributes in food decision processes—as traceable in mouse-tracking data—has not been investigated. Furthermore, past research tracing food decision processes with classical mouse-tracking tools has artificially reduced the occurrence of neutral food items, particularly on the taste attribute. This represents an important limitation as neutral items on taste are particularly likely to be influenced by higher-order level attributes, such as health, but also ethics. Extending previous research, two preregistered studies (Study 1, *N* = 77; Study 2, *N* = 92) aimed at filling these gaps using a novel one-dimensional mouse-tracking paradigm. Results showed that taste, health, and ethics all influenced food decisions and interacted over time during decision processes. Taste still had the strongest influence, hence replicating previous findings with the present novel mouse-tracking paradigm. Of importance, ethics and health also influenced decisions—and sometimes had an early significant effect—especially for food items rated as neutral on taste. Beyond these effects and taking full advantage of the use of mixed effects models for all analyses, graphical representations of the influence of taste, health, and ethical attributes for all individual food items were provided. Results are discussed considering previous findings and suggested levers for interventions.

Keywords: food decisions; food decision processes; health; taste; ethics

Understanding how perceptions of food attributes influence food decisions is important worldwide, including in France where 17% of adults suffer from obesity (French Ministry of Health and Prevention, 2019). Having a healthy diet, with limited saturated fat and a minimum of vitamins and nutrients (e.g., Delva et al., 2007) contributes to preventing many non-communicable diseases and obesity (Caprara, 2021). Mostly deciding to eat ultra-processed sugary and fat foods instead of unprocessed fruits and vegetables therefore represents unhealthy food decisions. Such unhealthy food decisions can be guided by taste and health attributes (Ha et al., 2016; Lim et al., 2018; Pearce et al., 2020; Sullivan et al., 2015; see also Lopez et al., 2018, for a review), with taste—operationalized as individuals' subjective liking of the food (e.g., Lim et al., 2018; Pearce et al., 2020)—having a stronger influence than health. As in past research, taste thus corresponds to liking, and not to specific tastes (e.g., saltiness, sweetness, bitterness).

Additionally, over the past decades, the environmental impact of some foods (e.g., meat) has been pointed out, leading to increased ethical concerns in food decisions (e.g., Coff et al., 2008). Besides environmental impact, ethical attributes of foods encompass concerns about animal and human rights (e.g., Bratanova et al., 2015; Honkanen et al., 2006; Zander & Hamm2010). Food decision making can be conceived of as a process requiring the integration of different attributes—such as taste, health, and ethics in the present research—over time (e.g., Leng et al., 2017; Pearce et al., 2020).

This process of integrating taste and health attributes has been examined with the use of mouse-tracking (MT) paradigms (Ha et al., 2016; Lim et al., 2018; Lopez et al., 2018; Pearce et al., 2020; Sullivan et al., 2015). MT is a tracing process method to unravel dynamics of decision processes, with mouse trajectories reflecting the course of mind (Freeman & Ambady, 2010; Spivey & Dale, 2006). Indeed, mouse tracking translates the competition between response alternatives at the cognitive level into movements of the hand which controls the mouse on the screen (Freeman & Ambady, 2010, 2011; Spivey & Dale, 2006). This allows tracing the decision making process in real time from early stages onwards, revealing information about all the steps, hesitations, and attractions to one or the other response option that contribute to the final decision (Hehman et al., 2015). Previous research has focused on taste and health attributes, but ethical attributes—particularly those related to animal and human well-being—are also known to influence consumers (e.g., Zander & Hamm, 2010). However, the influence of ethics on food decision processes and eating decisions as traced with MT is unknown. Also unknown is how taste, health, and ethics may interact over time during decision processes, and their respective weights for individual food items.

Our aim in the present research is to fill this gap by examining the influence of taste, health, and ethical attributes on food decisions in a sample of young French adults. We used a novel MT paradigm which allowed presenting one food item per trial to assess decision making processes (Gaboriaud et al., 2022), instead of two per trial as in previous research. This feature not solely reduces noise, as decision processes are traced for each individual food item but may also be closer to real-life food decisions (Schneider et al., 2019). This procedural change compared to previous research, combined with the advantages of using mixed effects models for all analyses, makes it possible—in addition to inferential statistics—to provide graphical representations of the influence of taste, health, and ethical attributes for each individual food item of the database. Such individual food-item level information may be particularly relevant for interventions aiming to increase awareness of health and ethical concerns surrounding food decisions.

A Dynamical Systems Approach to Food Decision Making

Mouse tracking translates the competition between response alternatives at the cognitive level into movements of the hand which controls the mouse on the screen (Freeman & Ambady, 2010, 2011; Spivey & Dale, 2006). Adopting a dynamical systems approach to decision making, decisions (or mouse trajectories) are unfolding through time as rolling over a multidimensional surface (e.g., Spivey & Dale, 2006; see also Gautheron et al., 2023, for an overview). Or, put differently, individual decisions are unfolding through time like a snowball may roll over a mountainous landscape, with the topography depending on the task constraints, processing of stimuli, and ongoing interactions with the paradigm. Depending on their starting point (initial bias in decision), snowballs will tend to enter and roll into deeper valleys until they settle at their bottom (reaching an attractor corresponding to the final decision). Random fluctuations may allow them to roll over small hills, or the accumulation of snow may on the contrary increase inertia. This latter snowball-like effect corresponds in decision-making to engaging in a given response by moving the mouse towards the associated location on screen, making it harder to come back and choose another response (Lepora & Pezzulo, 2015; Quinton & Smeding, 2015; Quinton et al., 2013).

In the present research for example, when participants consider eating or not (the two response alternatives or attractor basins) broccoli, there may be an initial attraction toward the not eat response and location (on screen). This early process in food decisions signals the individual's initial low taste of broccoli. Subsequently, healthiness of broccoli may come to mind, resulting in later attraction toward the eat response and location, changing the final decision if attraction is sufficient. Conversely, if after the early "gut feeling" process driven by taste, the attraction toward the not eat response and location is already very strong, the decision has already stabilized in the not eat attractor basin. Any later and less strong influences of taste and/or ethics (in the present research) are then unable to exert sufficient attraction to qualitatively change the dynamics and final decision but may be quantitatively reflected in deviations.

Taste and Health Attributes in Food Decisions

Making healthy food decisions—deciding to eat healthy, nutritious, low in saturated fats food and not to eat unhealthy, non-nutritious, high in saturated fats food—often results in a conflict or competition between food's tastiness and healthiness (Ha et al., 2016; Lim et al., 2018; Pearce et al., 2020; Sullivan et al., 2015). For example, using a MT paradigm to track binary food decisions, Sullivan et al. (2015) found that the influence of taste was observed earlier than that of health, and that the effect of taste was stronger than that of health. The earlier and stronger effect of taste compared to health was also found by Lim et al. (2018) and did not differ among groups with a different weight status (normal weight, overweight, obese). In other words, MT not only captured the stronger weight of taste compared to health, but also their differential influence in time: MT data signaled an early attraction toward food perceived as tasty, and an attraction toward food perceived as healthy, but later in time. Both attributes thus contribute to choosing the food, but taste does so quickly (“gut feeling”), while health requires more time (possibly reflecting more deliberation, or a longer process to extract or estimate health-related information from visual stimuli).

These studies (see also Gillebaart et al., 2015), and those examining food decisions among children (Ha et al., 2016, Pearce et al., 2020) assume that the conflict between taste and health requires one to exert self-control. Individuals need to exert self-control if there is an attraction toward the tastier but less healthy option (the tasty = unhealthy belief; e.g., Briers et al., 2020) competing with the healthier but less tasty option. These conflict trials may result in successful (trials where individuals choose the healthier but less tasty food) or unsuccessful self-control (trials where individuals choose less healthy but tastier options) (e.g., Pearce et al., 2020). There is some evidence in children regarding the impact of taste and health attributes on decision processes for these trials (Pearce et al., 2020). At MT level, this conflict corresponds to a dynamic competition between tasty versus healthy food alternatives, which are attracting preference to their respective response location on the screen during the decision process.

However, subsuming food decision processes under conflict trials has limitations. Conflict trials require the unambiguous categorization of foods as tasty versus untasty, and healthy versus unhealthy. Clear-cut categorization in terms of tastiness and healthiness can be evident for some food items, but many of those used in the literature and encountered in daily life may be more neutral on these attributes. To circumvent this ambiguity issue and increase the probability of observing conflict trials, previous research has explicitly discouraged participants from using neutral ratings (Pearce et al., 2020). Another solution has been to dichotomize ratings on a scale (Ha et al., 2016), but this procedure artificially smoothens subtler individual differences in food decisions. These procedures have been used with children, and may be even less adapted to investigate spontaneous food decisions in young adult samples for whom spontaneous taste ratings do not reflect, on average, extremes on taste and health ratings (Lim et al., 2018). Past research has also relied on the exclusion of food items rated as neutral on taste and health (Sullivan et al., 2015), which decreases variability at the item level and reduces external validity of the research. These various techniques to artificially reduce the occurrence of neutral items thus have several limitations and keeping the whole span of spontaneous ratings should be the favored option.

Furthermore, reducing the occurrence of—or excluding—neutral items is problematic for theoretical reasons. Based on early MT research on person construal and ambiguous stimuli (Freeman & Ambady, 2011; Freeman et al., 2011), extremizing responses via dichotomization or discarding stimuli based on neutrality may lead to overlooking important decision processes. For example, research investigating decisions on person categorization shows that the influence higher-order level attributes such as beliefs increased when items became more ambiguous or category-neutral at the perceptual level (Freeman et al., 2011; see also Freeman & Ambady, 2011, for theoretical developments).

Transposing these findings to food decisions, items rated as neutral on one attribute—particularly taste given its early influence and strong weight in food decisions (Lim et al., 2018; Sullivan et al., 2015)—should allow us to gradually observe the influence of health and ethics attributes given their expected later influence during the decision process. Such temporal dynamics are consistent with the idea that various inputs in time influence system dynamics and final decisions (see Wojnowicz et al., 2009, for a brief overview). In other words, foods rated as neutral—at the attribute's mean—on taste may also be representative of items for which individuals are particularly likely to take health or ethical attributes into consideration during food decision processes. As past research on food decisions has either deliberately reduced the occurrence of neutral trials or artificially reduced variability at the participant and item levels, past research has overlooked the influence of other attributes when foods are perceived as neutral on taste. The present research will fill this gap, an important endeavor given the initial predominance of taste in food decisions.

Ethical Attributes in Food Decisions

Contrary to taste and health attributes, the influence of ethical attributes in food decision processes—as traceable in mouse-tracking data—has not yet been investigated. However, a growing body of literature has examined the influence of ethical attributes on consumers' preferences, buying intentions, and willingness to pay (e.g., Dowd & Burke, 2013; Zander & Hamm, 2010). Among ethical attributes, Zander & Hamm (2010) reported that those related to animal and human rights (fair prices), and to environmental concerns (locally produced) were the most important for consumers (see also Honkanen et al., 2006; Lindeman & Väänänen, 2000).

Ethical attributes—here related to animal and human rights, and environmental concerns—are therefore also likely to influence food decision processes and final decisions. As past research has shown that an ethical attribute in food can also (positively) influence taste (Bratanova et al., 2015), these attributes can be expected to interact during food decision processes. However, given the weight of taste in food decisions, we expect the influence of ethics to be lower in magnitude than that of taste and, just like health, to influence the food decision process later in time. Investigating the influence of ethical attributes in food decision processes will also contribute to the still scarce literature using MT to study moral issues (Buttlar & Walther 2018, 2019; Gaboriaud et al., 2022; Koop 2013).

The Present Research

In the present research, using a novel 1-dimensional MT paradigm (adapted from recent work on moral decisions; Gaboriaud et al., 2022; Gautheron et al., 2023) in which one food item per trial was presented, we aimed in Study 1 to replicate with this new paradigm previous findings regarding the influence of taste and health attributes in food decisions. As in previous research, we expected a strong and early effect of taste, along with that of health which was expected to be of lower magnitude (e.g., Lim et al., 2018; Pearce et al., 2020). Extending previous work on taste and health attributes, Study 2 focused in addition on the influence of perceptions of ethical attributes on decision processes, with ethics known to influence consumers (e.g., Zander & Hamm, 2010). This makes it possible to test how taste, health, and ethics interact over time during decision processes, and to evaluate their respective weights for individual food items. Given the expected strong influence of taste, we expected the influence of ethics to be lower in magnitude than that of taste and, just like health, to influence the food decision process later in time.

Crucially for both theory and practice, in the present two studies and contrary to previous research which reduced the occurrence of or excluded neutral food items, the full range of food items and individual ratings was retained. This inclusiveness is important as past research on person perception has shown that the influence of higher-order level attributes such as beliefs increased when items became more ambiguous or category-neutral at the perceptual level (e.g., Freeman et al., 2011). Finally, by combining one-by-one presentation of items with the use of mixed effects models for all analyses, the present research makes it possible to provide graphical representations of the influence of taste, health, and ethical attributes for each individual food item. Such information may be particularly relevant for interventions aiming to increase awareness of health and ethical concerns surrounding food decisions. Preregistrations and data are available on OSF through anonymous links for study 1 (https://osf.io/kbz5n/?view_only=9e0a4229ae28426580ad46d6b014019c) and study 2 (https://osf.io/kf9re/?view_only=7727717f6c7141f997ba335c7e67250d). Full public access to materials, analysis scripts and outputs for both studies will be granted upon acceptance.

Study 1

Participants

We recruited 77 students from various disciplines (37 women, 40 men, M_{Age} = 21.4, SD_{Age} = 1.7) who participated individually on a voluntary basis. Four reported being vegetarian, 2 avoiding gluten and lactose, one having a nut allergy. Participants provided informed consent to participation in the research. The research was performed in accordance with the ethical standards of the

Declaration of Helsinki and was approved by the local ethics committee (CER-USMB). All measures, manipulations, and exclusions are disclosed.

Sample size calculation

We used the lowest and most proximal effect size of interest in Lim et al. (2018) which corresponded to an equivalent of Cohen's d = 0.45. With a sample size of 60 participants, the estimated statistical power ranged between .78 and .92. Given similarity with the present study, we determined the sample size based on Lim et al. (2018). Our final analytical procedure relying on more complex models (generalized mixed effect models with 2 random factors) for generalizability at both participant and item populations, we estimated statistical power with a sensitivity analysis on variance partitioning coefficients for terms that were missing in previous analytical results. As we anticipated possible exclusion of participants (outliers, failing the attention checks), additional data were collected. All data were collected prior to analysis.

Materials and Procedure

The study was fully computerized, and the experimental setup is illustrated in Figure 1. We used the materials shared on OSF by Lim et al. (2018), composed of 60 food images representing vegetables, fruits, beans, fast food, sweet desserts, processed meats, and fried foods. In this novel MT paradigm, food items were presented one by one. Six images were used for the training trials and the remaining 54 for the test trials. As in Lim et al. (2018), food items were rated for taste and health in different blocks (order counterbalanced across participants) on a continuous scale ranging from *very unhealthy* (left) to *very healthy* (right) for health ratings, and from *very bad* (left) *to very good* (right) for taste ratings. All ratings were made using a slider version of the mouse-tracking paradigm, i.e., participants could make their ratings anywhere on the x axis, either on or between the two response labels. Food images with an original size of 300 x 300 pixels were presented on a white background and resized to cover 35% x 44% of the screen.

For each trial, a slider of varying width became visible inside a horizontal bar once the trial was initiated by the participant (clicking on a central "START" area), then controlled by mouse movements along the X-axis of the screen (with mouse cursor hidden to participants). The slider had a linear color gradient to blend with the white background, with the most contrasting color at its center. The width of the slider varied with time: it decreased when the participants did not move the mouse and increased when they did, with a trial considered failed if the slider fully disappeared (reaching zero width). This feature was an adaptation of the "Faster" message of the classical mouse-tracking paradigm, encouraging quick answers and continuous moves.

Additionally, this 1D slider version of the mouse tracking paradigm allowed for quick decision dynamics, making it possible to present a larger sample of stimuli in a short period of time. After the health and taste rating tasks, participants completed the food decision task. Using the slider version of the mouse-tracking paradigm, they had to decide, for the same food images (6 training trials, 54 test trials), between two response options: *not eat* or *eat* (as in Lim et al., 2018). For all tasks, food images were presented in a random order. For the health and taste ratings, end coordinates on health trials (rescaled between -1 *very unhealthy* and +1 *very healthy*) and taste trials (rescaled between -1 *very bad* and +1 *very good*) were gathered. For the food decision task, X-coordinates in time were recorded (also between -1 *not eat* and +1 *eat*) and end coordinates were converted into binary *eat/not eat* decisions. An attention check was inserted at the end of each block (no participant was excluded based on this criterion).

Participants first provided informed consent, completed a socio-demographic questionnaire (age, gender, computer mouse or trackpad use, number of hours since their last food intake, level of hunger) and reported any specific diet if applicable. Participants subsequently performed the taste and health rating tasks (order counterbalanced across participants), the food-decision task, were thanked, and fully debriefed.

Figure 1

Experimental Setup and Procedure in Study 1 & Study 2

Note. Illustration of the paradigm for all attribute ratings (taste, health in Study 1 & 2, and ethics in Study 2 only), as well as final eat decisions, with nuanced responses impossible in Study 1 (grayed slider controlled by mouse movements) but possible in Study 2. Stimuli correspond to paired subsamples of those used in Study 1 (Lim et al., 2018 database in A & C panels) and Study 2 (Food-Pics Extended database in B & D panels; Blechert et al., 2019)

Analytic Approach

All analyses were conducted with R programming language, lme4 package (Bates et al., 2015) and additional packages for diagnostics and effects estimation (mainly DHARMa, lmerTest, emmeans). Linear mixed-effects models (LMM)—and generalized linear mixed-effects models (GLMM) for final food decisions, see below—were used to better account for inter-participant and inter-stimuli variability, at the same time allowing generalization of the results to both other participants and stimuli (Judd et al., 2012). The maximal mixed-effects model specified by the empirical design included the estimation of two main fixed effects (taste and health ratings) and their interaction effect on eat decisions (dynamics or final response), with two random factors (participant and food image) with associated random effects (identical to fixed effects) and correlations between random effects. The random structure of model was reduced to obtain a parsimonious model supported by the data, starting from the maximal model specification (Matuschek et al., 2017), for a more accurate estimation of fixed effects while preventing any significant lack of fit.

Between-item variations in health random effects and health-by-taste random interaction effects had a negligible impact on model fit, leading to the following final parsimonious model (as an R formula): DV ~ Taste*Health + (Taste*Health|Participant) + (Taste|Food). To facilitate comparison of effects between attribute ratings and given their distributions (M_{taste} = .34, SD_{taste} = .57, M_{health} = 0, SD_{health} = .69; see Figure 2), we standardized the predictors in all analyses. Whenever adequate, we estimated *p*-values for the different effects of interest using the Satterthwaite's approximation of degrees of freedom. Alpha threshold was set at .05 to determine significance of the effects. We excluded from the analyses all missed trials (i.e., those not leading to any decision from the participant, 0.5% of all trials).

For analyses on final decisions, a binomial GLMM was fit to binary *not eat/eat* decisions, given the dichotomous nature of this variable, explaining an equivalent to R^2 = 62% of variance. We opted to report effect sizes as odd-ratios (*OR*) and to standardize predictors. Therefore, we estimated *OR* for a change of +1SD on predictors around the mean, a specific configuration where these can be compared across studies and thus considered as standardized effect sizes.

For analyses on decision dynamics, we filtered out the 2% of trajectories that did not meet mouse-tracking continuity assumptions, preventing singularities and limiting the presence of outliers which may lead to anti-conservative results. Linear mixed models (LMM) were fitted on rescaled X-coordinates for each time step, using the same parsimonious model as for the analyses on final decisions (for consistency and comparison of results). To control for multiple testing through time, analyses were performed on 20 time bins on time-normalized trajectories, each time bin corresponding to 5% of the entire decision process duration (Hehman et al., 2015). Time therefore runs between 0% when clicking on the START button to 100% when clicking on the final decision.

Multiple testing was further accounted for by only reporting significant effects over more than 2 successive timebins. Additionally, analyses were conditioned on final decisions to estimate attraction by the opposite response (i.e., separately for not eat and eat decisions). For these analyses, reported raw effect sizes (b) therefore correspond to a change in X-coordinate for +1SD on predictors. Due to the integration of information through time, to the use of X-coordinates instead of binary responses, but mostly to the conditioning and type of models used for analyzing trajectories (LMM instead of GLMM for final decisions), results at 100% of trajectory time are not expected to match those reported on final decisions. They provide complementary information on the dynamical influence of taste and health which in turn lead to changes in eat / not eat response proportions.

Results

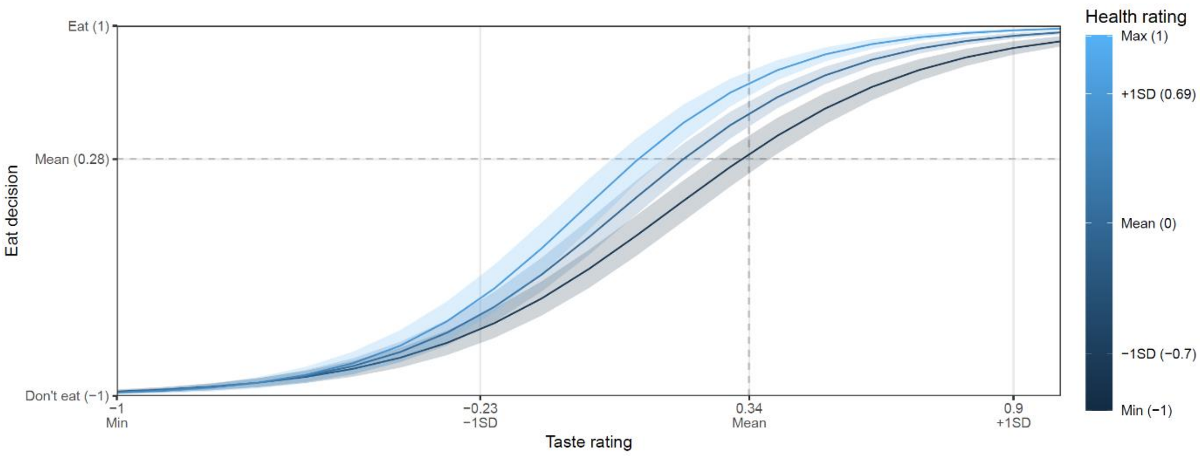
Final decision analyses. As expected, we found a strong and significant effect of taste ratings (*OR* = 11.35, *SE* = 1.98, *z* = 13.92, p < .001, 95% CI [8.06, 15.98]), with tastier foods more likely to result in *eat* decisions. We also found a significant effect (but of lower magnitude) of health ratings (*OR* = 1.71, *SE* = 0.26, *z* = 3.54, p < .001, 95% CI [1.27, 2.30]), with healthier foods more likely to result in *eat* decisions. This difference in magnitude applied to most participants, as health had a stronger influence than taste for only 8 participants (10.4%) when looking at participant-level random effects. These main effects were qualified by a significant interaction effect (*OR* = 1.34, *SE* = 0.11, *z* = 3.41, p < .001, 95% CI [1.13, 1.58]), with tastier and healthier foods more likely to result in *eat* decisions (see Figure 2). Simple effect of health ratings was significant at +1SD for taste rating (*OR* = 2.29, *SE* = 0.40, *z* = 4.80, p < .001, 95% CI [1.63, 3.21]), but not at -1SD (*OR* = 1.28, *SE* = 0.23, *z* = 1.39, p = .164, 95% CI [0.90, 1.81]). This reflected a stronger linear influence of health ratings for very high compared to very low taste rating.

Regarding neutral taste ratings—at the attribute's mean—since the higher variability and larger raw effect of health ratings found for these taste ratings (see center of Figure 2) could be attributed to binomial regression constraints, we confirmed it by introducing quadratic terms in the model. While this exploratory model did not substantially improve the overall fit (R^2 = 62%) nor qualitatively altered reported results, it led to a significant negative interaction effect between quadratic taste ratings and health ratings (z = -2.91, p = .004), with an increased effect of health ratings for neutral taste ratings. Interestingly, it also led to a reversed effect of health for extremely low taste ratings (OR = 0.11, SE = 0.09, z = -2.56, p = 0.01). Looking at the observations that drove this effect, they corresponded to ultra-processed food images indeed considered very unhealthy and untasty, yet associated with *eat* decisions (e.g., cheeseburgers, ice creams, jelly beans, nuggets, cupcakes).

To summarize, young people (given our participant sample) were all the more likely to eat foods if they were perceived as tasty and healthy; conversely, when foods were perceived as low on taste, health perceptions were unlikely to facilitate *eat* decisions. A few ultra-processed foods did not follow this pattern, as they were considered unhealthy and untasty, yet resulted in *eat* decisions. One reason may be that these caloric foods were associated with positive events (birthday parties, holidays, summer), therefore resulting in *eat* decisions, but this interpretation remains speculative. Finally, health ratings were more likely to guide *eat* decisions when foods were rated as neutral on taste.

Figure 2

Estimated mean eat decision proportions in Study 1



Note. Solid lines represent the estimated mean proportion of eat decision as a function of taste ratings (x-axis) and health ratings (-1SD, mean, +1SD in color), with associated standard error of the mean (shaded band).

Decision dynamics analyses.

For normalized times going from 0% to 100% and *eat* decisions, the model respectively explained 10 to 46% of variance, while it explained 11 to 45% for *not eat* decisions (relying on both R^2 and ω^2 standardized effect size). For *eat* decisions, we found a significant main effect of taste on X-coordinates from 60 to 100% of trajectories, with a peak in amplitude at 80% (b = 0.045, SE = 0.011, t(55.84) = 4.00, p < .001, 95% CI [0.023, 0.068]). The same was true for *not eat* decisions from 40 to 100% peaking at 75% (b = 0.044, SE = 0.012, t(76.14) = 3.63, p < .001, 95% CI [0.020, 0.069]), with an additional early significant effect from 5 to 20% (b = 0.012, SE = 0.005, t(42.53) = 2.45, p = .018, 95% CI [0.002, 0.023]). We also found a significant main effect of health from 40 to 90% of trajectories for *eat* decisions peaking at 65% (b = 0.052, SE = 0.011, t(74.84) = 4.65, p < .001, 95% CI [0.029, 0.074]). The same was true for *not eat* decisions from 40 to 80% with a peak at 70% (b = 0.049, SE = 0.017, t(52.41) = 2.96, p = .005, 95% CI [0.016, 0.082]), with an additional early significant effect starting from 5% to its amplitude peak at 30% (b = 0.019, SE = 0.007, t(119.72) = 2.51, p = .013, 95% CI [0.004, 0.033]).

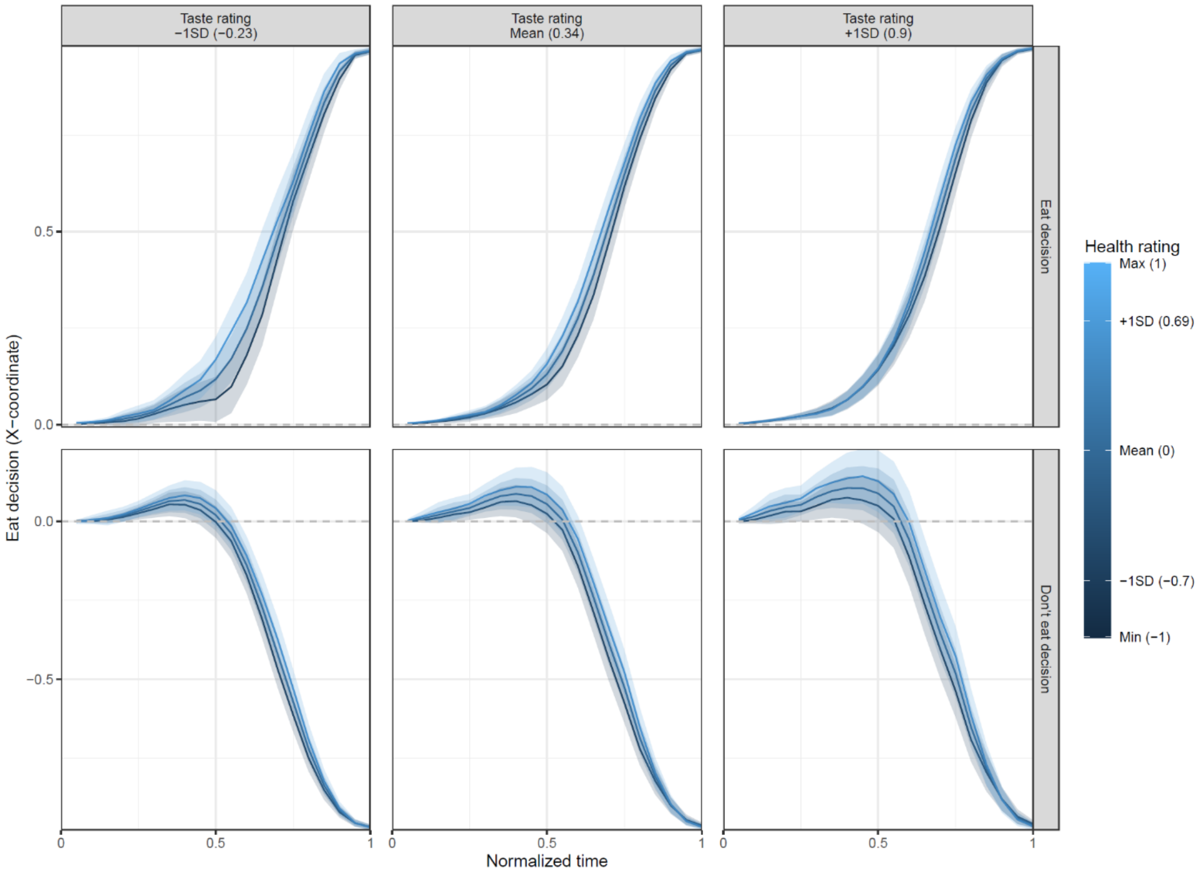
These effects were qualified by a significant interaction effect of taste and health from 45 to 60% for *eat* decisions (b = -0.033, SE = 0.010, t(590.42) = -3.37, p < .001, 95% CI [-0.052, -0.014]), with a significant simple effect of taste for -1SD on health from 45 to 100% peaking at 55% (b = 0.053, SE = 0.017, t(99.15) = 3.20, p = .002, 95% CI [0.020, 0.086]), and for +1SD on health from 70 to 80% (b = 0.048, SE = 0.018, t(99.90) = 2.65, p = .009, 95% CI [0.012, 0.084]). We also found a significant simple effect of health for -1SD on taste from 40 to 70% and 80 to 90% peaking at 55% (b = 0.072, SE = 0.017, t(234.12) = 4.31, p < .001, 95% CI [0.039, 0.105]), and for +1SD on taste from 55 to 80% peaking at 70% (b = 0.039, SE = 0.011, t(66.74) = 3.67, p < .001, 95% CI [0.018, 0.060]). This interaction pattern is illustrated in Figure 3 (see comparisons across top panels depicting results for *eat* decisions). As for final decisions, taste, and health ratings both exerted their influence roughly starting at the middle of the decision process. Of importance, health ratings were facilitating *eat* decisions for both foods perceived as tasty and untasty, a pattern not observed for final decisions.

Symmetric dynamics were found for *not eat* decisions, with a significant interaction from 0 to 20% (b = 0.006, SE = 0.002, t(238.11) = 3.12, p = .002, 95% CI [0.002, 0.010]). A significant simple effect of taste for -1SD on health was found from 65 to 100% peaking at 75% (b = 0.038, SE = 0.014, t(74.39) = 2.62, p = .011, 95% CI [0.009, 0.066]), and for +1SD on health from 5 to 35% and 40 to 85% peaking at 60% (b = 0.053, SE = 0.020, t(78.78) = 4.63, p = .010, 95% CI [0.013, 0.092]). We also found a significant simple effect of health for -1SD on taste from 45 to 80% peaking at 70% (b = 0.047, SE = 0.013, t(33.91) = 3.68, p < .001, 95% CI [0.021, 0.073]), and for +1SD on taste from 5 to 30 and 55 to its peak at 75% (b = 0.055, SE = 0.023, t(67.13) = 2.38, p = .020, 95% CI [0.009, 0.101]) (see comparisons across bottom panels on Figure 3).

These findings signal a descriptively earlier effect of taste and health ratings for *not eat* decisions compared to *eat* decisions. This effect was mainly driven by an early influence of taste for foods perceived as very healthy and of health for foods perceived as very tasty. Despite the final *not eat* decision, an early attraction toward the *eat* decision when both attributes were positively rated was observed. This is consistent with the *eat* incentive for these attributes observed on final decisions.

Figure 3

Estimated mean eat decision trajectories in Study 1



Note. Solid lines represent the estimated mean trajectory on eat decision trials (raw x-coordinate between -1 and +1 as a function of normalized time), conditioned by the final decision taken (*eat* on top row, *not eat* on bottom row), taste ratings (-1SD, mean, +1SD in columns) and health ratings (-1SD, mean, +1SD in color), with associated standard error of the mean (shaded band).

Discussion

Replicating previous findings with a novel 1-dimensional MT paradigm, results showed a strong effect of taste—with tastier foods more likely to result in eat decisions—and an effect of health, albeit, as in previous research, of lower magnitude. Overall, young adults thus prefer eating foods they like in terms of taste, even more so if tasty foods are also perceived as healthy, as indicated by the interaction effect between taste and health ratings. For foods considered less tasty (-1 SD on taste ratings), the influence of health was not sufficient to lead to *eat* decisions. However, of particular interest regarding the influence of health and adding to past research in which the occurrence of neutral food items was artificially reduced, higher health ratings increased the likelihood for neutral food items (i.e., at taste ratings' mean) to result in eat decisions. This is a novel finding for food items but is consistent with the literature on person construal signaling that the influence of higher-order level attributes—such as health—increases when items became more ambiguous or neutral (Freeman et al., 2011; see also Freeman & Ambady, 2011).

Beyond final decisions, the influence of taste and health on food decision processes was also found, which is also consistent with previous research. Specifically, for trajectories resulting in *not eat* decisions, results indicate that the influence of health peaked (descriptively) at about the same percentage of trajectories as the peak of taste, and both health and taste ratings had an early significant effect at the beginning of the trajectories (starting as early as 5% of trajectories). For trajectories resulting in *eat* decisions, the influence of health and the health peak were significant (descriptively) earlier (from 40% to 90%, peaking at 65%) compared to taste (from 60 to 100%, peaking at 80%). This early significance despite the lower amplitude of health effects compared to taste possibly results from a more consistent influence of health information in the decision process across food items and participants.

Decomposing the taste by health interaction effect, results further signal, for *eat* decisions, that the effect of health for negatively rated food items on taste (-1SD) was stronger and emerged significantly earlier compared to food items positively rated (+1SD). Furthermore, taken together, dynamics concerning this interaction effect indicate consistent attraction toward *eat* decisions when both attributes were positively rated (+1SD), along with a maximal attraction toward *not eat* decisions when both attributes were negatively rated (-1SD), despite a final *eat* decisions. Symmetric dynamics were found for *not eat* decisions, with also a maximal attraction toward the *eat* decision when both attributes were positively rated despite the final *not eat* decision.

Overall, findings are thus consistent with the literature regarding the strong effect of taste compared to health on food decisions. Furthermore, when both taste and health ratings were considered, findings signal an earlier significant effect of health and of stronger amplitude for untasty compared to tasty foods for trajectories resulting in *eat* decisions. Although this effect reflected a maximal attraction toward the *not eat* decision when foods were deemed untasty, it nevertheless illustrates the potential for health to influence decision processes, as these trials resulted in final *eat* decisions. Symmetric dynamics were found for *not eat* decisions, with a maximal attraction toward the *eat* decision when both taste and health attributes were positively rated despite the final *not eat* decision.

These patterns can be compared to conflict trials (which have been the focus of previous research), as they signal the influence of taste and health ratings on the decision process—with increased attraction toward the opposite response—and the final decision taken (e.g., final *eat* decision but with increased attraction toward the *not eat* decision during decision process). It should be noticed that when, as in the present research, the full range of food items was kept (i.e., not only those eliciting conflict), these conflict trials are in the numeric minority (as traceable in reported degrees of freedom), signaling that in daily life and for young adults, several food items are rated as more neutral in terms of taste and health.

It should be noticed that findings pertaining to *not eat* decisions may be interpreted with caution. The proportion of *eat* decisions was indeed much higher than *not eat* decisions (with our samples of participants and food items). Furthermore, result patterns were mostly symmetrical between *eat* and *not eat* decisions. Hence a focus on those findings for which estimations should be more accurate given the larger observation sample size. Furthermore, the present study's design focused on food decisions on single items, which may lead to different decision processes compared to other settings (e.g., cafeteria, multi-component meals as in Keller et al., 2022). For instance, *not eat* decisions may better fit a no-go task, or participants may turn away from the item to focus on alternative choices characteristics. Here, visual attention focuses on the presented item, and the saliency of the various attributes may be manipulated in future studies (see General Discussion).

Having established the relevance of the present 1-dimensional MT paradigm to test the influence of taste and health ratings on food decisions and decision processes, Study 2 aimed at extending the literature by including an important, yet unexplored, dimension in food decision processes, namely ethics. Including this novel higher-order level attribute, in addition to taste and health, in a single research allows examining their interactions over time during decision processes, and to evaluate their respective weights for individual food items. To refine our understanding of the relationship between attribute ratings and food decision processes, we also adapted the decision trials to capture participants' responses on a continuum (i.e., continuous scale instead of solely binary *eat/not eat* decisions).

Study 2

Participants

We recruited 92 psychology students from the same university as in Study 1 (88 women, 4 men, M_{Age} = 20.34, SD_{Age} = 4.39) who participated individually in exchange for course credit. Eight reported being vegetarian, 1 not eating dairy products, 1 other diet. Participants provided informed consent to participation in the research. The research was performed in accordance with the ethical standards of the Declaration of Helsinki and was approved by the local ethics committee (CER-USMB). All measures, manipulations, and exclusions are disclosed.

Sample size calculation

Based on Study 1, we estimated effect sizes for final responses equivalent to Cohen's d = 1.38 for taste, and d = 0.18 for health attributes with n = 77 (derivations adapted from Judd et al., 2017, to be used in PANGEA for a priori LMM statistical power estimation). The effect size using mouse-tracking and ethical dimension is unknown, but we also implemented several changes in the design to increase the effect size of health and ethics attributes. The mere inclusion of the ethics attribute would possibly increase the saliency of non-taste attributes in eat decisions (thus associated explained variance), but we also switched to another food database which should better represent health and ethics attributes distributions (Blechert et al., 2019), and turned to a continuous measure of *eat/not eat* food decisions. We therefore again aimed at the medium effect size of d = 0.45, matching the lowest and most proximal effect size of interest for health ratings in Lim et al. (2018). Given the repeated measures within-participant design and linear mixed model analyses, this led to a priori statistical power estimates similar to Study 1.

Materials

The study was fully computerized, and the experimental setup was similar to that of Study 1, with a one-by-one presentation of food images. Six food images were again included for training trials and 48 for test trials. For the attribute rating tasks, health and taste rating tasks were the same as in Study 1. An additional ethics rating task was introduced in this study, with participants rating each food item on a continuous scale ranging from *very unethical* (bottom left) to *very ethical* (bottom right). Because ethical attributes can encompass animal and human rights, along with environmental concerns, these components were made explicit in the instructions (*How ethical do you think this food item is? Please provide your perception independently of other criteria (taste, health…). Ethics may concern human rights, animal rights, or environmental impact*).

As in Study 1, all ratings were made using the slider version of the mouse-tracking paradigm. Order of health, taste, and ethics rating blocks was counterbalanced across participants. All participants ended with the food decision task, in this study on a continuous scale ranging from *not eat* to *eat* decisions, for a total of 4 blocks of 48 test trials. As in Study 1, an attention check was inserted at the end of each block (no participant was excluded based on this criterion).

Procedure

Participants first completed the same socio-demographic and specific diet items as in Study 1. They subsequently performed the taste, health, and ethics rating tasks (order counterbalanced across participants), the food-decision task, were thanked, and fully debriefed.

Analytic Approach

The analytic approach was roughly the same as in Study 1, except that we only used linear mixed-effects models (LMM) given the continuous nature of the food decision task. Despite the bounded nature of the response scale, results did not substantially differ nor diagnostics improve by relying on generalized mixed-effects models with beta distributions. Again, a parsimonious model supported by the data was obtained starting from the maximal model specification (Matuschek et al., 2017), including the estimation of three main fixed effects (taste, health, and ethics ratings) as well as the two- and three-way interaction effects on eat decision dynamics (trajectory or final response), with two random factors (participant and food image) with associated random effects (identical to fixed effects) and correlations between random effects.

After dropping several negligible random interaction effects for both participant and food item random factors, the final parsimonious model corresponds to (as an R formula): DV ~ Taste*Health*Ethics + (Taste+Health*Ethics|Participant) + (Taste+Health+Ethics|Food). As in Study 1, we standardized the predictors in all analyses given their distributions ($M_{taste} = .37$, $SD_{taste} = .57$, $M_{health} = 0.16$, $SD_{health} = .65$; $M_{ethics} = 0.17$, $SD_{ethics} = .59$; see figure 4). Contrary to Study 1 where eat decisions were binary, we also standardized eat decision variables (final response and X-coordinates for each time bin), in order to report standardized regression coefficients (β). We excluded from the analyses all missed trials (3.2%).

For analyses on decision dynamics, as in Study 1, we filtered out the less than 1% of trajectories that did not meet mouse-tracking assumptions and fitted linear mixed models on X-coordinates for each of the 20 time bins. We relied on the parsimonious model fitted on final responses and standardized X-coordinates for each time bin separately. Results near the end of trajectories are not reported below since consistent with previously reported results for end coordinates (final decisions), within range of small fluctuations due to the integration of information between 95% and 100% of normalized time ($|\Delta\beta| < 0.01$). The standardized coefficients were chosen to focus on the relative weight of each attribute throughout the decision process, assuming stable proportions of shared variance among predictors through time. Raw X-coordinates (ranging from -1 to +1) were used for estimated marginal mean trajectories reproduced on Figure 7, so that they directly translate into participants' mouse coordinates and movements.

Results

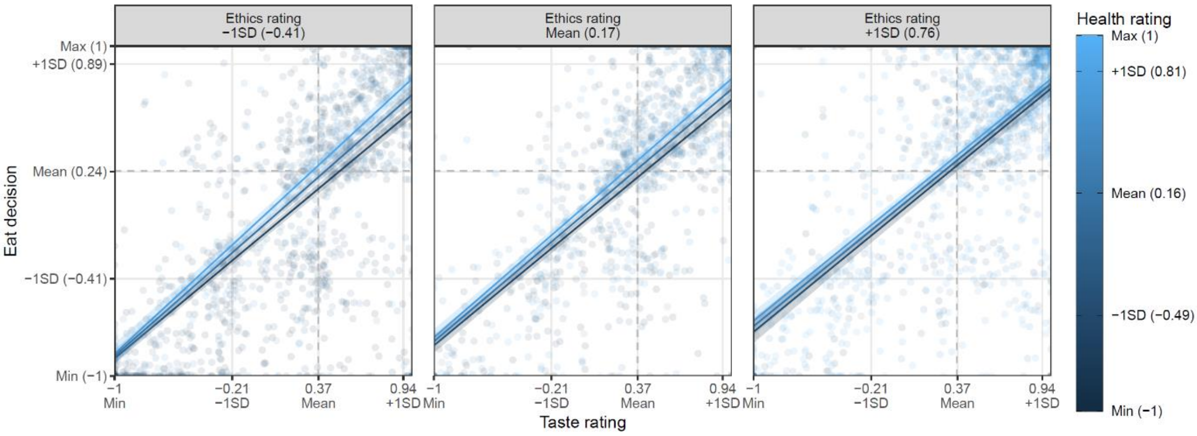
Final decision analyses. The model explained 70% of variance (relying on both R^2 and ω^2 standardized effect size). Figure 4 illustrates reported effects. Consistent with Study 1, we found a strong and significant effect of taste ratings ($\beta = 0.68$, $SE = 0.02$, $t(94.17) = 28.45$, $p < .001$, 95% CI [0.63, 0.72]), with tastier foods more likely to result in decisions leaning toward *eat* decisions. The effect of health ratings was significant but again of lower magnitude (β = 0.08, *SE* = 0.02, *t*(70.55) = 3.31, *p* = .001, 95% CI [0.03, 0.13]), with healthier foods more likely to result in decisions leaning toward *eat* decisions. Of particular interest here was the significant effect of ethics ratings which, while lower in magnitude than that of taste, was similar to health (β = 0.08, *SE* = 0.02, *t*(84.85) = 3.38, *p* = .001, 95% CI [0.03, 0.13]), with more ethical foods more likely to result in decisions leaning toward *eat* decisions. Differences in magnitude between attributes applied to most participants, as health and/or ethics had a stronger influence than taste for only 5 participants (5.4%) when looking at participant-level random effects. These main effects were qualified by a significant two-way interaction effect between taste and ethics (β = -0.02, *SE* = 0.01, *t*(564.01) = -1.99, *p* = .046, 95% CI [-0.05, -0.0004]), with a stronger simple main effect of ethics at -1SD on taste (β = 0.10, *SE* = 0.03, *t*(126.54) = 3.95, *p* < .001, 95% CI [0.05, 0.16]) than at +1SD on taste (β = 0.05, *SE* = 0.03, *t*(132.41) = 2.03, *p* = .044, 95% CI [0.001, 0.11]). The two-way interaction between taste and health was not significant (β = 0.02, *SE* = 0.01, *t*(258.22) = 1.26, *p* = .055, 95% CI [-0.06, 0.0006]).

These interactions were qualified by a significant three-way interaction effect (β = -0.02, *SE* = 0.01, *t*(940.63) = -1.98, *p* = .048, 95% CI [-0.04, -0.0002]). The simple two-way interaction between health and ethics was significant at +1SD on taste (β = -0.05, *SE* = 0.02, *t*(176.49) = -2.66, *p* = .008, 95% CI [-0.09, -0.01]), with the simple effect of ethics ratings stronger at -1SD for health ratings (β = 0.11, *SE* = 0.03, *t*(146.39) = 3.19, *p* = .002, 95% CI [0.04, 0.17]) than at +1SD (β = 0.004, *SE* = 0.03, *t*(152.33) = 0.11, *p* = .914, 95% CI [-0.06, 0.07]). Symmetrically, the simple effect of health ratings was stronger at -1SD for ethics ratings (β = 0.15, *SE* = 0.04, *t*(153.03) = 4.08, *p* < .001, 95% CI [0.08, 0.22]) than at +1SD (β = 0.05, *SE* = 0.03, *t*(86.39) = 1.49, *p* = .140, 95% CI [-0.02, 0.11]). On the contrary at -1SD for taste ratings, the simple two-way interaction between health and ethics was not significant (β = -0.01, *SE* = 0.02, *t*(165.89) = -0.63, *p* = .529, 95% CI [-0.05, 0.03]). However, at -1SD on taste, we found a significant simple main effect of ethics (β = 0.10, SE = 0.03, *t*(126.54) = 3.95, *p* < .001, 95% CI [0.05, 0.16]) as well as a significant simple main effect of health (β = 0.06, *SE* = 0.03, *t*(109.32) = 2.22, *p* = .029, 95% CI [0.006, 0.12]). These results indicate that health and ethics again facilitated decisions leaning toward *eat* decisions when foods were already rated as tasty but did not interactively facilitate these decisions for untasty foods, while keeping an independent influence on food decisions.

As in study 1, we introduced quadratic terms in the model for exploratory purposes. Beyond the linear effects reported above, we found a significant negative interaction between quadratic taste ratings and ethics ratings ($z = -3.16$, $p = .002$). This interaction signals an increased effect of ethics ratings especially for neutral taste ratings, with lower ethics ratings inhibiting *eat* decisions and higher ethics ratings facilitating these decisions.

Figure 4

Estimated mean eat decisions in Study 2



Note. Solid lines represent the estimated mean proportion of eat decisions as a linear function of taste ratings (x-axis), health ratings (-1SD, mean, +1SD in color) and ethics ratings (-1SD, mean, +1SD in panels), with associated standard error of the mean (shaded band).

Decision dynamics analyses.

For normalized times going from 0% to 100%, the model respectively explained 9 to 71% of variance (relying on both R^2 and ω^2 standardized effect size). We found an increasing significant main effect of taste on X-coordinates from 35 to 100% ($0.05 < \beta s < 0.68$, $ts > 2.59$, $ps < .012$). We also found a significant main effect of health ratings from 40 to 100% peaking at 55% ($\beta = 0.12$, $SE = 0.026$, $t(60.72) = 4.58$, $p < .001$, 95% CI [0.067, 0.171]) and of ethics ratings from 50 to 100% peaking at 75% ($\beta = 0.10$, $SE = 0.023$, $t(89.97) = 4.14$, $p < .001$, 95% CI [0.050, 0.141]).

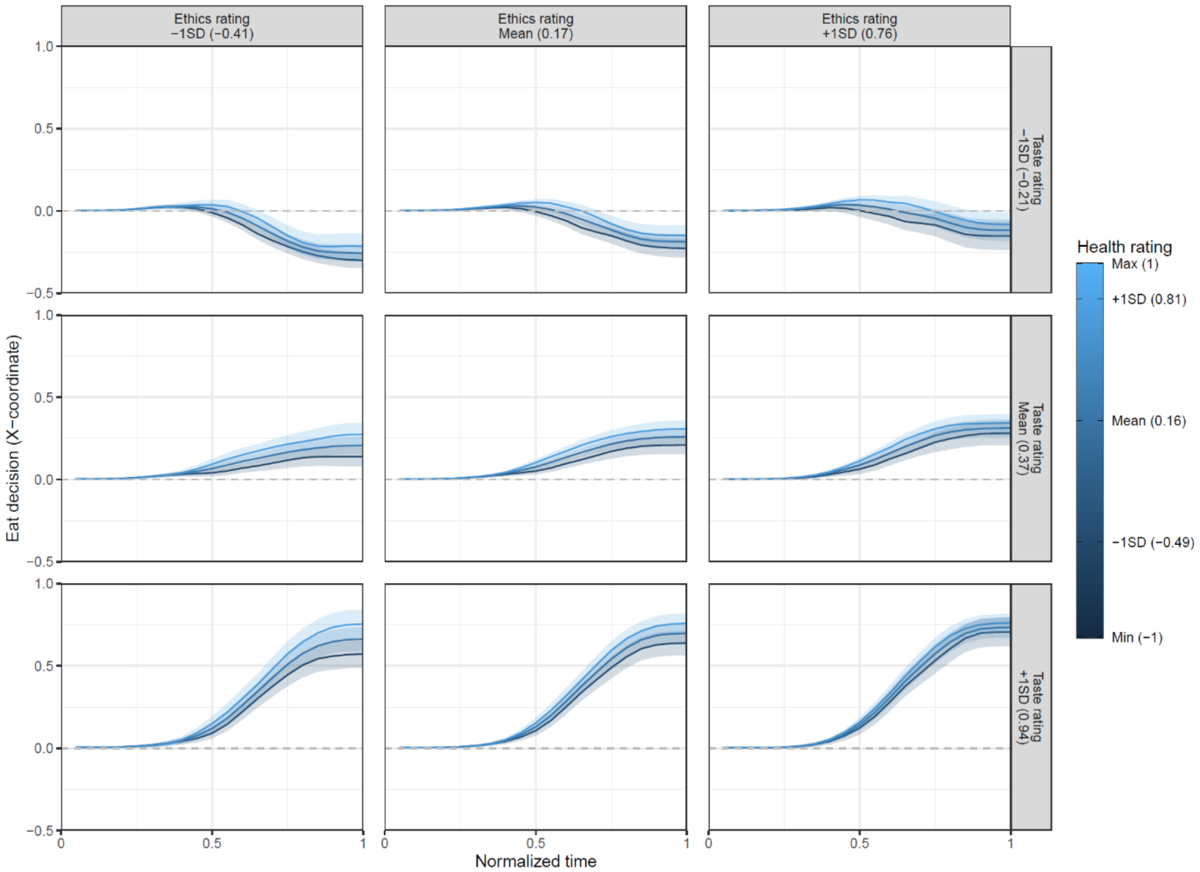
These main effects were qualified by a significant two-way interaction between taste and ethics from 70 to 100%, slightly decreasing in amplitude from 70% (β = -0.03, *SE* = 0.01, *t*(1100.29) = -2.59, *p* = .010, 95% CI [-0.061, -0.008]), with a significant simple main effect of ethics at -1SD on taste ratings from 55 to 100% peaking at 75% (β = 0.13, *SE* = 0.03, *t*(141.77) = 4.96, *p* < .001, 95% CI [0.08, 0.18]), stronger in amplitude than at +1SD, yet also significant from 55 to 100% peaking at 65% (β = 0.08, *SE* = 0.03, *t*(124.54) = 3.05, *p* = .003, 95% CI [0.03, 0.13]). The two-way interaction between taste and health oscillated but remained non-significant as for final responses (|βs| < 0.02, |*t*s| < 1.33, *p*s > .184).

These interactions were again qualified by a significant three-way interaction effect from 80 to 100%, decreasing from 80% (β = -0.03, *SE* = 0.01, *t*(1543.48) = -2.61, *p* = .009, 95% CI [-0.05, -0.006]). The simple two-way interaction between health and ethics was significant at +1SD on taste from 80 to 100% peaking at 95% (β = -0.05, *SE* = 0.02, *t*(163.69) = -2.57, *p* = .011, 95% CI [-0.09, -0.01]), with the simple effect of ethics ratings at -1SD for health ratings significant from 50 to 100% peaking at 90% (β = 0.11, *SE* = 0.03, *t*(150.52) = 3.31, *p* = .001, 95% CI [0.04, 0.17]), but being non-significant at +1SD and peaking at 65% (β = 0.06, *SE* = 0.03, *t*(110.93) = 1.89, *p* = .061, 95% CI [-0.003, 0.13]). Symmetrically, the simple effect of health ratings at -1SD for ethics ratings was significant from 40 to 100%, peaking at 95% (β = 0.14, *SE* = 0.04, *t*(148.01) = 3.98, *p* < .001, 95% CI [0.07, 0.21]; bottom-left panel on Figure 5) and stronger than at +1SD, yet significant from 35 to 85% and peaking at 55% (β = 0.14, *SE* = 0.04, *t*(141.71) = 3.52, *p* < .001, 95% CI [0.06, 0.22]; bottom-right panel on Figure 5). On the contrary at -1SD for taste ratings, the simple two-way interaction between health and ethics was not significant. However, as for final responses, we found a significant simple main effect of ethics (reported above), and a significant simple main effect of health from 40 to 100% peaking at 55% (β = 0.13, *SE* = 0.03, *t*(124.37) = 4.11, *p* < .001, 95% CI [0.07, 0.19]). Taste, health, and ethics thus all had an influence on the decision process from the middle of trajectories onwards, but their three-way interactive effect only appeared near the end of trajectories.

As for final decisions, looking at the extended model with quadratic terms, a significant and increasing negative interaction effect between quadratic taste ratings and ethics ratings was found from 65 to 100% (β = -0.15, *SE* = 0.04, *t*(981.51) = -3.70, *p* < .001, 95% CI [-0.24, -0.07]). We also found a temporary interaction effect between quadratic taste ratings and health ratings from 40 to 55% peaking at 50% (β = -0.05, *SE* = 0.02, *t*(1574.63) = -2.46, *p* = .014, 95% CI [-0.09, -0.01]). Both effects are consistent with an increased effect of health and ethics ratings for neutral taste ratings.

Figure 5

Estimated mean eat decision trajectories in Study 2



Note. Solid lines represent the estimated mean trajectory on eat decision trials (raw x-coordinate between -1 and +1 as a function of normalized time) depending on taste ratings (-1SD, mean, +1SD in rows), ethics ratings (-1SD, mean, +1SD in columns) and health ratings (-1SD, mean, +1SD in color), with associated standard error of the mean (shaded band).

Influence of taste, health, and ethical attributes for each individual food item.

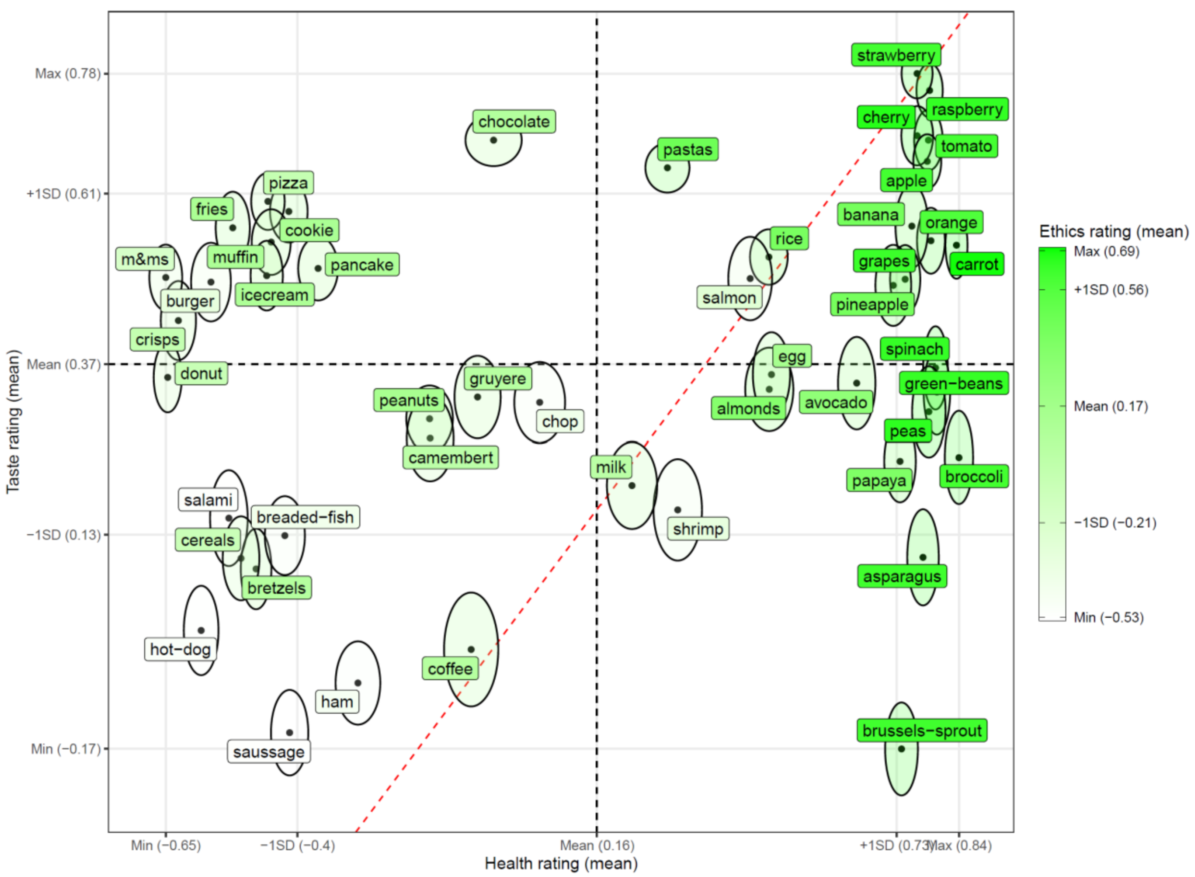
Figure 6 represents mean taste, health, and ethics ratings for each food item from Study 2, and the associated standard deviations across participants. For instance, *rice* and *ice cream* are similarly rated as relatively tasty (above the mean at M = 0.49 – 0.52, but with lower variability among participants for *rice*), slightly differ in their mean ethical rating (above the mean for *rice* with M = 0.40, below for *ice cream* with M = 0.10), and greatly differ in their mean health rating (above the mean for *rice* with M = 0.49, largely below the mean for *ice cream* with M = -0.46), leading to responses more oriented toward eat decision for *rice* (M = 0.44) than for *ice cream* (M = 0.21). These examples illustrate how Figure 6 can be used to characterize ratings of each individual food item. The white-green color gradient visually signals ethics ratings: the whiter the ellipse, the lower the perceived ethics; the greener, the higher the perceived ethics. Moreover, foods located on the left side of the figure are perceived as less healthy, and those on the right as healthier. Tastier foods are located on the upper side, and less tasty foods on the lower side. For instance, a vertically elongated green ellipse in the bottom-right corner corresponds to Brussels sprouts, thus a food item considered ethical, healthy, yet untasty despite a greater interindividual variability in taste perception.

Figure 7 reproduces the associated estimated random effects for the food item random factor from the linear mixed effects model (shifted by the fixed effect to be more easily interpreted). Based on the estimates of this model, Figure 7 thus illustrates how the different ratings impact eat decisions at the item-level. Beyond the fixed effects reported above on eat decisions and decision processes, results from this model further indicate a relatively large inter-item variability, with 5.8% of variance explained solely by item random effects (smaller than the 26.6% explained by participants random effects). For instance, as illustrated on Figure 7, the fact that participants rate *rice* as tasty or untasty has the lowest impact on eat decisions compared to other food items (still β = 0.56 against an average over all items of β = 0.68, that is, the fixed effect of taste ratings), while the health rating has an average impact (β = 0.07) and ethical rating has a near maximal influence (β = 0.20, with the maximum being at β = 0.21). On the contrary, *ice cream* demonstrates the lowest and even negative influence of ethical ratings (β = -0.04), but near maximal effects of health (β = 0.17) and taste (β = 0.73).

The white-green color gradient thus visually represents the influence of ethics ratings on food decisions: the whiter the ellipse, the smaller the influence of ethics on food decisions, and the greener, the stronger this influence. Moreover, foods located on the left side of the figure are those for which the influence of health on food decisions is lower than for those on the right side. Foods in the middle are those for which health ratings have an average impact. The same logic applies for the influence of taste on food decisions (upper versus lower side). Beyond each specific food item, Table 1 summarizes by item-level correlations (above diagonal), while also reporting participant-level correlations (below diagonal).

Figure 6

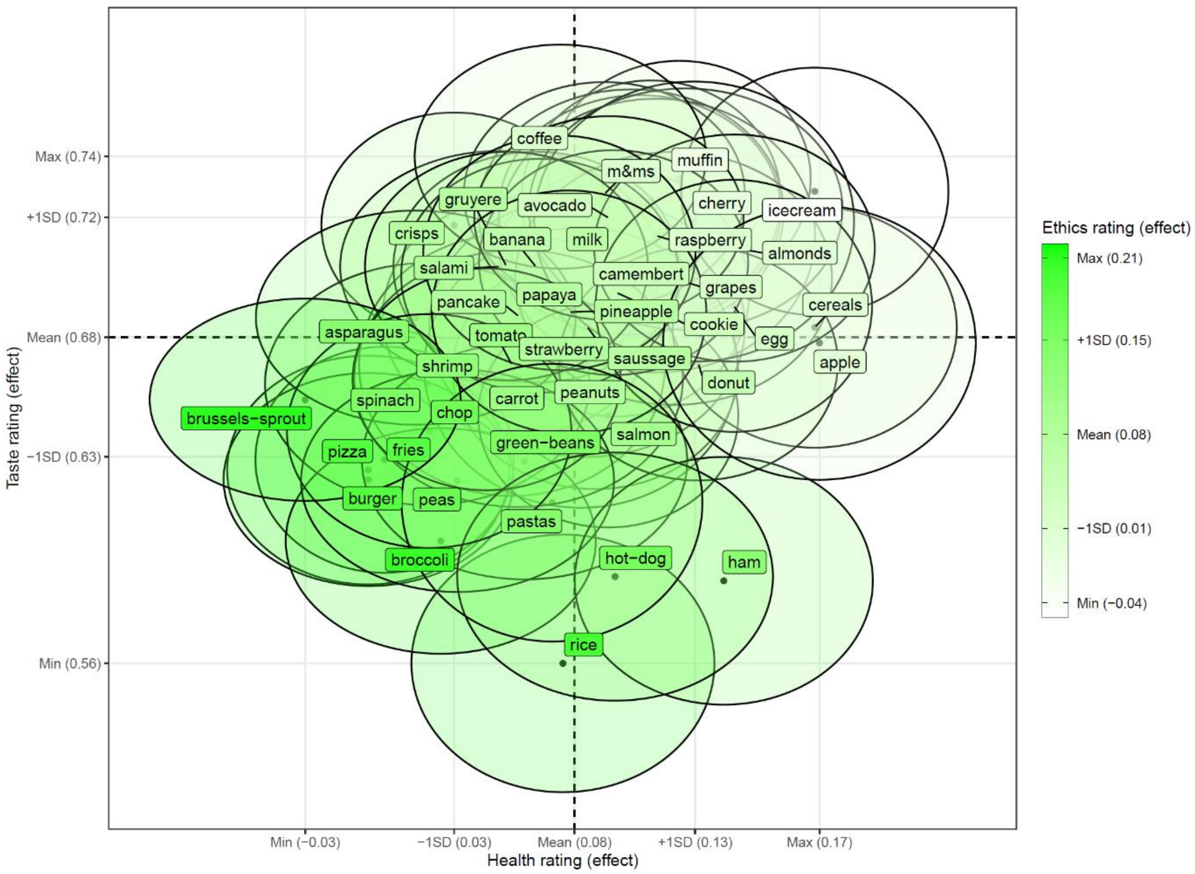
Mean taste, health, and ethics ratings for each food item in Study 2



Note. Points represent the mean ratings for each food item (labels) on taste (y-axis), health ratings (x-axis) and ethics ratings (color gradient), with associated standard deviation across participants (shaded ellipsoids). Exact equivalence between health and taste ratings corresponds to the first bisector (red dashed line). Item references from the Food-Pics Extended database are available on OSF.

Figure 7

Estimated random effects of taste, health, and ethics ratings for each food item in Study 2



Note. Points represent the estimated random effects of taste (y-axis), health ratings (x-axis) and ethics ratings (color gradient) on eat decisions, with associated standard deviation of the estimate (shaded ellipsoids). Dashed lines correspond to estimated standardized fixed effects of taste and health ratings. Item references from the Food-Pics Extended database are available on OSF.

Table 1

Correlations between taste, health, and ethics ratings in Study 2

(Mean)	Eat	Taste	Health	Ethics
Eat		.97 ***	.34 *	.55 ***
Taste	.57 ***		.24 †	.44 **
Health	.33 **	.34 ***		.81 ***
Ethics	.34 ***	.15	.28 **	

Note. Zero-order correlations between the four continuous measures collected in Study 2. Values and significance levels reported below the diagonal correspond to Pearson's correlation tests at participant-level, while those above the diagonal correspond to item-level correlations (*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .1$).

Discussion

Findings from Study 2 were both in line and extended previous findings in important ways. Regarding final decisions, increases on taste and health attributes favored (as expected) decisions leaning toward *eat* decisions. This pattern was also observed for ethics: as for the other attributes, increases on the ethical attribute favored decisions leaning toward *eat* responses. The influence of ethics was particularly likely on food items rated as neutral on taste (at the attribute's mean) with lower ethics ratings inhibiting eat decisions and higher ethics ratings facilitating these decisions. With the addition of the ethical attribute, the influence of health on neutral tasting foods seemed to be reduced for final decisions given the shared variance between attributes (e.g., green vegetables), albeit still observed on food decision processes. Together, findings reflected a saturation of *eat* decisions for food items that were rated as both tasty and healthy, or tasty and ethical, given the strong weight of taste. However, health and ethics had more room to impact decisions in neutral or conflicting configurations of attributes for tasty food items. They therefore both represent relevant levers for interventions to promote healthy and ethical diets.

Findings for decision processes were consistent with, yet extended, those for final decisions. Specifically, an early significant and lasting effect of taste was observed, followed by later significant effects (and peaks) for health and then ethics. Furthermore, as for final decisions, ethics had a stronger influence than health on decision processes for foods neutral on taste, although both had an increasing effect during decision processes, with the peak for health observed earlier than that of ethics. In other words, taste is activated early and gains a large influence during the decision process; subsequently, health activates and gains influence, followed by ethics. The influence of health and ethics during the decision process thus varies depending on levels of taste, particularly for neutral tasting food items.

Finally, turning toward results for individual food items, which have often been overlooked in previous research, it was possible not solely to provide mean ratings for all items on all attributes, but also to depict estimated random effects for all items and attributes. These estimates from the mixed effects model depicted in Figure 7 may be particularly useful to identify foods for which health and ethical attributes are likely to influence *eat* decisions, a point to which we will return below.

General Discussion

The present studies' findings consistently showed that young adults' food decisions were strongly influenced by food items' perceived taste. This replicates previous findings (Ha et al., 2016; Lim et al., 2018; Pearce et al., 2020; Sullivan et al., 2015) with a novel 1-dimensional MT paradigm and signals that in this population, tasty foods are more likely to result in *eat* decisions, compared to less tasty foods. Notwithstanding this expected effect of taste, health and ethical attributes also exerted their influence on food decisions, with effects of lower magnitude compared to taste. This finding aligns with previous research which also reported an effect of health but of lower magnitude compared to taste. It is extended in the present research to the ethical attribute, which also favored decisions leaning toward *eat* responses.

Of importance, adding to previous research which artificially reduced the occurrence of neutrally rated food items, both higher health and higher ethics ratings increased the likelihood for neutral food items (i.e., at taste ratings' mean) to result in *eat* decisions. This is a novel finding for food items yet is consistent with the literature on person construal signaling that the influence of higher-order level attributes—such as health and ethics here—increases when items became more ambiguous or category-neutral (Freeman et al., 2011; see also Freeman & Ambady, 2011). The focus on the influence of health and ethics for neutral food ratings also yields particular importance for interventions, beyond its theoretical stakes. Indeed, despite the strong impact of taste on food decisions, there is still some room for the other attributes to influence the decision. In other words, although most individuals eat foods first and foremost because they like them, when taste reduces its influence, attributes such as health and ethics can take over and guide food decisions.

This finding, which yields important implications for interventions simultaneously signals the importance of a theoretical understanding of food decisions. Indeed, food items rated as neutral on taste are those for which indecisiveness is high (compared to very tasty and very untasty items). Individuals hesitate between *eat* and *not eat* decisions, with an a priori equiprobability. According to models of action selection, alternative choices compete for action while evidence is accumulated continuously for one or the other alternative (for a review, see Cisek & Kalaska, 2010). In our mouse-tracking paradigm, accumulated evidence is reflected by participant-controlled mouse movements, and by the chosen response when the accumulated evidence in favor of one alternative reaches a threshold. Health and ethical attributes are the type of higher-order level information that foster evidence in favor of *eat* decisions for neutral tasting foods, compared to *not eat* decisions. Given the a priori equiprobability of *eat* versus *not eat* decisions for neutral tasting foods, interventions aiming at promoting healthy and/or ethical consumption should have the strongest impact on those foods.

These rather neutral food items on taste encompass among others, donuts, gruyere, chop, almonds, eggs, avocados, but also green-beans, peas, and spinach. Combining this individual food item-level information with estimated random effects for health and ethical attributes for *eat* decisions, spinach, chop, peas, and green-beans (for ethics), and eggs, donuts, and almonds (for health) are particularly likely to be targeted by interventions. Such interventions might increase (e.g., peas) or decrease (e.g., chop) the ethical attribute rating, leading to a respective increase or decrease in associated food decisions. To go beyond the present database, specifying these results for an even larger selection of food items seems promising, especially given that the use of mixed models allows generalizability at both the participant and item level. In any case, as in the present research, future studies on food decisions ought to keep the whole range of food items, especially as it concerns ratings on the taste attributes, to meaningfully guide interventions aiming at promoting healthy and/or ethical food consumption. Interventional research may further focus on associating data obtained with the current multitrial MT paradigm to, for instance, purchase intentions or decisions for a restricted number of food items. Indeed, as highlighted by others (e.g., Stillman et al., 2018), MT data on a single trial (e.g., a given purchase decision) are often noisy, which limits the use of MT when only a few food items are of interest.

Related to the importance of fully considering items with neutral taste ratings, future research may further investigate whether these items are indeed rather neutral—that is, are neither perceived as extremely tasty or untasty—or whether some foods may also elicit ambivalence (see Schneider et al., 2016; Schneider & Mattes, 2021). This past research has shown that the same ratings may express neutrality—neutral feelings, neither positive or negative—or ambivalence—mixed feelings, both positive and negative. Neutrality and ambivalence are therefore sometimes intertwined for items such as those from the International Affective Picture System (Schneider et al., 2016) or more abstract words with predetermined valence (Schneider & Mattes, 2021). The present 1-dimensional MT paradigm may be particularly well suited, as it has already been implemented for more complex linguistic stimuli (see Gautheron et al., 2023). Indeed, one issue raised in the MT literature is its limited suitability for complex stimuli that are longer to process, such as abstract words or sentences (Stillman et al., 2018). The present novel MT paradigm circumvents this limitation, increasing variability of the range of stimuli to be investigated.

Distinguishing neutrality from ambivalence is particularly important when items' valence is at stake, with valence measured on a single scale with positive and negative feelings as endpoints of the same construct. This is less problematic for taste ratings measured as in the present research. Indeed, participants were asked to rate food items on tastiness, from very untasty to very tasty. Given this measurement scale, ratings at the scale's mean were most likely to reflect neutrality and indecisiveness regarding whether participants liked the food or not. In addition, given that possible conflict stemming from other dimensions—such as health and ethics—was measured in the same study, conflict trials (for which ambivalence is likely to be highest), were included in analyses.

However, such trials were in the numeric minority, signaling that in daily life and for young adults, many food items are indeed perceived as rather neutral. This may question the focus on conflict trials in previous research, at least for some populations.

As the present research aimed to test the influence of ethics, along with that of taste and health, on food decision processes, we retained an inclusive definition of ethics. However, ethics can relate to different domains (animal and human rights, environmental concerns), which may be separately relevant in food decisions, depending on individuals. For instance, some persons may be particularly sensitive to working conditions and human welfare in general, others may be more concerned about animal welfare (e.g., Murphy, & Neely, 2012). As we did not differentiate between the different domains of ethics, an endeavor for future research would be to disentangle how each of them affects food decisions (i.e., their weight, dynamics, and possible interactions). Some food items may be particularly relevant in this endeavor. For example, a beef steak may elicit concerns about both animal welfare and environmental impact. Each type of concern may weigh in food decisions, but they may not add up to make the influence of the ethics attribute twice as strong in the decision process for most consumers. However, their cumulative influence may result in earlier influence in the decision process compared to only one or the other. In addition, the way the same type of meet is depicted may in itself elicit more or less awareness for ethics in general (e.g., beef presented as a rare steak versus in Bolognese sauce) or for one ethical domain over the other (e.g., steak image background focusing on tarnished nature versus intensive farming). Ethics attributes may therefore be perceived differently not solely by individuals, but also depending on the situation.

Testing attribute manipulations for interventional research is particularly important. Indeed, the present research and the existent literature on the influence of attribute perceptions on food decision making processes is mainly based on correlational studies. While manipulating taste, given its phenomenological status, seems difficult, health and ethics are related to different recognized characteristics and domains (e.g., vitamins, nutrients, saturated fats, calories for the former; human rights, animal rights, or environmental impact for the latter). These characteristics and domains, which all contribute to define healthy and ethical foods, may therefore be manipulated separately. Such manipulation—for instance by priming one or the other characteristic or domain—would be particularly relevant for researchers investigating effects of these attributes separately. Here, as food decision making was conceived of as a process of integration of different attributes, the observed correlations between attributes (despite instructions to respond independently) was not a concern. However, this overlap must be considered if independent effects are of interest.

Conclusion

Overall, the present findings confirm that young adults first and foremost eat foods they like, and that this large influence of taste operates throughout the entire decision process. Notwithstanding this necessity for foods to be tasty, health and subsequently ethical attributes also gain influence during the decision process, with their influence still present on final decisions. Their ability to favor *eat* decisions is particularly likely for food items rated as neutral on taste, a type of items which has been largely overlooked in past research but has important implications for interventions. Interventions aiming at promoting healthy and/or ethical food consumption are therefore most likely to impact young adults' food decisions for those foods where they become necessities because taste alone cannot guide decisions.

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Author contributions

All authors designed and conducted the studies. J.C. Quinton analyzed the data, while all authors were involved in data interpretation. A. Smeding wrote the first draft of the manuscript, and all authors contributed to and have approved the final manuscript. All authors had full access to the studies' data.

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