Battle of the Primes

The Effect and Interplay of Health and Hedonic Primes on Food Choice

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Battle of the primes – the effect and interplay of health and hedonic primes on food choice

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Abstract:

People making food choices are often exposed to different cues that can activate relevant goals that influence the choice outcome. Hedonic goals are frequently primed by advertising while health policy enlists primes that activate health goals in the moment of food decision-making – e.g., healthy food labels. However, little is known about the effect of such goal-priming cues on the population level and how people respond when exposed to both types of primes simultaneously. The results of this study, based on a large, representative sample (N=1,200), show no effect of health-goal priming on healthy food choices. Being exposed to a sole hedonic prime, however, reduces healthy choices by 3%. This effect completely disappeared when both primes were presented at the same time. All effects remained insensitive to people's gender, hunger status, level of dietary restraint, and BMI. These findings cast doubt over the effectiveness of health goal primes as a tool to increase healthy food choices but suggest a protective effect against competing hedonic primes and could thereby prevent less healthy choices.

1 Background & contribution

In the debate about the ongoing obesity crisis many researchers have advocated for the importance of food environments in stimulating unhealthy dietary choices, and much research has focused on the effects of increasing availability and marketing of foods high in fat and sugar (Hall, 2018). Psychological research in nonconscious self-control stipulates that various cues, for instance images of tasty energy-rich foods, in the choice environment can activate short-term goals of indulgence (Elliston et al., 2017; Harris et al., 2009; Papies, 2016b) and thereby contribute to caloric overconsumption. It is thought that exposure to attractive food cues triggers simulations of consuming the food and the reward associated with ingestion (Papies, 2019). Goal priming can be considered a core mechanism of marketing efforts to increase consumption, but the same priming mechanism has been advocated as a tool to foster healthier dietary choice by priming health goals in the moment of food decision-making (Papies, 2016a). Health goal priming, whereby people are exposed to cues that are thought to activate health goals that people have, such as slim figures, has shown to effectively foster healthier dietary choices in a number of studies in laboratory and field experiments (Bauer & Reisch, 2019; Buckland et al., 2018; Papies, 2016a; Van der Laan et al., 2016; Wilson et al., 2016).

There appear to be at least two gaps in our knowledge on the effects of health goal priming. First, it is unknown how robust health goal priming effects are over larger and more diverse populations. Although there are exceptions (e.g., Forwood et al., 2015), most previous studies were performed in relatively small and narrow samples. Significant findings are often based on small samples that may indicate false positives, rather than actual effects of manipulations (Zebregs & de Bruijn, 2017). Even though a meta-analysis of priming effects across domains (Weingarten et al., 2016) showed that goal priming effects are robust and that this literature shows little evidence for publication bias, the priming literature is at the core of the ongoing replication crisis (Doyen et al., 2012; Ioannidis, 2014; Simmons et al., 2011).

The samples of many previous studies were limited and consisted of, for instance university students which may have a distinct response to the experimental manipulations (Cappelen et al., 2015; Hanel & Vione, 2016). In other studies, results were limited to sub-groups or conditional on situational factors (e.g., hunger) (Forwood et al., 2015). Also, it has been suggested that the mechanisms driving health goal priming effects, namely the strength, accessibility, and activation of health goals, might systematically vary along the socio-economic gradient and behavioural responses to specific primes could vary accordingly (Custers & Aarts, 2005). To assess the robustness of health goal priming effects over larger and more diverse populations, the present study was preregistered and conducted with a large, stratified sample representing the wider population of a Western country, namely the Netherlands.

The second knowledge gap concerns the interaction of health goal primes with competing (i.e., hedonic) primes. Virtually all studies on food related health goal priming tested the sole effects of health goal primes. While these studies made important progress in our understanding of health goal priming effects, as a policy instrument, targeted prime interventions would rarely act in an otherwise cue-free environment. Efforts trying to activate long-term health goals in the free market would certainly compete with other cues from producers and marketeers likely priming hedonic goals. The increased accessibility of goals through hedonic primes in the obesogenic environment might inhibit competing long-term goals such as losing weight or eating healthily (El Dahr & Fort, 2008; Förster, Liberman, & Friedman, 2007). Also, previous studies have shown that primes work at least partly through shifts in attention towards choices that are congruent with the primed goal (Van der Laan et al., 2016). If different goals are primed simultaneously the cues compete for limited attention and it is yet unclear how this affects subsequent choice. Such interplay of different primes has received only little attention in the literature to date. The present study helps filling this gap through its experimental design that does not only allow for analyzing the isolated effects of health and hedonic primes on food choice but as well for studying their interaction.

The aim of this study was to investigate the single and combined effects of health and hedonic primes on food choice in a large representative sample of the Dutch population. Building on previous literature, we hypothesized that the sole presence of health primes would increase the proportion of healthy choices (H1), and that the sole presence of a hedonic prime would reduce the proportion of healthy choices (H2), when compared to choices made in the absence of any goal prime. Further, we hypothesized that health and hedonic primes interact in their effects on healthy food choices. Health goal priming in combination with a hedonic prime reduces the effect of the health goal prime compared to the combination with a neutral prime (H3).

We were additionally interested in the exploration of factors that moderate the effect of the health goal primes. On principle, the diversity and size of the sample allows us to explore the effects of such potential moderators. First, since previous findings were based on predominantly female students samples, and as there are known sex differences in food cravings, preferences, and cue responses (Hallama et al., 2016; Manippa et al., 2017), we stipulated that gender moderates the effect of our primes. Second, gender differences might, however, be partially explained by differences in dietary goals. The concept of goal priming rests on the assumption that individuals have a healthy eating goal to be activated. We hypothesized that individuals high in dietary restraint and healthy eating goals respond differently to the primes. Third, food cues reponses have previously been linked to BMI (van Meer et al., 2016) and the state of hunger in the decision situation (Forwood et al., 2015); we tested both for potential moderation of the primes. We additionally explore whether the relative position of the prime matters, i.e. whether the respective prime is presented above or below a competing or a neutral cue, and whether other social-demographic charateristics moderate the main effects of our results.

2 Method

2.1 Design

The experiment is presented as a 2x2 between subject design with health prime (present versus absent) and hedonic prime (present versus absent) as independent variables, resulting in four experimental conditions. The data collection plan and the analytical strategy were pre-registered on the Open Science

Framework (https://osf.io/tehd2). The study was approved by the Ethical Committee of the Department of Communication Science at the University of Amsterdam.

2.2 Procedure

The experiment was performed by individuals online and participants finished the study individually, on their own devices and at their own pace. Upon providing consent, participants were asked about their age, gender, and income linked to the pre-set quotas. After that, participants were asked about their current state of hunger and then randomized into one of the four experimental conditions, where they made 18 food choices. Thereafter, all participants were asked to report their satisfaction and willingness-to-pay for the products they chose in the previous task. Subsequently, participants provided health and taste ratings for a random selection of the products presented in the choices. Participants provided additional socio-demographic information, i.e., household size, income, employment status and education, before completing questions about dietary restraint, food knowledge, and attitudes towards healthy eating. Thereafter, participants were debriefed and redirected to the survey provider where they were reimbursed for their participation.

2.3 Participants

Study subjects were invited to participate in the study for a small financial compensation using existing participant panels through the company Qualtrics from the 1.10.2018 to the 27.10.2018. To achieve a good representation of the Dutch population quotas for age, gender and income were derived from Statistics Netherlands and provided the basis for the sampling (see Table S3 for details). In total, 4,835 participants responded to the invitation. Data cleaning followed an iterative process where participants failing to meet the pre-set quality criteria were removed and resampled. The detailed procedure is outlined in Supplemental Material (Table S1). As the final sample only marginally deviated for the pre-set quotas no sampling weights were used in the analyses. The average age in years was 49 with 50% of the participants being female. Table 1 indicates basic descriptive statistics.

TABLE 1 ABOUT HERE

2.4 Experimental Manipulation

For the choice experiment, the present study mimicked an online supermarket. The competing health and hedonic primes were presented through two advertisement banners for cooking recipes above the choice set and included a slogan. The health primes were designed as recipe advertisements containing text that promoted the healthiness of the meals. This included phrases like “healthy” or “low calories” and was accompanied by images of low-caloric and healthy meals. Similar prime words have been successfully used in previous studies (Papies et al., 2014) as well as the concept of displaying recipe banners (Van der Laan et al., 2016). The hedonic primes were similar in design but focused on pleasure and taste aspects contain words like “just delightful” or “tasteful and delicious” and showed pictures of tempting foods high in sugar or fat. In the absence of one of the two primes, we presented neutral banners with an advertisement not related to food, namely household utensils (see Figure S1 for examples). These neutral advertisement banners were shown to control for the visual distraction from the mere presence of the banner itself. Both banners were presented above the choice sets. The order of the banner was alternated with each choice to avoid any ordering effect (see Figure 1).

2.5 Measures

Food choice

For our main outcome variable of interest, participants made 18 choices in a hypothetical online supermarket, each selecting one preferred product out of six alternatives via a mouse click. Participants were given a scenario to purchase groceries for themselves for the next two days, considering breakfast, lunch, dinner, and snacks. We instructed them not to overthink these choices and select the product they intuitively prefer. The 18 meal categories and overall set-up of the task partly draws from Van der Laan et al., (2016). The six alternatives were presented on-screen in a 2 (row) x 3 (column) design. Each screen presented three healthy and three unhealthy product options in an alternating but fixed order (see Figure 1). When participants made their choice, they clicked on a “next” button on the bottom right corner of the screen to get to the next choice (see Figure S2 for examples of the choice set).

Most products were pre-tested in a previous study (Van der Laan et al., 2016), but we replaced items that were not longer commercially available. To test whether participants identified our selected products as more or less healthy, they were asked to rate one randomly selected item of the six from each category (see Table S4). Using a regression model to account for product category fixed-effects and the nested data of the product ratings, we found that products pre-selected to be healthier choices (M = 6.04, SD = 2.08) were rated as 1.54 points healthier (OLS: t = 41.33, p<.01; 9-point scale 1 = “not healthy at all” to 9 = “very healthy”) compared to the unhealthy options (M = 4.49, SD =2.16). This subjective assessment reflects an objective difference in their average caloric content (healthy: M= 180.74 kcal/100g, SD = 148.09; unhealthy: M = 348.04 kcal/100g, SD = 180.74).

We also asked about tastiness (9-point scale 1 = “not tasty at all” to 9 = “very tasty”) and products in the unhealthy category (M = 6.11, SD = 2.16) were rated as 0.75 points tastier (OLS: t = 2.28, p =.02) than the healthier options (M = 6.03, SD = 2.16).

The main outcome variable was the individual proportion of healthy choices made in the 18 choice sets, ranging from 0 (no healthy option was selected in the 18 choice sets) to 1 (the participant selected a healthy alternative in all 18 choices). Figure S3 presents a histogram of the outcome variable.

FIGURE 1 ABOUT HERE

Additional measures.

Dietary restraint was measured with the Dutch Eating Questionnaire (DEBQ, $\alpha = .92$) (van Strien et al., 1986). Current hunger was measured on a 100-point slider Visual Analogue Scale (VAS) ranging from “not at all hungry” to “extremely hungry”. This measure is used commonly in the field (e.g. Almiron-Roig et al., 2013; Wilkinson & Brunstrom, 2016). To ease the interpretation of our results, we calculated z-scores for Body Mass Index (BMI) and dietary restraint, which both do not have a meaningful value of 0 on the measurement scale. A full list of variables and measurement tools is presented in the pre-registration (https://osf.io/tehd2).

2.6 Statistical Analysis

We used a linear regression, i.e. ordinary least squares (OLS), to test our three pre-registered hypotheses about the effects of the different priming banners and their combination. In this pre-registration, we did not explicitly state the analytical approach of a 2x2 design in our analysis plan but referred to the four treatment groups rather than two factors with two levels. We later recognized that the latter analytical strategy is more suitable for our experimental design to answer our research questions concerning the effects of the competing primes. Furthermore, Hypothesis 3 was originally formulated as a negative effect of the hedonic prime reducing healthy choices compared to the health prime alone. This is, however, analytically identical to a positive effect of the health prime increasing healthy choices compared to the hedonic prime alone. We hence adapted our analysis accordingly.

In the present analysis, respective banner presence was coded as a 2x2 design using binary indicators for whether a healthy or hedonic prime was displayed. The healthy and hedonic dummy were interacted to obtain the differential effect of the condition with both banners present. Further analysis of moderating effects in this study relied on the same analytical framework, i.e., moderation was analyzed as a three-way interaction of both experimental factors with the respective moderator in the regression. Further details are presented in the section below. All statistical analyses were conducted using STATA version 16. In our pre-registration and consequentially the analyses presented here, we do not adjust p-values for multiple comparison. We present a discussion and results using different adjustment methods in the Supplementary Material.

3 Results

3.1 Main results

Our main analysis focuses on the three pre-registered hypotheses concerning the main effect of our experimental conditions. Table 2 outlines these results by showing the regression results of our 2x2 design. These results are also graphically displayed in Figure 2.

Hypothesis 1 stipulated that exposure to the health prime using health goal related banners would lead to an increase in healthy choices. Our results from a linear regression provide no support for this hypothesis. We find no difference in the mean of proportions of healthy choices between participants who have been primed with a health banner (and a neutral banner) compared to those exposed to two neutral control banners (b = -0.003, t = -0.19, p = .85).

The data did support the hypothesized effect of the hedonic prime, formulated in Hypothesis 2. People exposed to the hedonic prime opted on average 51.3% for the healthy choices (SD = 0.19), which is less than those who were exposed to the neutral control banners (M = 54.5%, SD = 0.18). Hence, being exposed to a hedonic priming banner led to a decrease of healthy choices by 3.2% (b = -0.03, t = -2.12, p =.04).

We further hypothesized an interaction effect when both primes were presented. The actual results provide a complex picture. While no main effect was found for the health prime alone, presenting participants a combination with the hedonic prime revealed a negating effect of the former (interaction effect: b = 0.046, t = 2.06, p = .04). Being exposed to both primes showed overall the highest point estimate for the mean of the proportions of healthy choices with 0.56 (95%CI[.53,.58]), which is significantly different from the mean proportion of the hedonic prime 0.51 (95%CI[.49,.53]), but not from the health prime 0.54 (95%CI[.52,.56]) or the neutral control condition 0.55 (95%CI[.52,.57]). Figure S4 displays a graphical comparison of the group means.

TABLE 2 ABOUT HERE

FIGURE 2 ABOUT HERE

3.2 Moderation analysis

Based on prior literature we explicitly planned four potential moderators as a follow-up analysis in the pre-registration: gender, hunger, dietary restraint, and BMI. The regression table with all four moderation analyses is provided in Supplemental Table S5.

Gender was measured as a categorical variable with six participants reported that their sex did not fit into either male or female. While we kept those observations in all other estimations, they were removed from the gender analysis as we could not attribute them to either of the binary categories, but sample of six was too small for a separated analysis. Main gender differences in the outcome were significant with men making fewer healthy choices (b = -0.044, t = -2.05, p = .04). However, none of the interaction terms were statistically significant and we found the main effects being not moderated by gender.

Hunger, measured on scale from 0 to 100, had a negative main effect on the proportion of healthy choices with an estimated 1.4% fewer healthy choices for an increase of hunger by 10 points (b = -0.001, t = -3.35, p = 0.001). This negative effect in the control condition was not significantly altered by any of the priming conditions (see in Figure 3 for a plot of the linear predictions).

FIGURE 3 ABOUT HERE

In line with the theoretical predictions, dietary restraint had a main effect estimating an 7.7% increase in healthy choices to be associated with 1 SD increase in dietary restraint (b = 0.077, t = 8.30, p = < 0.001). There was no significant interaction between any condition and dietary restraint.

FIGURE 4 ABOUT HERE

No significant main effect was observed for BMI (main effect: b = -0.005, t = -0.52, p = .60). Interacting the 2x2 design with BMI, neither the interaction with the simple effects nor the three-way-interaction of both primes and BMI were statistically significant (b = 0.044, t = 1.92, p = .06).

FIGURE 5 ABOUT HERE

3.4 Exploratory analysis

The experimental design showed two banners simultaneously above the choice task. We altered the position of the banners aiming to balance any potential effects of their relative position. We provide an analysis of the banner position within each treatment condition contrasting the proportion of health choices made depending on whether the respective banner was shown in the top or bottom position (displayed in Figure S5). The results indicate that position mattered. All significant, unadjusted regression coefficients remained statistically significant after adjusting for multiple comparison (see Table S6 and S2). Comparing the choices with the health prime in top position to those where the health banner was at the bottom showed about 10% fewer healthy choices. Whether the second banner was the hedonic prime (Δ = 0.097, F(1,1199) = 51.50, p < .001) or the neutral control (Δ = 0.096 , F(1,1199) = 63.83, p < .001) made little difference. The proportion of healthy choices when the sole health prime was in bottom position was even lower compared to the control with two neutral banners (Δ = 0.046, $F(1,1199) = 8.01$, $p = .005$). We observed also differences for those exposed to the hedonic and the control banner. The proportion of healthy choices was reduced by 12% when the hedonic banner was in the top position (Δ = 0.122, $F(1,1199) = 78.22$, $p < .001$). We saw an asymmetric effect for the interaction. Comparing choices with both primes in the top position between cases where neutral or the competing prime were in the bottom position, choices only differed with the hedonic prime in top position (Δ = 0.055, $F(1,1199)$ = 9.55, $p = .002$) but not for the health prime (Δ = 0.009, $F(1,1199) = 0.21$, $p = .645$). The presence of the health prime at the bottom reduced the effect of the hedonic prime but the opposite effect was not observed.

In addition to the preregistered moderation analyses, we test whether the effects of the primes and their interaction depended on other socio-demographic characteristics (see Table S7 for the respective descriptive statistics). Table S8 presents the exploratory moderation analyses testing whether the effects differ depending on participants age, marital status, education or income. While age, martial status, and income yielded no significant moderation, results differed by educational level. Education had no main effect ($b = 0.033$, $t = 1.90$, $p = .057$), but higher education was associated with boosting healthy choices in the health prime group ($b = 0.050$ $t = 2.03$, $p = .043$). With higher education, the positive effect of adding the hedonic prime was significantly reduced ($b = -0.084$ $t = -2.36$, $p = .019$). When adjusting for multiple comparison, none of the interaction effects remained significant (see Table S2).

We also measured choice satisfaction and willingness-to-pay for the items selected in the choice task. The priming manipulations had no effect on choice satisfaction or willingness-to-pay in the full sample (see Table S9 for details). Willingness-to-pay values however included some unrealistic values. At some cut-offs e.g. when including only values above the 10th percentile (5€) and below the 90th percentile (50€), significant effects emerged. As these were however sensitive to the specific cut-off, we do not present them here.

4 Discussion

In the present study we investigated the sole and combined effects of health and hedonic primes on healthy food choices. Based on a large, representative sample we found no effect of a sole health goal prime on healthy choices, but we did observe less healthy choices by participants who have been exposed to a hedonic prime. Importantly, exposing participants to both primes simultaneously nullified the negative effect of the hedonic banner on healthy food choice.

Based on the extant knowledge of health goal priming effects, we hypothesized that the health goal prime would result in more healthy food choices. Our results do not support this hypothesis. A number of previous studies had observed positive effects of visual health goal primes on food choice (Forwood et al., 2015; Van der Laan et al., 2016). Overall, these findings have been frequently based on small and narrow samples (e.g., a student population, Van der Laan et al., 2016). Studies that included wider samples found health goal priming effects on food choice to be limited to more educated participants that were hungry (Forwood et al., 2015). A larger body of literature has studied effects on food intake, rather than choice between different alternatives. A meta-analysis summarizing this work until 2018 found trivial but significant effects of weight control cues on food intake (Buckland et al., 2018). It could thus be that the effect of health goal primes on intake are larger than on choice. However, given the high statistical power of the current study, our observed null effect cast some doubt on the generalizabilty of the frequent positive findings of health goal priming to the population level.

In line with our second hypothesis we found that the hedonic prime resulted in fewer healthy food choices. The proportion of healthy choices was reduced by 3% which translates into 174 less healthy choices in a sample size of 300 participants making 18 choices each –about one healthy choice less for every second participant. These findings are in line with the results of several previous studies that found an effect of hedonic or food-enjoyment related cues on intake of unhealthy food (e.g., Peláez-Fernández & Extremera, 2011). As both priming manipulations were comparable in design, these results suggest that, on a population level, hedonic primes are more effective in reducing healthy food choices than similar health primes are in promoting them. Priming effects can differ if some of our selected stimuli were more likely to tap into the goals of our participants than others (Papies, 2016b). An alternative explanation can be found in research relating the distance of a goal to motivational strenght. On average, the hedonic goals in food choice are associated with the immediate pleasure of consumption, while food related health goals have a long-term perspective. Results from animal and human studies have shown that motivation for goal-directed behaviour increases when the goal gets closer (Förster, Liberman, Friedman, et al., 2007).

Our third hypothesis was that when two competing primes would be present simultaneously, they would influence each others effects. For this, we tested the effect of showing the hedonic and healthy prime simultaniously. Following Goal Conflict Theory, the activation of one goal should suppress the activation of another competing goal (Stroebe et al., 2013). Given the balanced design of our experiment, what goal dominated the decision might have differed between individuals, reflecting individual differences in goal strength or response to the stimuli, or could alter between different food categories within the same participant. However, as the main effect of the health prime did not yield a positive effect on healthy choices, one would suspect that this null effect would replicate in the treatment condition with both primes and lead to a dominating effect of the hedonic prime. We, however, observe that the negative effect of the hedonic prime was fully negated after adding the health prime. Compared to the hedonic prime alone, people being exposed to both primes increased their healthy choices by 4% or 232 choices in our sample of 300 participants. These findings suggest that a specific goal prime might be unable to actively cause goal-consistent behaviour but can still inhibit the activation of a conflicting goals. The existence of such a protective effect of health goal priming has some theoretical but also practical implication.

The study has implications for self-control theory and more particularly for the role of conflict therein. Several models of self-control give conflict a central position (Inzlicht et al., 2021). For instance, dual process models posit that in a situation without conflict, decisions are made habitually. Only when a conflict is detected (and thus needs to be resolved), the control system is activated. We found no effect of the sole health goal prime but we did find that the health goal prime cancelled the effect of the prime intended to activate the opposing, hedonic, goal. Though we did not directly measure conflict detection in the current study, it could be argued that the combination of opposing goal primes triggered conflict detection and thereby served as a kind of ‘alarm bell’ to leave the habitual system and activate control processes. Future studies could investigate this by further comparing choice situations with and without competing health goal primes and employing measures of conflict detection, such as reaction times.

Our exploratory analysis of the relative position of the priming cues, whether they were in the top or bottom position, adds additional insights. We saw more healthy choices in choice sets where the health prime was in the top position vs. the bottom. These effects were insensitive to the content of the second banner, i.e. hedonic or neutral. The effect of the hedonic prime was also more pronounced if presented at the top but could be attentuated by a health prime being placed at the bottom compared to the neutral control. This asymmetric response is in line with our interpretation of an inhibiting effect of the health prime.

Drawing on previous studies that identified specific subgroups (e.g., females) or states (hunger) that may affect health goal priming effect, we here explored the moderating effects of several factors. The moderation tests of sex, hunger, dietary restraint, and BMI did not yield any noteable interaction. Hence, we cannot replicate previous findings that showed hunger to be a relevant condition for a health prime to affect behaviour (Forwood et al., 2015). Similarly, measurements of dietary restraint have been frequently used to proxy the presence of dietary health goals and was found to moderate priming effects. For people with strong weight control goals the effects of priming on food intake were larger, i.e., small-to-moderate (Buckland et al., 2018). However, previous studies using a similar paradigm did not find a moderation effect for dietary restraint (Van der Laan et al., 2016). High BMI has been associated with stronger sensitivity to external food cues (van den Akker et al., 2014), for which we stipulated that BMI might moderate the effect of either prime. However, our results using the z-score of BMI do not support this assumption. Similiarly, our exploratory moderation analyses showed no moderation based on age, marital status or income. However, the health prime was associated with more healthy choices when education was higher. That people with higher education reacted more positively to a primining intervention has also been observed in prior studies (Forwood et al., 2015). Our findings were however not longer statistically sigificant after we adjusted for multiple comparison.

Some limitations should be considered when interpreting the presented results. People executed a hypothetical food choice task on their home computers without any real-life consequences. Such lack of incentive compatability has been associated with stronger influences of social-desirability and overestimation of willingness-to-pay/-buy for products (Harrison, 2014). These challenges, however, are unlikely to affect between treatment group comparisons but rather concern the external validity of our findings (Buckell et al., 2020; List et al., 2006). Furthermore, sex, hunger, and dietary restraint have the expected main effect on our main outcome variable, which we interpret as a validation of the outcome measure itself. Beyond these potential biases, the task itself did not include an option that would allow participants to rejects all six option in a specific food category and forced a choice of their relatively prefered item. While such measurements reduce missing values, they might introduce noise to the data if people respond by selecting a product at random. Furthermore, we did not measure goal activation in the present study. This has limitations as we cannot make strong claims about the strength of the health and hedonic primes. However, we nevertheless decided to not measure goal activation as explicit measures of goal activation may have drawn attention to health and thereby affect choices, and implicit measures (e.g., a lexical decision task) cannot be incorporated in a choice task.We see some practical implications of these results if taken at face value. From a public health perspective, the fact that we used very similar stimuli to change behaviour through a health and a hedonic prime but only managed reduce healthy choices compared to neutral control is relevant. If it is, all else equal, easier to activate hedonic goals through environmental cues, public health campaigns will be at a technical disadvantage compared to efforts through food advertisement and marketing campaigns. Further research should replicate our findings to test whether the observed differences between health and hedonic goals were linked to our specific experimental design or are universal.

However, we observed a protective effect of health goal priming when presented together with the hedonic stimuli inhibiting its negative effect on healthy food choices. We see two implications here. First, food labels and some healthy-food nudges leverage the concept of health goal priming but are often tested in isolation or against a neutral control. These studies might therefore underestimate the effect of these interventions if the working mechanism does not lead to more health choices in itself but through a protective effect against hedonic stimuli frequently encountered in an obesogenic enviornment. Second, to design successful interventions more generally, a more careful consideration of the implementation environment could be helpful to not only encourage healthier choice but also disarm competing cues. Our results exploring the importance of the banner position however suggest that the effects of health and hedonic priming might not only be senstive to the presence of competing priming cues but also depend on their positioning, peoples' sequence of attention, and potential choice-unrelated distractions. Further research is needed to better understand how competing goal primes affect food choices in real-life setting and under which circumstances public health efforts can place health-goal related cues most effectively.

Our findings suggest a potential of using health-goal primes as nudges to counter hedonic cues intentionally placed in commercial environments. Such practices have been advocated before (Schmidt, 2017; Sibony & Alemanno, 2015), but whether and how well it works specifically for health primes to "battle" unhealthy primes has, however, been less explored. The present study offers some insights and calls for further research to elevate the evidence level of these early findings for policy (IJzerman et al., 2020).

5 References

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Figures

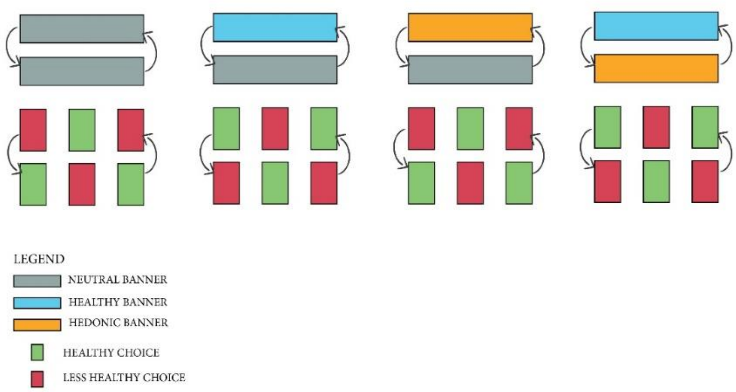

Figure 1 Experimental design. *Choice task for each treatment group with alternating banner positions and choice orders.*

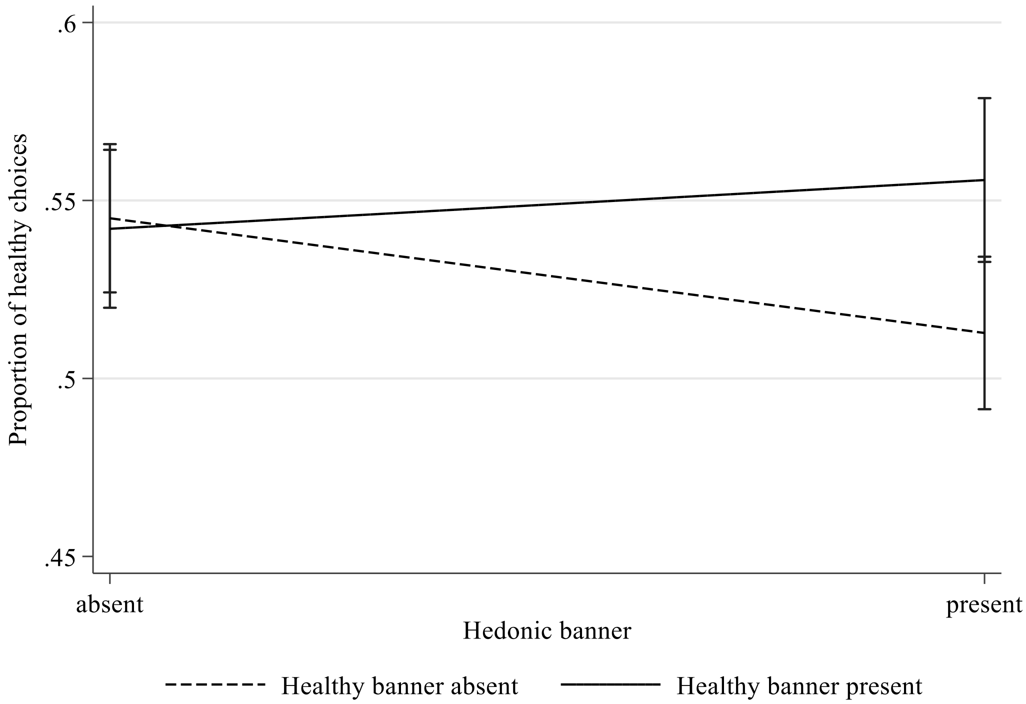

Figure 2 2x2 Effects. *Point estimates display marginal effects from an OLS model (Table 2). Error bars indicate unadjusted 95% CIs.*

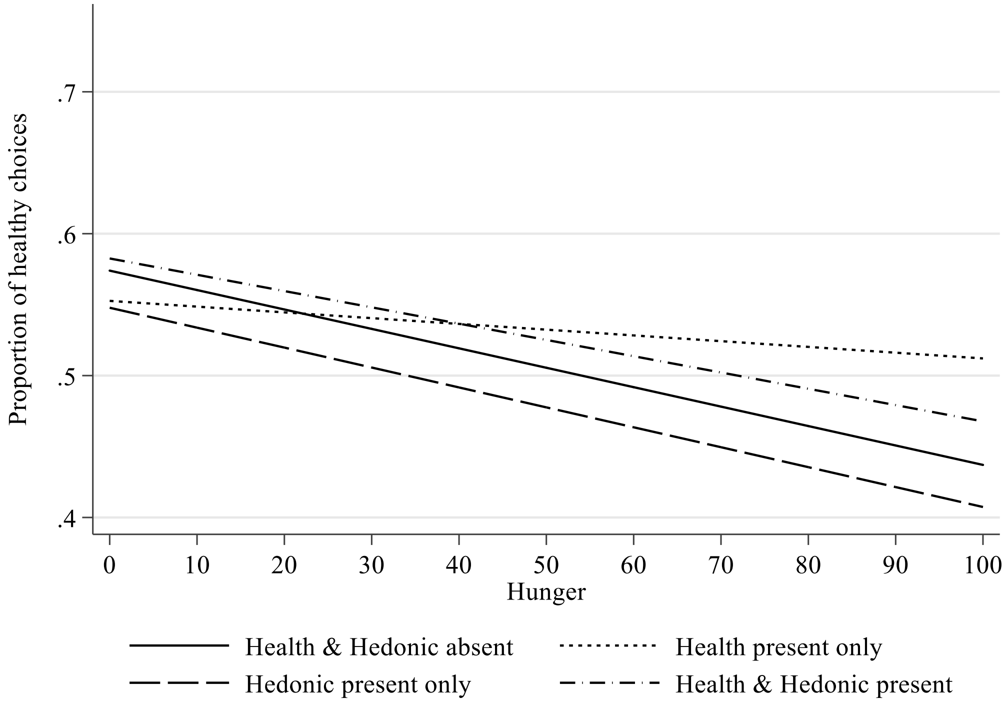

Figure 3 Moderation of hunger and primes. *Predicted proportions of healthy choices from an OLS regression with 2x2 design specific slopes moderated by hunger. For details see Table S5.*

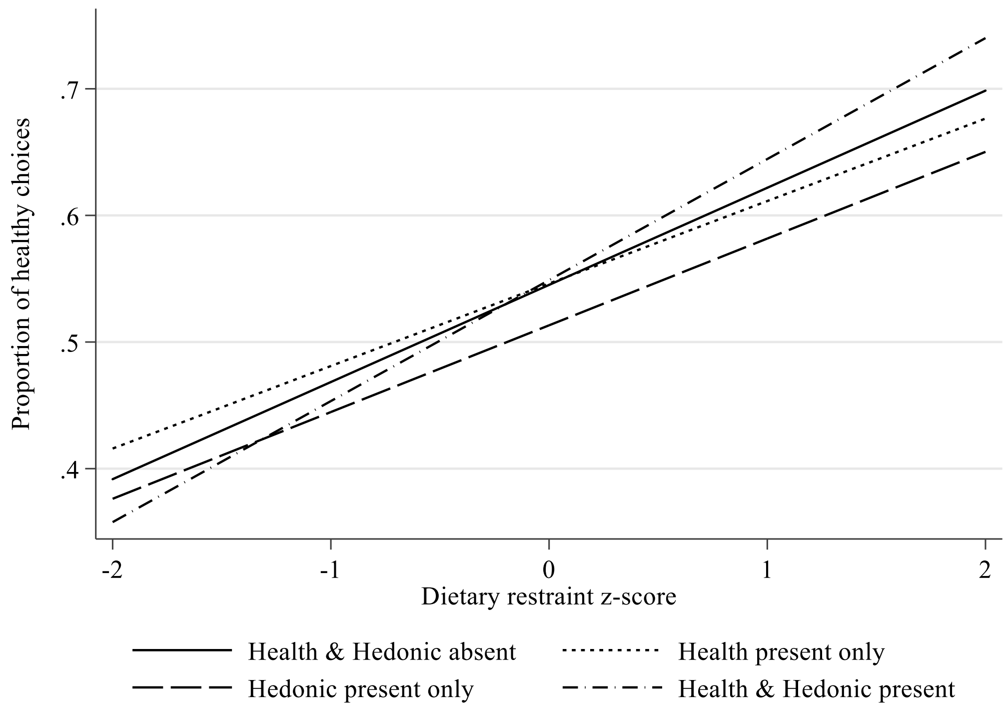

Figure 4 Moderation of dietary restraint and primes. *Predicted proportions of healthy choices from an OLS regression with 2x2 design specific slopes moderated dietary restraint. For details see Table S5.*

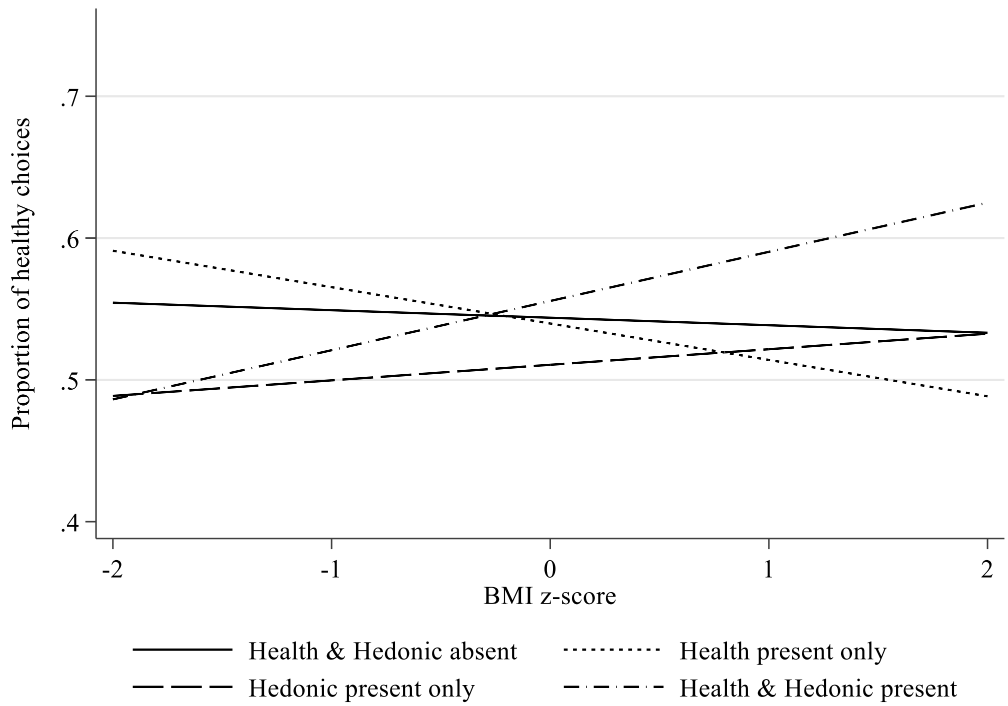

Figure 5 Moderation of BMI and primes. *Predicted proportions of healthy choices from an OLS regression with 2x2 design specific slopes moderated by BMI. For details see Table S5.*

Tables

Table 1 Descriptive statistics

	Total	Control	Health	Hedonic	Mixed
Male (%)	50	48	48	53	51
Age (years)	49.15	50.79	48.36	49.28	48.18
	(16.03)	(16.19)	(16.17)	(16.12)	(15.58)
BMI (kg/m²)[1]	25.83	25.88	25.16	26.42	25.85
	(5.17)	(5.23)	(4.22)	(6.40)	(4.47)
Dietary Restraint	28.22	28.21	27.69	28.17	28.82
	(8.34)	(8.33)	(8.53)	(8.61)	(7.86)
Hunger	23.91	21.17	26.18	24.95	23.34
	(25.07)	(23.46)	(26.47)	(25.49)	(24.61)
Observations	1200	300	300	300	300

[1] Total sample size reduced to N=1194 after recoding six very low BMI values below 15 as missings.

Notes: Sample standard deviation in parenthesis. Dietary restraint measured using the DEBQ (van Strien et al., 1986). Hunger measured using a slider from 0 “Not at all hungy” to 100 “Extremely hungry”.

Table 2 Regression results from OLS

Dependent variable	Average proportion of healthy choices
Independent variables	
Health	-0.0030
	(0.016)
Hedonic	-0.0322**
	(0.015)
Health x Hedonic	0.0459**
	(0.022)
Intercept	0.5450***
	(0.011)
N	1200

Notes: Heteroscedastic robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Supplementary Material: Battle of the primes

This is the accepted version of the manuscript and may differ from the authoritative version published in *Appetite* (https://doi.org/10.1016/j.appet.2022.105956)

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Contents

Data cleaning

Data was cleaned in an iterative process with replacement to match the pre-set quotas as good as possible. The following Table S1 describes the final sample including all participants that intended to participate in the study but failed to end up in the final sample, because their quota was already filled, they failed relevant quality measures (as described in the pre-registration: https://osf.io/tehd2) or were not eligible, e.g., because of their location.

Table S1 Data cleaning procedure

	Removed from final sample	Total before removal
Intended to participate		4835
Quota was full	2134	4835
Not eligible determined by Qualtrics (e.g. non-Dutch GeoIP):	175	2701
Attention check question 1|2:	285	2526
Speeding (1/3 of the median response time):	51	2241
Manual deletes (i.e., straight lining):	233	2190
Incomplete Responses	757	1957
Final completes		1200

Multiple comparison

There is an ongoing debate about the need for adjusting p-values due to the potential inflation of the probability for obtaining a false-positive result when a study tests multiple null-hypotheses (Bender & Lange, 2001; Frane, 2021; Rubin, 2021). While there is consensus that the expectation to obtain at least one false-positive result increases with each test presented in an article, whether the empirical support for a specific research hypothesis is subject to inflated type-1-error rates dependents on how many tests are relevant for making a judgement about this hypothesis or are considered a discovery. In our pre-registered comparisons, only the supported H2 and H3 are potentially suspect to a type 1 error (Rubin, 2021). Given the specific hypotheses, we argue that the underlying tests imply different needs to adjust the respective p-values.

Regarding H2, support for the hypothesis is based on a single pre-defined measure of outcome and a single comparison of the mean proportion of healthy choices between control and the sole hedonic prime. For such a test, many researchers argue that no adjustment is required (Bender & Lange, 2001; Cramer et al., 2016). Furthermore, the reported p-value supporting H2 is based on a two-sided test using a significance level of 5%. Given the direction of H2 – hedonic primes increase unhealthy choices – only a rejection of the related null-hypothesis towards less, but not more, healthy choices would have provided support for the hypothesized effect.

The multiple testing issue for H3 is likely to differ as more than one comparison of means can lead to a rejected of the null hypothesis that there is no interaction. When there is evidence for an interaction in a 2 x 2 design, researchers are recommended to look at the simple effects, i.e. the comparisons of the four group means (Frane, 2021). Assuming that none of the four groups differ in the population, a type-1-error for either of the hedonic or health prime group can result in a significant interaction. As argued by Rubin (2021), such scenarios require an adjustment for multiple comparison as the significant interaction supporting H3 might be subject to an inflated type-1-error rate. Following Frane (2021), a sufficient correction to efficiently manage inflated error rates is $\alpha_c = \frac{\alpha}{3.54} = \frac{.05}{3.54} = .0141$.

The simple effect for the group-mean differences between the hedonic condition and the one with both primes is p = .008 (see Figure S4), which is below the corrected threshold. Similarly, adjustments based on Tukey's method (p = .033) or Bonferroni (p = .039) do not render the observed difference insignificant and increase our confidence in the conclusion that the presence of the health prime qualifies the effect of the hedonic prime.

The significant exploratory findings are equally suspect to inflated type-1-error rates. Even though all tests were conducted in response to reviewer comments – which reduces the risk of selective reporting – these findings should be interpreted with caution. For exploratory tests, the family of tests is not clearly defined which makes it difficult to identify the correct number of tests. A common approach is to consider each null-hypothesis test conducted in an exploratory finding. Following this approach, our remaining results are affected in the following ways: see Table S2.

Table S2 Adjustment for multiple comparison in moderation and exploratory analysis.

Variable	Observed unadjusted p-value	Corrected significance threshold	Judgement after adjustment
Pre-registered moderation analyses (Table S5)			
Gender (main effect)	.04029388	.0125[1]	Not significant
Hunger (main effect)	.00084464	.0125[1]	Significant
Dietary restraint z-score (main effect)	.0000000000000002736	.0125[1]	Significant
Exploratory analyses: Banner position (Table S6)			
Health	.00472907	.0083[2]	Significant
Health x Hedonic	.00002991	.0083[2]	Significant
Health top	.000000000001250	.0083[2]	Significant
Hedonic top	.00000000000000003225	.0083[2]	Significant
Hedonic present x Health top	.0000001398	.0083[2]	Significant
Exploratory analyses: Moderation (Table S8)			
Education x Health	.04250276	.0125[1]	Not significant
Education x Health x Hedonic	.01850572	.0125[1]	Not significant

[1] the number of significance tests in the model testing the effect of the moderator (main effect moderator or interactions with prime conditions) is 4.
[2] the number of significance tests in the model testing the effect of the banner position is 6.

Figures

Figure S1 Banner examples. *Healthy, hedonic, and neutral (top to bottom)*

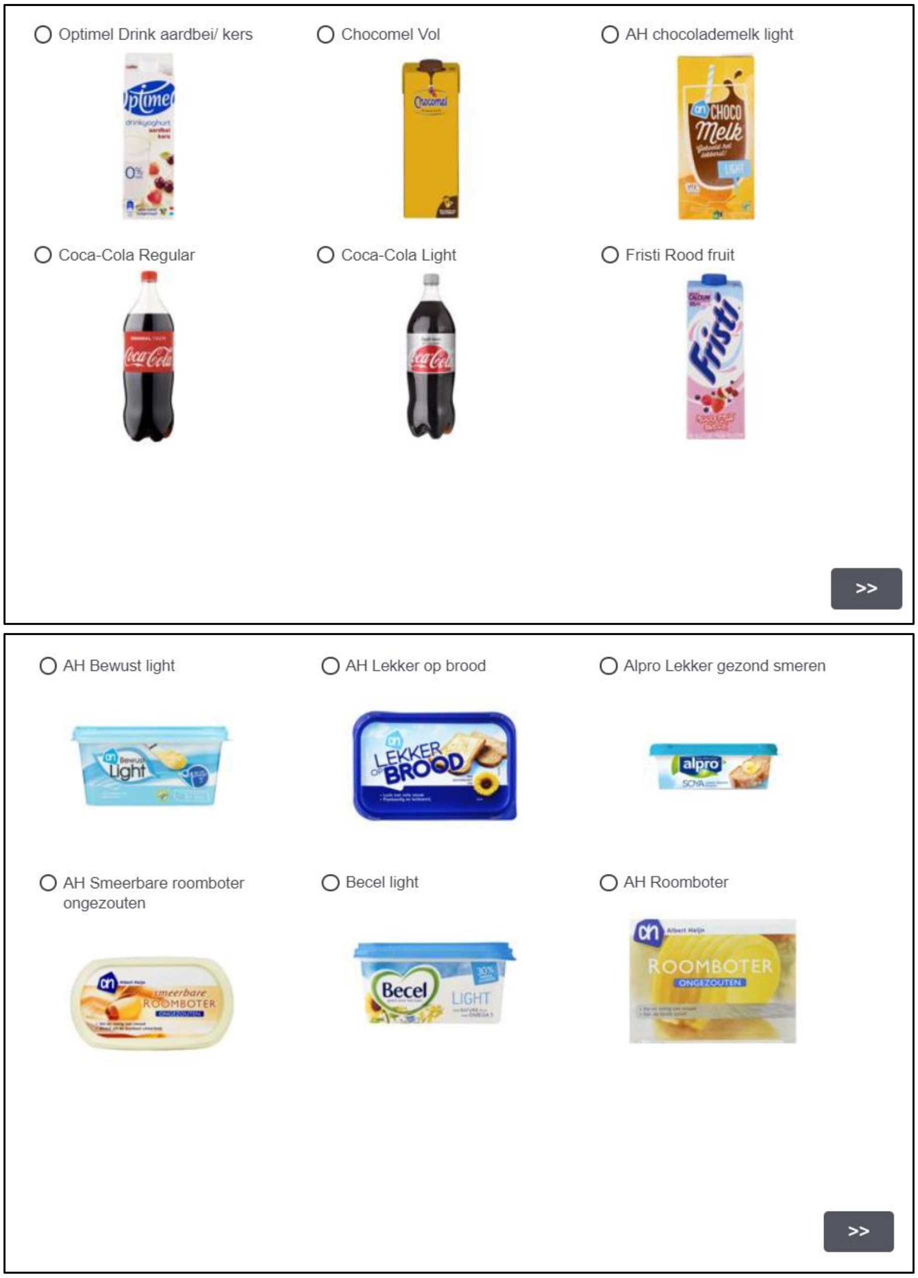

Figure S2 Choice set examples. *Two of the 18 choice sets with six products. Three healthy and three unhealthy.*

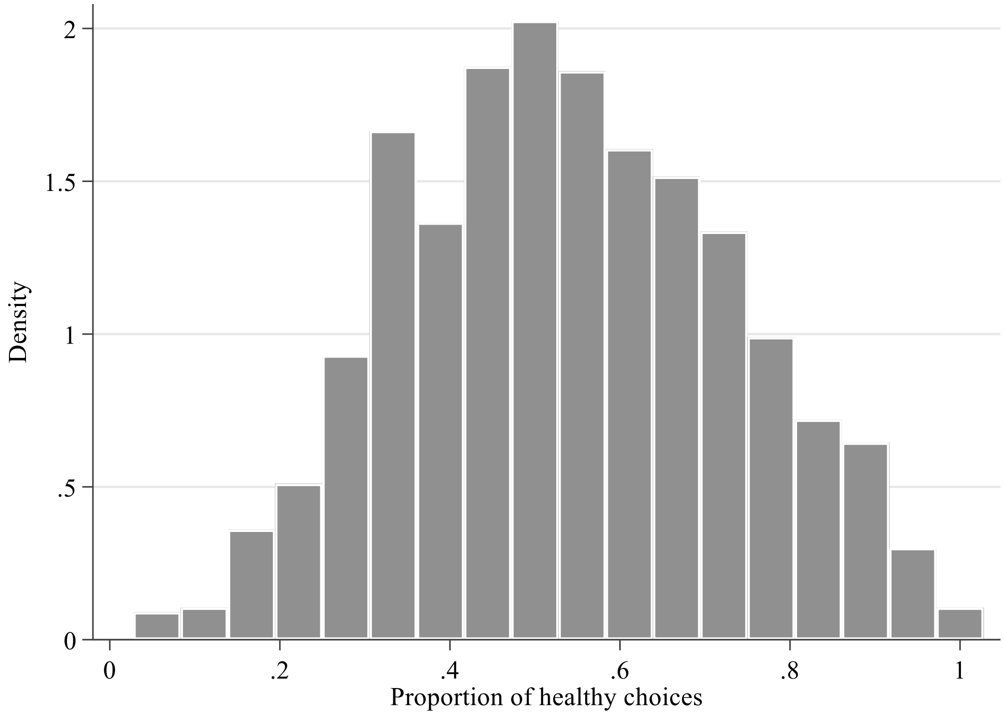

Figure S3 Histogram of healthy choices. *Distribution individuals' means of healthy choices of the full sample.*

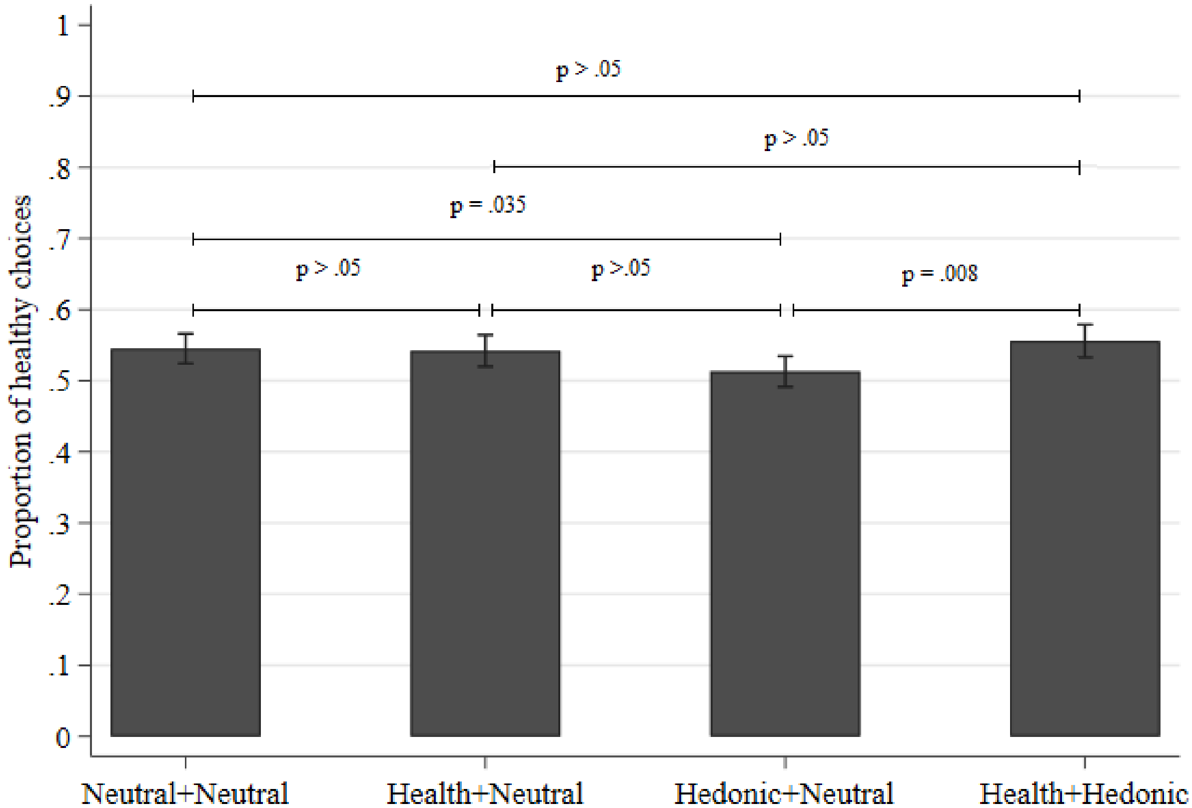

Figure S4 Group comparisons. *Figure displays the mean proportion of healthy choices by treatment group. Significance tests are based on unadjusted individual T-tests. Error bars indicate unadjusted 95% CIs.*

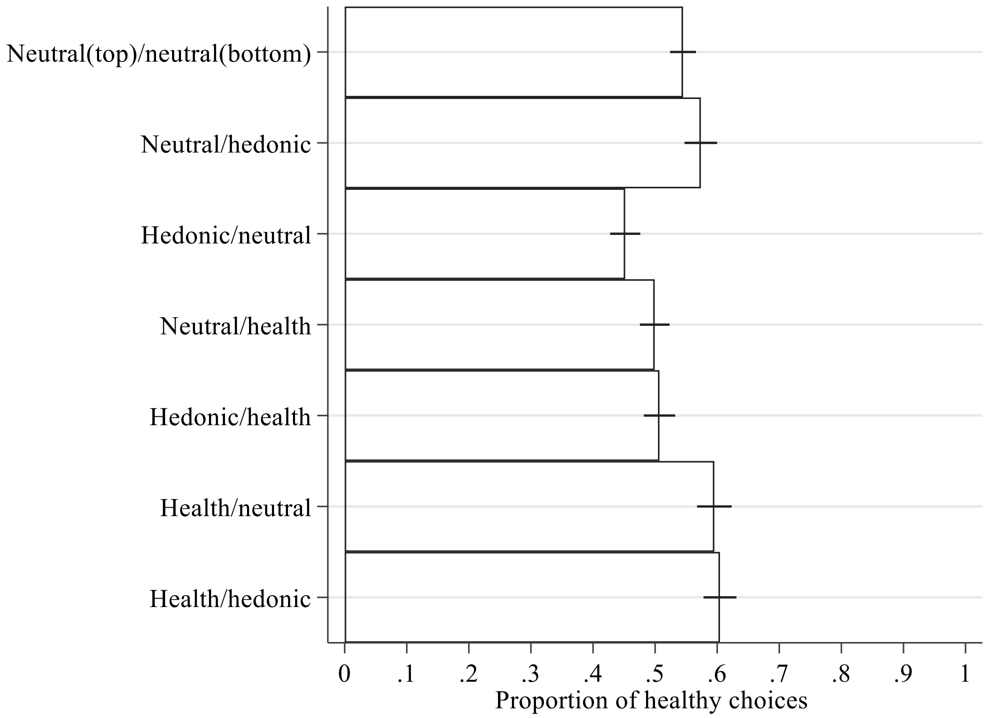

***Figure S5 Analysis of banner position**. Linear prediction of the proportion of healthy choices based on treatment condition and banner position. Error bars indicate unadjusted 95% CIs*

Tables

Table S3 Quota and final sample

Category		Target		Finale	
	Population	Share	Frequency	Share	Frequency
Gender (18+)					
Male	8417135	0.496	595	0.500	600
Female	8561985	0.504	605	0.495	594
Other	0	0.000	0	0.005	6
Total	16979120	1	1,200	1	1200
Age (18+)					
18-24	1467864	0.108	130	0.080	96
25-34	2088343	0.154	185	0.148	178
35-44	2129395	0.157	188	0.159	191
45-54	2567263	0.189	227	0.208	250
55-64	2224366	0.164	197	0.180	216
65+	3085308	0.227	273	0.224	269
Total	13562539	1.000	1,200	1.000	1200
0-18 (not in quota)	3416581				
Total (overall)	16979120				
HHIncome (all) x 1000					
< 9.999€	282.4	0.037	44	0.038	45
10.000€-19.999€	722.3	0.095	114	0.098	117
20.000€-29.999€	1137.6	0.149	179	0.155	186
30.000€-39.999€	911.7	0.120	144	0.123	147
40.000€-49.999€	751.6	0.099	118	0.101	121
50.000€-99.999€	2473.3	0.325	390	0.343	411
100.000€-199.999€	1190	0.156	187	0.123	148
>200.000€	150.9	0.020	24	0.021	25
Total	7619.8	1.000	1,200	1.000	1200

Notes: Population frequencies for 2016 obtained from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37325/table?ts=1537789265335

Table S4 product ratings

Dependent variable	Health rating	Taste rating
Independent variables		
Health products	1.5427***	-0.0746**
	(0.037)	(0.033)
Choice-set dummies	Yes	Yes
Observations (choices)	21600	21600
N (participants)	1200	1200

Notes: Data is on the choice level. Robust standard errors clustered on the individual level in parentheses. * p < .1, ** p < .05, *** p < .01.

Table S5 Moderation regression for sex, hunger, restraint, bmi

Dependent variable	Proportion of healthy choices			
Moderator	Sex	Hunger	Restraint (z-score)	BMI (z-score)
Independent variables				
Health	0.0044	-0.0213	0.0011	-0.0041
	(0.022)	(0.021)	(0.014)	(0.015)
Hedonic	-0.0228	-0.0262	-0.0319**	-0.0332**
	(0.023)	(0.022)	(0.014)	(0.015)
Health x hedonic	0.0477	0.0561*	0.0346*	0.0491**
	(0.033)	(0.031)	(0.020)	(0.022)
Male	-0.0436**			
	(0.021)			
Health x male	-0.0153			
	(0.031)			
Hedonic x male	-0.0150			
	(0.031)			
Health x hedonic x male	-0.0050			
	(0.044)			
Hunger		-0.0014***		
		(0.000)		
Health x hunger		0.0010		
		(0.001)		
Hedonic x hunger		-0.0000		
		(0.001)		
Health x hedonic x hunger		-0.0007		
		(0.001)		
Restraint z-score			0.0767***	
			(0.009)	
Health x restraint			-0.0116	
			(0.014)	
Hedonic x restraint			-0.0082	
			(0.014)	
Health x hedonic x restraint			0.0386*	
			(0.020)	
BMI z-score				-0.0053
				(0.010)
Health x BMI				-0.0204
				(0.017)
Hedonic x BMI				0.0163
				(0.013)
Health x hedonic x BMI				0.0441*
				(0.023)
Constant	0.5664***	0.5740***	0.5451***	0.5438***
	(0.015)	(0.014)	(0.010)	(0.011)
N	1194	1200	1200	1194

Notes: Robust standard errors in parentheses. * p < .1, ** p < .05, *** p < .01.

Table S6 Banner Position results from a LPM

Dependent variable	Probability of healthy choice
Independent variables	
Health	-0.0457***
	(0.016)
Hedonic	0.0287*
	(0.017)
Health x Hedonic	0.1009***
	(0.024)
Health top	0.0961***
	(0.013)
Hedonic top	-0.1219***
	(0.014)
Hedonic present x Health top	-0.1205***
	(0.023)
Observations (choices)	21600
N (participants)	1200

Notes: Robust standard errors clustered on the individual level in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$.

Table S7 Descriptive statistics of for the exploratory moderators

Category	Sample percentage
Married (N=1200)	68%
Education (N=1172)	
Low	7%
Middle	44%
High	49%
Income (N=1200)	
<9.999	4%
10.000-19.999	10%
20.000-29.999	15%
30.000-39.999	12%
40.000-49.999	10%
50.000-99.999	34%
100,000-199.999	12%
>200.000	2%

Notes: Married (binary, 1= married, 0 = single, widowed, divorced), Education low (Geen onderwijs gevolgd of niet afgemaakt, Lagere school or Lager beroepsonderwijs), Education middle (Voorbereidend middelbaar beroepsonderwijs, Middelbaar algemeen onderwijs or Voortgezet algemeen onderwijs), Education high (Hoger beroepsonderwijs or Wetenschappelijk onderwijs), Income (annual gross household income).

Table S8 Exploratory moderation analysis

Dependent variable	Average proportion of healthy choices			
Moderator variable	Age	Married	Education	Income
Independent variables				
Health	-0.0549	0.0396	-0.0703*	0.0085
	(0.049)	(0.030)	(0.037)	(0.036)
Hedonic	-0.0589	-0.0144	-0.0035	0.0052
	(0.047)	(0.028)	(0.039)	(0.036)
Health x Hedonic	0.0969	0.0099	0.1635***	0.0438
	(0.069)	(0.042)	(0.056)	(0.053)
Moderator (M)	0.0013*	0.0364	0.0334*	0.0068
	(0.001)	(0.024)	(0.018)	(0.006)
Health x M	-0.0011	-0.0619*	0.0495**	-0.0029
	(0.001)	(0.035)	(0.024)	(0.008)
Hedonic x M	0.0006	-0.0241	-0.0212	-0.0099
	(0.001)	(0.034)	(0.025)	(0.008)
Health x Hedonic x M	-0.0011	0.0516	-0.0841**	0.0005
	(0.001)	(0.050)	(0.015)	(0.012)
Constant	0.4796***	0.5192***	0.4969***	0.5194***
	(0.036)	(0.021)	(0.026)	(0.027)
N	1200	1200	1172	1200

Notes: Moderation variables are: Age (numeric), Married (binary, 1= married, 0 = single, widowed, divorced), Education (3-item ordinal scale, 0 = low, 1 = middle, 2 = high), Income (11-item ordinal scale from 0 <1000 to 10>=4501 Euro of net monthly income). Robust standard errors in parentheses. * p < .1, ** p < .05, *** p < .01.

Table S9 Choice satisfaction and willingness-to-pay

Dependent variable	Choice satisfaction	Willingness-to-pay
Independent variables		
Health	-0.2900	0.6314
	(1.419)	(3.714)
Hedonic	-0.8067	-0.1316
	(1.507)	(3.611)
Health x Hedonic	0.7433	0.7278
	(2.065)	(5.029)
Constant	72.7333***	34.1872***
	(1.005)	(2.686)
N	1200	1200

Notes: Robust standard errors in parentheses. * p < .1, ** p < .05, *** p < .01.

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