Tailoring through choice.

Comparing the effect of randomly assigned vs. self-chosen behavioural interventions in promoting healthier snack choice.

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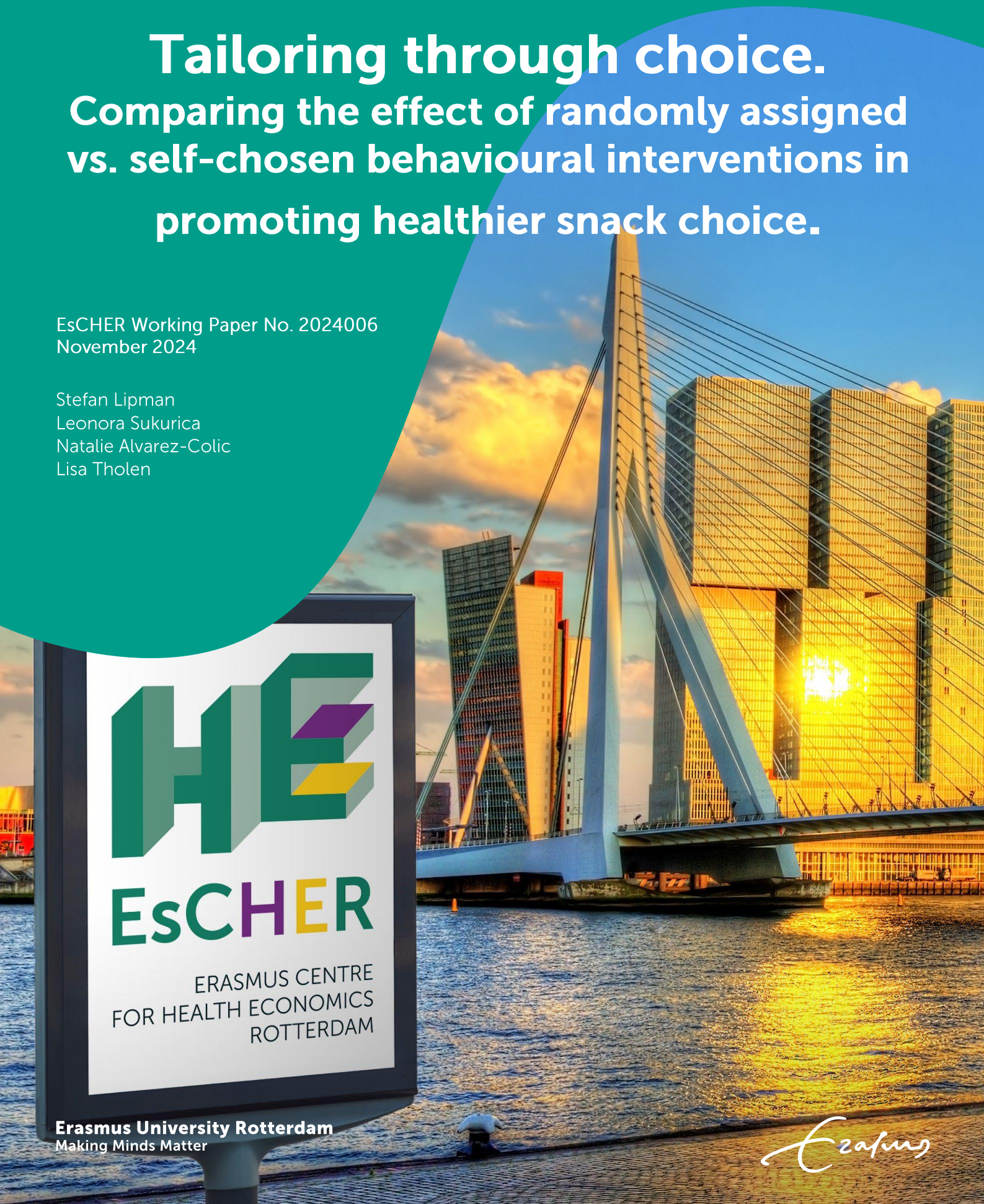

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Tailoring through choice. Comparing the effect of randomly assigned vs. self-chosen behavioural interventions in promoting healthier snack choice.

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Abstract

Objectives: Public policy seeks to encourage healthier diets through various interventions, such as small financial incentives, calorie labeling, or social-norm nudges. While some evidence suggests these interventions can promote behavior change, effects vary widely among individuals. This variability has led to interest in tailoring interventions to individuals, e.g., by allowing them to choose their preferred approach. This study investigates whether individual choice among interventions can improve effectiveness.

Methods: In a field experiment, participants chose between healthier and less healthy snacks under (n)one of three conditions: (i) a financial incentive of 10 cents for selecting the healthier snack, (ii) calorie information for both options, or (iii) a social norm message indicating that 60% of previous respondents chose healthily. A baseline measure of effectiveness is established by randomly assigning interventions to half of a sample of 839 university students, while the remainder selected and received their preferred intervention.

Results: Most participants made healthier choices across all conditions. Among those given a choice, 51%, 41%, and 8% selected financial incentives, calorie labeling, or social norms, respectively. Self-selected interventions significantly increased healthy snack choices compared to the no-intervention control. Randomly assigned interventions also increased healthy choices, though not significantly. When accounting for individual characteristics, chosen calorie labeling and social norm interventions significantly increased healthy choices, while financial incentives did not.

Discussion: Allowing participants to choose their intervention appears more effective than random assignment. These positive effects are driven by selection into calorie labeling and social norms, although participant characteristics only partially explain this effect.

Introduction

Overweight and obesity rates continue to rise worldwide, prompting many countries to implement policies and interventions to stimulate healthier food choices (Malik et al., 2020, WHO, 2022). In the Netherlands for example, such interventions often involve the provision of information (e.g. the Wheel of Five by the Netherlands Nutrition Centre, see Feunekes et al., 2020), and guiding citizens towards healthier food options (e.g. Nutri-Score on pre-packaged products in supermarkets, Ter Borg et al., 2021). However, while interventions that rely on informing people can effectively change behaviour (Cecchini and Warin, 2016), their impact can be limited (Temple, 2020), because they are based on the assumption that people have unlimited capacity to weigh information and make rational choices (van Bavel, 2020, Kuehnhanss, 2019) in a choice-context that often supports the unhealthy choice. This manifests itself, for example, in that people are not always able to resist unhealthy temptations in their environment despite intentions to eat healthy (Stok et al., 2015, WHO, 2022). For example, nearly 1/3rd of Dutch adults report unplanned purchases of unhealthy snack foods on a daily to weekly basis (CBS, 2022). Although snacking need not be unhealthy, without compensation for the associated increase in calory intake such (unplanned) snacking will likely contribute positive energy balance and overweight (Mattes, 2018). Realizing that food choices are not rational, 'nudges', i.e. non-coercive interventions relying on behavioural insights (Thaler and Sunstein, 2009), may be considered to support individuals in resisting temptations. Many examples exist, such as providing information about relevant others' consumption as a form of social proof (Venema et al., 2020, Salmon et al., 2015), but to some, such nudges are sees as manipulative (Hansen and Jespersen, 2013, Hausman and Welch, 2010) or paternalistic (Sugden, 2017). More intrusive policies, such as taxation or the use of financial (dis)incentives also seem successful in encouraging healthier food choices (Temple, 2020, Brambila-Macias et al., 2011, Nuffield Council on Bioethics, 2007), but implementing such policies may spark public debate and stiff opposition from food corporations and lobbyists and the public (Temple, 2020, Nuffield Council on Bioethics, 2007, Espinosa and Nassar, 2021, Eykelenboom et al., 2021).

In line with this heterogeneity in the acceptability of different policies to stimulate healthier food choices, the effectiveness of such policies differ between subgroups of people as well (Colchero et al., 2016, McGill et al., 2015, Egnell et al., 2020, Higgs et al., 2019, Thorndike et al., 2016). For example, interventions that influence the price of unhealthy food appear to be most effective for people with a low income (Colchero et al., 2016, McGill et al., 2015) and people with a higher education benefit more from information-based interventions (Nuffield Council on Bioethics, 2007). Not only do some people benefit less or not at all from a particular intervention, people may also experience negative treatment effects for a type of intervention, possibly hidden by an positive average treatment effect (Varadhan and Seeger, 2013). For example, calorie labelling could result in choosing foods with higher calories under people with a binge eating disorder (Haynos and Roberto, 2017); promoting healthier food choices through incentives or taxation may cause the 'crowding-out effect' (Frey and Oberholzer-Gee, 1997), where intrinsic motivation to consume healthy food can be crowded-out by extrinsic motivation; and social norm nudges could backfire due to the 'boomerang-effect' where those already the desirable behaviour regress to undesirable behaviour due to the social norm message (Cho and Salmon, 2007). These heterogenous treatment effects suggest that one-size-fits-all interventions, that are equally effective for everyone, are unlikely to exist. Instead, we may need to tailor interventions, i.e. differentiate interventions based on individual characteristics, contexts and needs (Cohen et al., 2019, Varadhan and Seeger, 2013).

Moving beyond one-size-fits-all interventions through tailoring, however, comes with a set of analytical, practical and ethical challenges. Analytical challenges include determining how exactly to operationalize tailoring to individuals' characteristics, context and needs. Methods used for example include a theoretical model, necessitating a measurement of the theory-relevant characteristics used to decide who receives which interventions and when (e.g. Lustria et al., 2013); economic theory can (Lipman, 2020) help develop interventions to match the recipient's time preferences (Woerner, 2021) or risk preferences (González-Jiménez, 2024); or data-driven machine-learning algorithms to tailor interventions to an individual's characteristics or context (Opitz et al., 2024), often employing 'just-in-time adaptive interventions' to provide the best intervention at the right moment (Nahum-Shani et al.,

2018). Practical challenges resolve around the need for reliable measurement of or data on personal or contextual characteristics, as the assignment of interventions may be ineffective due to measurement errors. Finally, ethical concerns may be raised when policy makers (using theoretical models) determine what will work best for whom without the involvement of recipients (Nuffield Council on Bioethics, 2007), or relegate that decision to data-driven algorithms in contexts where some individuals may be algorithm-averse (Burton et al., 2020). Given these challenges, a potentially more feasible way of tailoring interventions is enabling individuals to choose their own interventions.

In the context of stimulating healthier food choices, it has been shown that preferences for food policies tend to differ between people (Dieteren et al., 2023, Lancsar et al., 2022, Morley et al., 2012). For example, although less intrusive interventions are favored on average (Dieteren et al., 2023), yielding a preference for calorie-labeling over policies involving incentives or taxation –some groups of respondents were in favor of all types of interventions whereas others where explicitly against all types of interventions. Yet, although it is clear that preferences for, and expectations of, effectiveness of food interventions differ between people (Dieteren et al., 2023), it is unclear if providing people with their preferred food intervention leads to better effectiveness. On the one hand, choice can provide people with a sense of autonomy, one of the driving forces of intrinsic motivation according to the self-determination theory (Deci and Ryan, 2008), which subsequently may lead to a higher effectiveness of the chosen intervention. Choice can also be a tool that helps individuals find out what works for them, in a process enabling a process of explorative self-experimentation (Fedlmeier et al., 2022). On the other hand, choice-based interventions could result in people choosing an ineffective measure for themselves, for example, due to an overestimation of own abilities in choosing an intervention (Kim et al., 2016), a low awareness of the lack of self-control that might cause unplanned snacking (Hey and Lotito, 2009), or a tendency to opt for an ineffective but attractive interventions (e.g. akin to the search for quick fixes for weight loss, that often do not lead to long term success, e.g. Franz (2001)). A meta-analysis by Carlisle et al. (2022) found that choice-based interventions for a wide range of health behaviours result in significantly less participant drop-out and increased adherence compared to interventions not offering choice, but the effect of choice-based interventions on behavioural change is still unclear (Carlisle et al., 2022). Some studies that explored the effect of choice on behaviour change have focused on different versions of the same policy (i.e. different types of financial incentives, Lipman, 2020, Lipman et al., 2023, Woerner et al., 2021), but it is not clear what the effect of choice is between different policies altogether (e.g. between financial incentives or information).

Therefore, this study investigates the preferences for different types of interventions that stimulate healthier food choices and explores the effect of assigning individuals their preferred food choice interventions compared to randomly assigned interventions without choice. For this purpose, three interventions, demonstrated to be effective in existing work, were selected and implemented to promote healthier food choices in a field experiment: i) providing information on calory labelling (Cecchini and Warin, 2016), ii) financial incentives (Purnell et al., 2014) and iii) social norm nudges (i.e. providing information about others' food choices, Robinson et al., 2014). The field experiment was implemented on a Dutch university campus, where a total of 839 respondents were offered a choice between a healthy and a unhealthy snack – where the aim of interventions was to promote healthier snack choices. The study used what is sometimes referred to as a doubly-randomized control trial design (Delevry and Le, 2019), which enables testing both the effect of choice as well as the effect of different types of interventions. That is, respondents are assigned to a *random condition* or a *choice condition,* where in the former they are randomly assigned to different 'treatments' (in this case interventions) and in the latter they themselves choose from the same 'treatments'. This design enables the identification of three basic contrasts, which are each explored separately. First, by comparing snack choice between all respondents that were randomly assigned an intervention to those who chose interventions, we identify the overall effect of choosing interventions (*Contrast 1: Choice vs. Random)*. Second, within the randomly assigned respondents we identify if each of the interventions are effective, as within this group effectiveness will not be affected by self-selection of individuals into different types of interventions (*Contrast 2: Randomly assigned interventions)*. Third, by comparing the characteristics of those selecting interventions when offered that opportunity compared

to those randomly assigned the same interventions, we can identify if selective sorting takes place (i.e. if people with specific characteristics prefer specific interventions). Furthermore, we compare the effectiveness between chosen and assigned interventions within intervention types (*Contrast 3: Chosen vs. randomized interventions*).

Pilot study

Before conducting the field study, a pilot study was conducted between April and May 2023. The pilot study had three aims: i) determining which healthier and unhealthier snacks were feasible for the main study, ii) collecting data to inform the social norm nudge, such that the social norm communicated in the main study fit the target population, and iii) providing some insight into the effects of choice as well as the three interventions to inform sample size calculations. All data was collected by two graduate respondents using Qualtrics. Respondents for the pilot were recruited from the general public and were all at least 18 years or older, with no specific inclusion or exclusion criteria being applied. A convenience sampling strategy was used, where respondents were mainly recruited on the campus of the Erasmus University Rotterdam, as well as the campus of the Delft University of Technology. The data collection took place during lunchtime, at places where people have lunch. A total amount of 127 respondents were included in this study of whom the majority (65.4%) were between the ages of 18 and 24. The sample had an approximately equal gender distribution between men and women, with the slight majority of respondents identifying as male. The pilot was ran with two possible food combinations with pairings based on having a similar price per pair. We also considered it important that snacks were packaged such that they need not be immediately consumed, as we wanted to avoid food waste as well as avoid consumption of snacks in respondents that were not currently inclined to eat. The snacks used were i) Food combination A: single mandarin vs. a snack-sized (18 gram) candy bar (e.g. Mars) with an approximate price of ~0.20 euro, and ii) Food combination B: 70 grams of grapes (packaged in plastic bags) vs. a small bag of Lays potato chips (40 grams), with an approximate price of ~0.40 euro. Interventions were operationalized as described in Table 1 (see also Appendix A). The pilot was implemented with a doubly randomized control trial design, i.e. respondents were randomly assigned to a control and a choice condition, which determined if they would be randomly assigned interventions or chose between them (see Figure 1).

Table 1: Operationalisation of calorie labelling, financial incentive and social norm information intervention for Food combinations A and B

Intervention	***Food Combination A***	***Food Combination B***
Calorie labelling (Label: 'Being shown the calories of both options')	Mandarin: ~28 calories per fruit Candy bar: ~94,8 calories per piece (on average)	Grapes: ~54,8 calories per bag (= 70 grams) Lays chips bag: ~235,4 calories per bag
Financial incentives (Label: 'Receiving money if I choose the healthy option')	'If you choose the fruit you will receive 10 cents'	'If you choose the fruit you will receive 10 cents'
Social norm information (Label: Being told how other students chose in a similar study)	'In a similar experiment to this one, 40% chose the healthy option'	'In a similar experiment to this one, 40% chose the healthy option'

Note: The social norm information was based on a previous study by Zhang et al. (2024), who ran a lab-based study on snack choice with students on the same campus.

The graduate students collecting the data recruited respondents for a study on food choice, where they checked for food allergies or other dietary wishes before assigning snack pairs. If respondents had no dietary wishes, snack pairs were randomly assigned. In case one of the snacks was precluded due to their dietary wishes (e.g. nut allergies and being vegan preclude candy bars), the alternative was assigned. Respondents reported how hungry they were (before any snack choices), and afterwards were asked to state their hypothetical preference between snack choices. Next, they were informed that the Dutch government can consider different interventions on food choice. In the random condition they were informed that one of the discussed interventions would be implemented, whereas in the

choice condition they received the following instructions*: Imagine if we would implement an intervention to encourage you to pick the healthier option. Which of the following interventions would be most effective for you?* They were asked to choose from the 3 interventions in Table 1 (with the description being identical to the 'Label' in Table 1). Then, respondents were asked again to indicate their preference between the same snack choice. Respondents received the snack item that they picked in this second choice, as well as receiving a 0.10 cents if they were assigned or chose financial incentives.

Figure 1. Doubly randomized control trial design used in pilot study

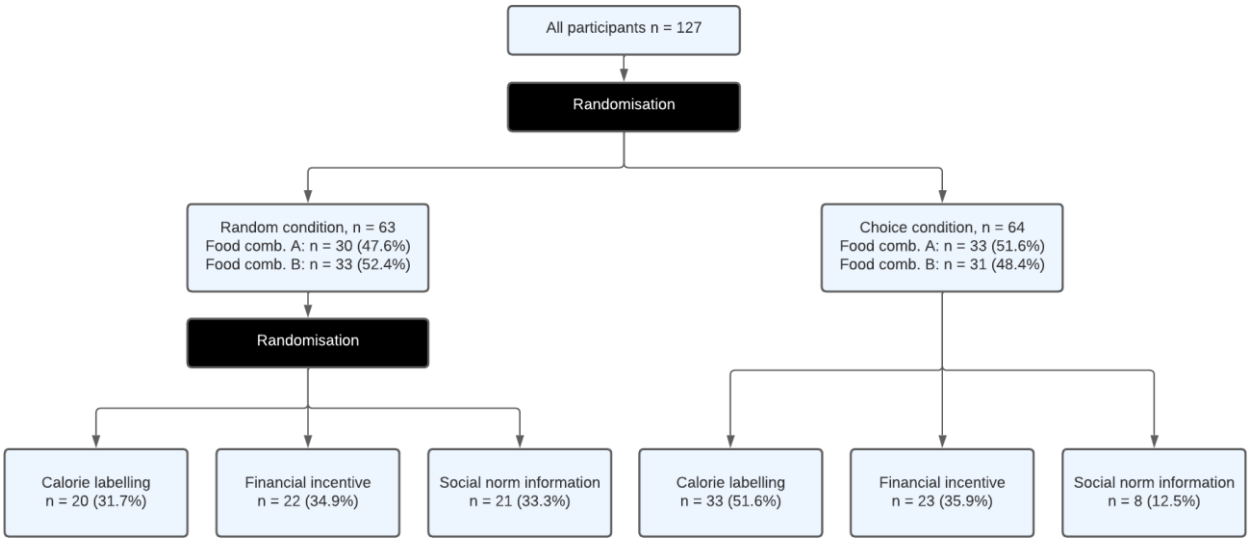

Figure 1 shows the distribution of respondents across conditions and interventions. It shows that respondents given the opportunity to choose are disproportionally likely to choose calorie labelling, whereas social norm information is not chosen frequently. Snack pairings should result in sufficient heterogeneity such that intervention effectiveness can be identified (e.g. if nearly all respondents prefer grapes, no interventions are 'needed'). Overall, most respondents, when asked to state a hypothetical preference between healthy and unhealthy food items preferred healthy snack foods. Food combination A yielded 56.2% healthy choices and Food combination B yielded 77.2% healthy choices. Many respondents were unaffected by interventions, a total of 82 out of 127 (64.5%) respondents chose the healthy food item both with and without interventions. Interestingly, only a single student changed from preferring unhealthy food to healthy food after being randomly assigned an intervention (social norms), compared to a total of 11 respondents with the same combination while choosing an intervention (unhealthy without intervention, healthy with interventions). In line with the distribution across the chosen interventions, 7 out of those 11 had chosen calorie labels, 2 had chosen incentives and 2 had chosen social norms. As such, key learnings of the pilot were: i) the chosen food combinations provided reasonable heterogeneity in preferences between healthy and unhealthy food items, ii) some differences exist in preferred interventions, and iii) randomly assigned interventions were ineffective, chosen interventions promoted healthier choices in 11 out of 64 respondents (17%).

A few operational changes were included to improve the design of the main study. In the pilot, no control condition was included: respondents' initially preferred snack without intervention was treated as a control. Yet, this preference was hypothetical, whereas choices with interventions in place were incentivized. Additionally, respondents may have anchored on their initial choice, decreasing the potentially effectiveness of interventions. As such, the main study implemented a no-intervention control to better identify effects of interventions and choice. Furthermore, in reflecting on the data collection it became clear that many respondents did not accept the 0.10 cents incentive when offered it by the experimenter. This could have at least two interpretations: i) choosing for incentives means that respondents opt out of interventions, as they are actually choosing not to receive anything, and ii)

receiving the financial incentive involves some transaction costs, which outweigh the value of the incentives. Increasing the size of incentives (e.g. to 0.50 euro) may help offset transaction costs but this would quickly imply the use of incentives that are higher than the price of the food products themselves. As such, we tried to ensure that no transaction costs were involved with receiving the incentive, the main study was set-up such that the incentive was received together with the healthy snack (taped to the product). Finally, rather than relying on the Zhang et al. (2024) study, which included different food items and identified a lower proportion of healthier choices than our study, the social norm information was updated based on the pilot to: 'In a similar experiment more than 60% of people chose the healthy option'

Field study

Experimental design & Procedure

Figure 2 shows the experimental design used for the field study: a doubly randomized trial including a control condition. Note that the control condition was implemented in the random arm, i.e. some respondents were randomly assigned no intervention. To avoid offering respondents the opportunity to opt-out, we decided not to include a no-intervention control in the choice condition. The experimental procedure was similar to that of the pilot study, albeit the field study included additional measures to explore a set of characteristics that may be associated with self-selection into different interventions (see 'Measures'). Given that a control condition was included, no hypothetical choice between food items was included. The framing used to introduce (choice between) interventions remained identical

Sample (size) & Recruitment

The sample size for the field study was informed by the results of the pilot. That is, based on an a priori power analysis ran with the *pwr package* in RStudio, with a recommended statistical power of 0.8 and a significance level of 0.05, and a small to medium effect size (Cohen's h = 0.40)[1] recommends a minimum sample size of n=98 based on binomial tests (with two populatiosn). As such, we decided to recruit 800 respondents, equally distributed across the random and choice condition. This ensured that approximately 100 respondents would be allocated to the interventions and no-intervention control, providing slightly higher power than the pilot suggested was necessary. In line with the pilot, recruitment took place on Erasmus University Rotterdam's campus as well as the university campus in The Hague. Data collection took place between October 2023 and December 2023, was paused in January (to avoid New Year's resolutions affecting snack choices) and was resumed in February 2024. Unfortunately, given that participation was anonymous, we were unable to exclude respondents who completed the pilot study (or to avoid double-participation in the main study).

Measures

Before making their snack choices, respondents reported their hunger (on a scale from 1: Extremely hungry to 9: Extremely full). All other measures were completed after the respondent received an intervention (if not in control-group), chose a snack, and the experimenter handed respondents the chosen snack. Besides basic demographics, which included age (in years), gender, weight and height, measures included self-reported behaviours, as well as a set of concepts broadly clustered as economic, psychological and intervention-related. Note that, seeing as we provided no other incentive for survey completion than the snack individuals' chose, we intended for the survey to be possible to complete within 5-10 minutes.

Self-reported behaviours

We obtained self-reported measures of diet quality ('How healthy would you rate your current diet?' with answering scale ranging from 1: Very unhealthy to 7: Very Health), fruit and vegetables

[1] The pilot suggested that in the choice condition 17% changed from healthy to unhealthy snacking, while in the random condition only 1 out 63 showed behaviour in this direction. We interpreted this as chosen interventions having a 16 p.p. higher chance of being effective than random interventions. Cohen's h effect sizes depend on the baseline probability, but averaging between 0-84% baseline probability increases of 16 p.p. yield Cohen's h effect sizes between 0.32-0.8 (with mean effect size Cohen's h = 0. 40)

consumption ('How often do you eat fruit/vegetables' with answering scale ranging from 1) Never, to 5) At least once a day)), and exercise ('How often do you exercise on average (e.g. sport or physically active pastime?' with answering scale ranging from 1: Never to 5: More than 5 hours per week). These questions adapted from the European Health and Behaviour Survey (Wardle and Steptoe, 1991).

Economic concepts

First, demand for commitment was measured, in line with questionnaire-based methods implemented in Lipman et al. (2023). That is, respondents were asked: *'Imagine you have made plans to invest some amount of effort on a task you would normally not enjoy much, but has benefits in the future, for example: exercising, doing taxes, going to the doctor/dentist. To make sure you actually stick to your plan next week, you are offered to pay a small deposit. That is, you can pay €5 that you will receive back in full if you indeed stick to your plan (i.e., go exercise, do the taxes, visit the doctor), but is lost if you forget or postpone. Would you pay this deposit?'*. Respondents could respond on 5-point answering scale (1: Yes, absolutely, 2: Yes, probably, 3: I'm not sure, 4: No, probably not, and 5: No absolutely not). Respondents with scores of 1 and 2 are considered to have a demand for commitment. Furthermore, three statements were included to measure economic preferences, adapted from (Drichoutis and Vassilopoulos, 2021). That is, we measure risk preference (I am generally a person who is fully prepared to take risks) and time preferences (I am generally an impatient/impulse person), each scored on a scale from 1-5 (Strongly disagree to strongly agree).

Psychological concepts

Attitudes towards the food products were measured with the following question: 'Based on taste, how would you rate the healthy/unhealthy option that was provided to you', scores from 1) Very distasteful to 7) Very tasteful. Need for autonomy was measured with a scale inspired by the Health Causility Orientations Scale developed in Altendorf et al (2019). It asked respondents they agreed on a scale from 1-5 (Strongly disagree to strongly agree) with the following statements: i) If I had to change my behaviour to get healthier, I would motivate myself, ii) If I had to change my behaviour to get healthier, I would ask family and friends to motivate me, iii) If I had to change my behaviour to get healthier, I would ask an expert to motivate me, iv) If I had to change my behaviour to get healthier, I would wait to get motivated eventually. The agreement on the first statement captures autonomy orientation, i.e. the need for autonomy. The second and third signal controlled orientation and the fourth statement signals impersonal orientation. Finally, health motivation was measured by asking respondents, following Croker et al. (2009), their agreement, on a scale from 1-5 (Strongly disagree to strongly agree), to the statement: 'The effect of fruit and vegetables on my health is important to me'.

Intervention-related concepts

A single statement related to individuals potential preference for or response to each of the three interventions was adapted from earlier work, with respondents reporting their agreement on a scale from 1-5 (Strongly disagree to strongly). For simplicity, we will interpret these as susceptibility to the interventions. The statement capturing susceptibility to calorie labelling was '*I spend time looking at nutritional labels while shopping for my food'*, adapted from Ellison et al. (2013). The statements capturing susceptibility to financial incentives and social norms were: '*The cost of fruit and vegetables is important for me'* and *'The amount of fruit and vegetables other people eat is important to me'*. Both statements were adapted from Croker et al. (2009), respectively.

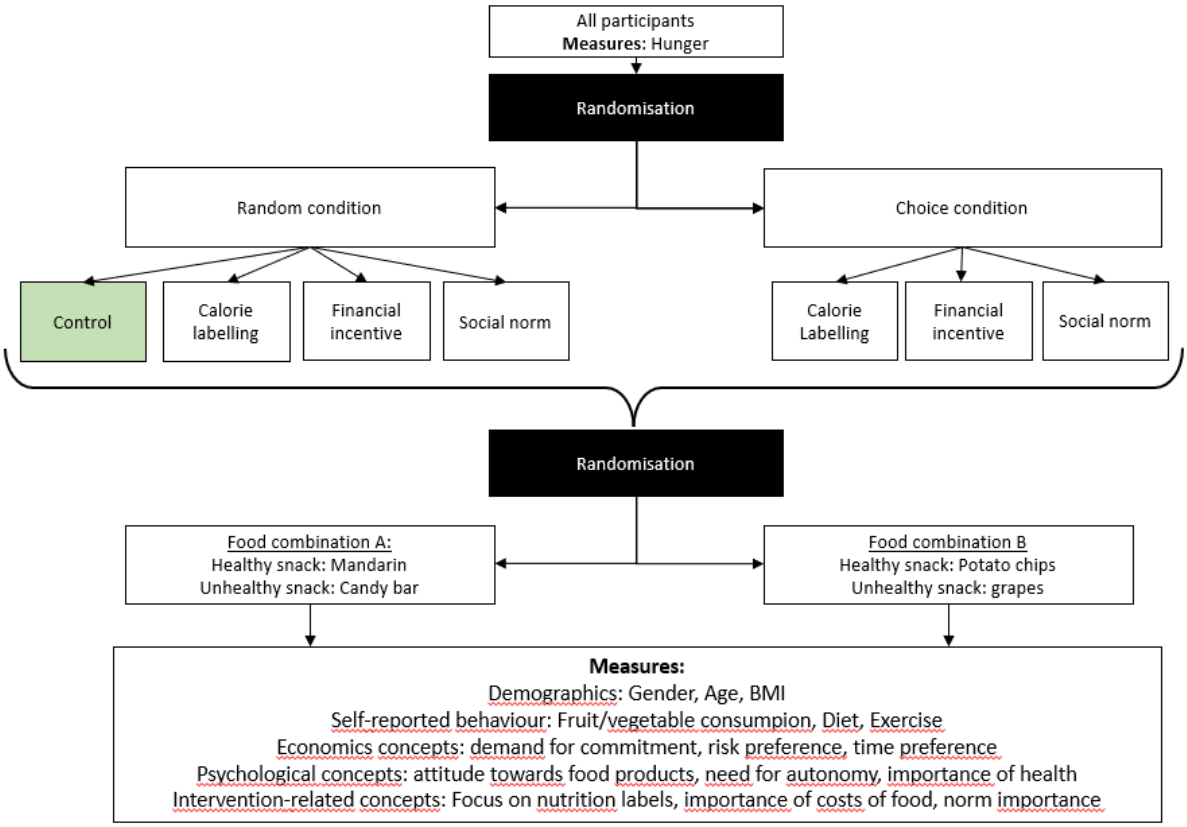

Figure 2. Design and included measures for field study

Data-analysis

The data analysis of the field study's data follows the three contrasts the doubly randomized control trial enables. To test Contrast 1 (Choice vs. Random) we compiled choices across Food Combination A and B and used Chi-squared tests to determine if the proportion of healthier choices differed between respondents who chose interventions, were randomly assigned an intervention, or were randomly assigned no intervention at all. Contrast 2 (*Randomly assigned interventions)* was also tested with Chi-squared tests, comparing the proportion of healthier choices between the control condition and randomly assigned interventions. Finally, Contrast 3 (*Chosen vs. randomized interventions*) was studied with two sets of analyses. First, we compared outcomes on the measures included between respondents selecting into three interventions in the experiment using a set of univariate tests (i.e. ANOVAs or Chi squared tests). Note that we rely on univariate tests here because the number of measures is quite large compared to the sample size, meaning that multivariate regression models would likely be uninformative. These univariate analyses provide an indication of which types of individuals self-select into particular interventions, but cannot rule out that some measures may capture similar variation. In the final analyses we compare the effectiveness of these interventions for those self-selecting to those that were randomly assigned. That is, we report the results for binomial tests comparing the proportions of healthier choices between respondents in the random and choice condition within each intervention. To explore if having a choice, rather than self-selection by specific types of respondents, influences the effectiveness of interventions, we also report a set of logistic regressions (per intervention) with snack choice (unhealthy vs. health) as the dependent variable, random vs. choice as independent variable and include characteristics that are univariately associated with self-selection as independent variables as well to control for them.

Results

Sample demographics

Descriptive statistics for the sample are shown in Table 1, which shows that the sample slightly overrepresents females and is generally quite young. Respondents generally consume fruits and vegetables on a daily basis, get a reasonable amount of exercise, and have a healthy BMI. Interestingly, average attitude towards healthy food is more positive than towards unhealthy food, respondents report a small but significant difference between the two food items ($t(725)=4.28$, $p<0.001$). In line with the timing of the data collection collected around lunch, respondents were on average neither hungry or full. Importantly, randomization appeared successful, as no differences were observed in these sample demographics. It is also worth nothing that more missing data is observed for question asked alter in the survey.

Distribution across interventions and main descriptive result

Figure 3 summarizes the main descriptive results of the study, i.e. it shows how respondents were distributed across the interventions depending on their condition, as well as reports the proportion of healthy snack foods chosen in the study (choice frequencies across conditions are reported Table A1 in the Appendix). The sample was slightly skewed towards respondents in the random condition (which includes the no-intervention control), but we found no evidence against independence with a Chi-square test ($p=0.16$). Respondents randomized to interventions were, as expected, roughly equally distributed across interventions, with slightly (but not significantly: Chi square = 2.92, $p=0.43$) fewer completing the study in the no-intervention control. Respondents that could choose their own intervention were most inclined to choose a financial incentive, followed by the calorie labelling intervention. Only very few (30 out of 399) self-selected into social norm information. Visual inspection of Figure 3 suggests that the proportion of healthy choices slightly increases from control (59.4%) to randomly assigned interventions (66.6%) and self-chosen interventions (69.7%)

Contrast 1 (Choice vs. Random) & Contrast 2 (Randomly assigned interventions)

Overall, when comparing the distribution of healthy and unhealthy choices (see Figure 3) between the choice and random conditions, we find no evidence against independence (Chi-squared = 3.83, p value = 0.15). Similar conclusions are reached when comparing the proportion of healthy choices between the control condition and random condition (Chi-squared = 1.41, p value = 0.23). When comparing the proportion of healthy choices between no-intervention control and self-chosen interventions, some evidence against independence is found (Chi-squared = 3.29, p value = 0.07), suggesting respondents are more likely to choose healthier snack items when they can choose their own intervention, compared to no intervention at all (a result substantiated by logistic regressions reported in Table 4 – model 1). Although individuals receiving small financial incentives, calorie labelling and social norm interventions were ~11, 7 and 4 pp. more likely to choose a healthy snack than in cases where no interventions were present. Chi-squared tests comparing the effectiveness of interventions within the random arm to control provide no evidence against independence (Chi squareds <2.37, all ps>0.12). A logistic regression suggests that the effect of financial incentives trends towards significance (Table 4 – model 2).

Contrast 3 (Chosen vs. randomized interventions

Table 3 shows results of univariate analyses for all demographics with the chosen intervention as dependent variable. We find evidence for selection effects for the following variables: age, diet, demand for commitment, attitudes towards the healthy food, need for autonomy and susceptibility to calorie labelling and financial incentives. As can be seen in Table 3, respondents selection incentives and social norms seem younger than respondents selecting calorie labelling. Financial incentives are preferred by those with on average lower BMI and calorie labelling are preferred by those with an average higher BMI. The (small) group of respondents choosing norms has a relatively low diet quality, is unlikely to demand commitment, has the least positive attitude towards healthy food, and has the lowest need for autonomy. Self-rated susceptibility seems to follow selection into interventions: respondents with the highest agreement that they look at calorie labels when shopping chose the calorie labelling, and respondents with the highest agreement that the price of food is important are inclined to select into financial incentives. In order to determine if the effect of choice occurs through such selective sorting, we ran logistic regressions in which all concepts above are also

included as independent variable and thus controlled for, see Table 3. These analysis suggest that respondents choosing calorie labels (model 3[d]) and social norms (model 3d) are significantly more likely to choose healthier foods. We find no evidence against differences between chosen and assigned interventions (models 4-6). For all models, the sign and significance of effects of choice does not change/diminish between models (models 1, 3-6) with and without demographics (1d, 3d-6d). Some main effects related to the demographics are worth mentioning. Older respondents were more likely to select healthier food items. This trend is marginally significant when using all data (model 1d), and seems driven by respondents in the financial incentive condition (model 5d). Those with healthier diets more likely choose healthier snacks (model 1d), particularly those self-selecting in the calorie labelling intervention (model 4d). Demand for commitment is negatively associated with healthy food choice (in most models), significantly so only for respondents selecting into calorie labelling interventions (model 4d). Unsurprisingly, positive attitudes towards healthy food are a strong and significant predictor in all models. Finally, we find a trend for higher proportions of healthy snack choices in respondents who more strongly agree that they look at calorie labels (susceptibility: calorie labelling).

Figure 3. Proportion of healthier snack choices by condition and intervention.

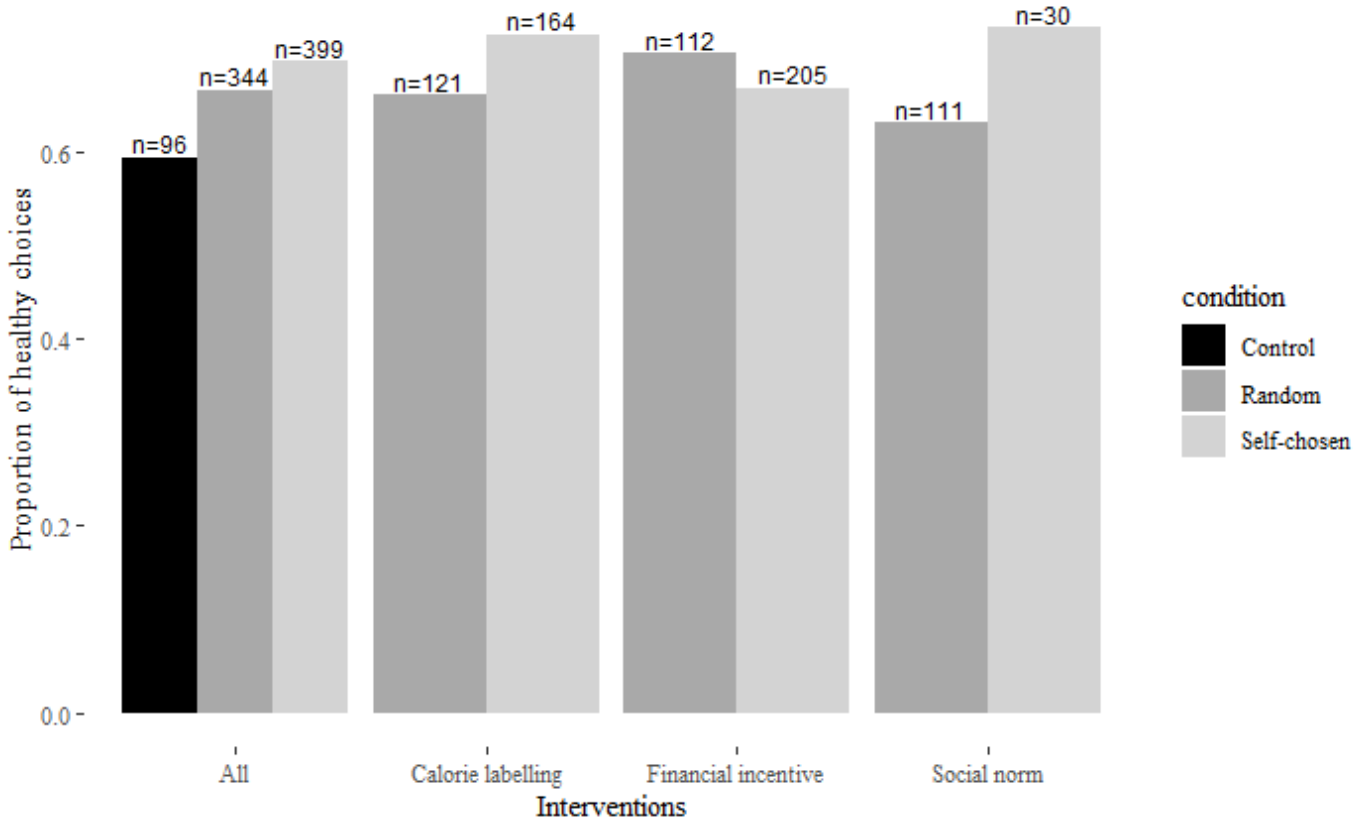

Table 1. Sample demographics (including split by condition)

	n[a]	Full sample **n=839**	**Choice** condition **N=440**	**Random** condition **N=399**
Age - M (SD)	725	21.9 (4.55)	21.76 (4.65)	22.02 (4.47)
Gender	726			
Female		483 (57.6%)	213 (53.4%)	270 (61.4%)
Male		226 (26.9%)	113 (28.3%)	113 (25.7%)
Other		17 (2%)	9 (2.3%)	8 (1.8%)
Hunger - M (SD)	839	4.31 (1.81)	4.32 (1.8)	4.31 (1.82)
Diet - M (SD)	795	4.96 (1.77)	4.95 (1.76)	4.98 (1.79)
Attitude: healthy - M (SD)	773	6.79 (1.29)	6.76 (1.3)	6.82 (1.29)
Attitude: unhealthy - M (SD)	748	6.49 (1.45)	6.52 (1.4)	6.47 (1.5)
Fruit consumption	795			
At least once a day		420 (50.1%)	183 (45.9%)	237 (53.9%)
Every 2 or 3 days		249 (29.7%)	119 (29.8%)	130 (29.5%)
About once a week		89 (10.6%)	45 (11.3%)	44 (10%)
Less than once a week		29 (3.5%)	14 (3.5%)	15 (3.4%)
Never		8 (1%)	5 (1.3%)	3 (0.7%)
At least once a day		581 (69.2%)	265 (66.4%)	316 (71.8%)
Vegetable consumption	795			
Every 2 or 3 days		163 (19.4%)	79 (19.8%)	84 (19.1%)
About once a week		39 (4.6%)	17 (4.3%)	22 (5%)
Less than once a week		10 (1.2%)	5 (1.3%)	5 (1.1%)
Never		2 (0.2%)	0 (0%)	2 (0.5%)
Exercise	795			
Never		37 (4.4%)	21 (5.3%)	16 (3.6%)
Less than 1 hour per week		107 (12.8%)	54 (13.5%)	53 (12%)
1-3 hours per week		265 (31.6%)	123 (30.8%)	142 (32.3%)
3-5 hours per week		220 (26.2%)	95 (23.8%)	125 (28.4%)
More than 5 hours per week		166 (19.8%)	73 (18.3%)	93 (21.1%)
BMI - M (SD)	718	22.34 (3.11)	22.33 (3.23)	22.35 (3.01)

Note: a: complete observations reported for the full sample to illustrate missingness across the different survey questions

Table 2. Descriptive and frequency statistics for respondents choosing calorie labelling, incentives and social norm interventions

	Calorie labelling n=164	**Financial incentive** n=205	**Social norm** n=30		
				Sig.	n
Demographics					
Age– M (SD)	22.71 (6.14)	21.08 (3.08)	21 (2.26)	**	334
Sex: Female (%)	82 (50%)	114 (55.6%)	17 (56.7%)		335
BMI– M (SD)	23.04 (3.59)	21.7 (2.79)	22.66 (3.1)	**	328
Self-reported behaviour					
Hunger – M (SD)	4.39 (1.71)	4.2 (1.91)	4.8 (1.40)		399
Diet – M (SD)	5.06 (1.8)	4.95 (1.72)	4.23 (1.77)	+	366
Eats fruit daily (%)	77 (47%)	94 (45.9%)	12 (40%)		366
Eats vegetables daily (%)	112 (68.3%)	134 (65.4%)	19 (63.3%)		366
Exercises > 3 hours/week (%)	77 (47%)	81 (39.5%)	10 (33.3%)		366
Economic concepts					
Demands commitment (%)	77 (47%)	99 (48%)	6 (30%)	*	338
Risk preference – M (SD)	3.31 (1.12)	3.36 (1.01)	3.35 (1.07)		332
Time preference: impatience - M (SD)	3.35 (1.11)	3.17 (1.11)	3.13 (1.25)		338
Time preference: impulsiveness - M (SD)	3.17 (1.21)	3.12 (1.18)	3.13 (1.25)		329
Psychological concepts					
Attitude healthy food – M (SD)	6.69 (1.45)	6.89 (1.09)	6.26 (1.56)	+	355
Attitude unhealthy food – M (SD)	6.61 (1.45)	6.61 (1.4)	6.47 (1.5)		349
Need for autonomy – M (SD)	4.2 (0.77)	4.01 (0.88)	3.78 (0.67)	*	331
Controlled orientation – M (SD)	3.28 (1.03)	3.16 (1.07)	3.15 (0.84)		331
Impersonal orientation – M (SD)	2.99 (1.26)	2.89 (1.32)	2.96 (1.36)		332
Health motivation – M (SD)	4.38 (0.88)	4.34 (0.82)	4.26 (0.62)		331
Intervention-related concepts					
Susceptibility: calorie labelling– M (SD)	3.46 (1.31)	2.9 (1.39)	3.22 (1.35)	**	331
Susceptibility: financial incentive– M (SD)	3.7 (1.18)	4 (0.95)	3.91 (1.12)	*	329
Susceptibility: social norm– M (SD)	2.76 (1.22)	2.59 (1.19)	2.7 (1.15)		331

Note: +,*,**,*** signify *p<0.10*,<0.05, *<0.01 and <0.001* respectively, in ANOVA tests (for continuous variables, reported with M (SD)) and Chi-squared tests for nominal/ordinal variables (reported with %).

Table 3. Logistic regressions with the healthy food choice as dependent variable.

	1 All data	2 Random	3 Choice	4 Calorie	5 Incentive	6 Norm	1d All data	3d Choice	4d Calorie	5d Incentive	6d Norm
Choice	0.45 (0.23)+			0.30 (0.26)	-0.17 (0.25)	0.48 (0.46)	0.64 (0.28)*		0.53 (0.32)	-0.18 (0.33)	0.70 (0.65)
Random intervention	0.30 (0.24)						0.39 (0.28)				
Calorie labelling		0.29 (0.28)	0.59 (0.27)*					1.24 (0.61)*			
Financial incentive		0.49 (0.29)+	0.32 (0.25)					0.47 (0.31)			
Social norm		0.16 (0.29)	0.63 (0.46)					0.88 (0.34)*			
Control variables											
Age							0.04 (0.02)+	-0.002 (0.03)	0.04 (0.04)	0.09 (0.05)+	0.12 (0.08)
BMI							-0.01 (0.03)	0.03 (0.04)	-0.04 (0.04)	-0.04 (0.06)	0.04 (0.08)
Diet							0.10 (0.06)+	0.17 (0.08)*	0.16 (0.10)*	-0.06 (0.11)	0.02 (0.14)
Demands commitment							-0.28 (0.19)	-0.22 (0.26)	-0.69 (0.34)*	0.14 (0.32)	-0.55 (0.48)
Attitude healthy							0.62 (0.08)***	0.72 (0.11)***	0.53 (0.13)***	0.88 (0.17)***	0.66 (0.22)**
Need for autonomy							0.07 (0.12)	-0.003 (0.10)	0.34 (0.23)	-0.05 (0.20)	0.17 (0.30)
Susceptibility: calorie labelling							0.12 (0.07)+	0.08 (0.12)	0.09 (0.13)	0.10 (0.12)	0.06 (0.16)
Susceptibility: social norm							0.06 (0.08)	0.10 (0.16)	0.11 (0.14)	0.14 (0.16)	0.22 (0.19)
Sample size	**839**	**399**	**495**	**285**	**317**	**141**	**245**	**393**	**232**	**251**	**121**
AIC	**1063.7**	**574.7**	**625.7**	**351.7**	**400.3**	**185.0**	**767.7**	**434.9**	**257.1**	**276.7**	**149.7**

Note: +,*,**,*** signify *p<0.10,*<0.05, *<0.01 and <0.001* respectively. Models 1(d)-3(d) use the control condition as baseline. Models 4(d)-6(d) are run on respondents that received one of the three interventions and take randomly assigned interventions as baseline.

Discussion

This study investigated the effectiveness of three types of interventions (calorie labelling, financial incentives and social norm nudges) to promote healthier snacking and compared the effectiveness of those interventions between individuals randomly assigned and those who selected interventions themselves. In a field experiment conducted on university campuses, we find that high proportions of respondents (~60%) prefer healthier over unhealthier snacks, even without interventions. Overall, self-chosen interventions significantly increase the proportion of healthy snack choices compared to no-intervention control, whereas, randomly assigned interventions increase the proportion of healthy choices but not significantly so. This result is in line with earlier work showing beneficial effects of choice-based interventions (Lipman et al., 2023; Carlisle et al., 2022). Interestingly, despite random assignment to conditions, fewer respondents completed the study in the choice condition compared to the random condition (albeit not significant). Earlier work suggested that choice-based interventions have less participant drop-out and higher adherence and do not always translate to beneficial effects of choice (Carlisle et al., 2022), but our findings seem to point in the opposite direction. A potential explanation for this discrepancy lies within the short duration of our field experiment, which involved only a single snack choice. By asking respondents to choose between intervention, complexity may have increased, which might have contributed to drop out in the short term. If, as in most lifestyle interventions, chosen interventions are implemented on longer timeframes, the autonomy this enables and its' associated increase in motivation may stimulate adherence (among those that did not drop out). Alternatively, the specific intervention choices presented may not have resonated with all respondents (as found in Dieteren et al. (2023), where certain groups of respondents opposed all types of listed interventions), potentially backfiring the positive effect of adherence for choice.

In the (pilot and) field experiment reported in this manuscript, we relied on interventions for which evidence suggests they are effective to promote individual healthy food choices (Purnell et al., 2014). Our study, through its' random condition adds to this evidence base, as comparing randomly assigned interventions to the no intervention control allows estimating a causal effect related to the interventions (contrast 2). Indeed, when we randomly assigned these interventions to respondents to promote healthier snack choices, the proportion of healthy snack choices was higher for all three interventions. Yet, this difference was only (marginally) significant for the financial incentive intervention, suggesting that the causal effect of calorie labelling and social norms is zero (or smaller than our study was powered to detect). Previous work aligns with our positive result for financial incentives to change dietary behaviour, whereby higher effects are found for larger incentives (Purnell et al., 2014). The financial incentive used in our study was small in absolute terms (previous work has used amounts such as 14 dollar per percentage of weight loss after a few months, e.g. Purnell et al., 2014, rather than the 0.10 euro we relied on). However, respondents were only making a single snack choice between products of 0.20-0.40 euro value, meaning that the incentive was a considerable intervention in relative terms. It is worth exploring how larger (e.g. 1 euro), but perhaps even more so, smaller financial incentives for healthier snack choices affect decision-making (e.g. 0.01 euro). Understanding the effect of smaller financial incentives, in particularly when used over a prolonged timeframe (such as those used by Bachireddy et al. (2019) for physical activity), will likely provide relevant for extending our results to practice.

The lack of effects for the randomly assigned interventions of calorie labelling and social norms contrasts with previous work. Two potential explanations may account for the lack of effects for the randomly assigned calorie labelling condition. First, respondents might have had difficulty to put calorie content into perspective and to determine whether the given amount represents a high calorie value (for an unhealthy snack), especially since only calorie information was provided without additional nutritional details. As such, a traffic light system has been shown to be more effective in promoting healthy choices through food labelling (Cecchini and Warin, 2016). Second, due to the small serving size the participants were offered, participants might anticipated beforehand the calories in the unhealthy snack were higher than the actual amount, which could have influenced them to opt for the unhealthy choice (Tangari et al., 2019). Similarly, two potential explanations might have led to the ineffectiveness of the social norm message for the random condition. First, the proportion choosing the healthy option in the social norm message was relatively low at 60%, compared to

previous studies that used percentages such as 80% (Robinson et al., 2014). Second, a boomerang effect may have influenced some respondents, leading respondents to react against perceived pressure to conform to the social norm message by choosing the opposite behaviour (Cho and Salmon, 2007).

Our study, by offering respondents the option to choose between interventions, also allows studying the type of interventions respondents prefer and expect will help them (i.e. contrast 3). While less intrusive policies are generally favoured (Nuffield Council on Bioethics, 2007, Dieteren et al., 2023, Lancsar et al., 2022), most respondents in this study chose the more intrusive intervention, i.e. financial incentive. Two possible explanations may account for this preference. First, earlier work studying preferences for intervention types usually explores this within the context of policies enacted by public bodies, and, as such, involves implementation of policies on long timeframes. This experiment is framed on a much shorter timeframe, i.e. it asks respondents what intervention would help them for one snack choice. Second, allowing participants to choose may have provided them with a sense of control, making them more open to interventions that might otherwise are experienced as imposed. The choice for different interventions based on intrusiveness might also be linked to participant characteristics. Although not statistically significant, those selection calorie labelling had the highest mean need for autonomy, for example. On the other hand, financial incentives were more commonly chosen by participants who demand commitment, suggesting that those with demand for commitment may recognize their need for a more intrusive intervention.

Finally, with the doubly randomized design we utilized, we can compare effects of the same intervention between those that chose it or to whom it was randomly assigned (with and without controlling for characteristics that predict choice). A set of regression analyses suggests that after controlling for demographics that are associated with the choice of intervention, chosen calorie labelling and social norm interventions significantly promote healthier food choices (compared to no intervention control), whereas we find no evidence for beneficial effects of chosen financial incentives. Collectively, these results suggest that a) the overall beneficial effects of choice are driven by selection into calorie labelling and social norms interventions, and b) characteristics associated with preferring interventions do not (fully) explain the beneficial effects of choice. When we compare the effects of each intervention for the random and choice condition, we find no significant differences between intervention effectiveness (both with and without controlling for demographics). However, the signs of the coefficients suggest that selecting into calorie labelling and social norms may indeed increase the propensity to choose healthier snacks but this propensity decreases when respondents choose financial incentives. Note that our study is likely not sufficiently powered to identify these differences, even though they seem economically significant.

The reversed sign for choosing financial incentives (compared to calorie labels and social norms) would suggest that choosing financial incentives decreases the effectiveness of the intervention compared to when this is randomly assigned (not significant). This result has a few potential explanations. First, characteristics that we did not include in our survey may be associated with preferring financial incentives, which are also associated with unhealthier snack choices. An example could be SES, which has been found to affect preference for and effectiveness of incentives (Resnik, 2015, Mantzari et al., 2015) as well as high propensity to consume unhealthy foods (Hulshof et al., 2003). As such, without controlling for such characteristics, potential beneficial effects of choice may be masked as these respondents would have higher baseline propensity to choose unhealthily. Second, this may be a consequence of respondents strategically selecting an intervention that they stand to gain from. Regardless of individuals' characteristics, financial incentives may still provide a compelling reason to change behaviour if the potential upside is large enough (note that the exact amount was not specified when respondents chose interventions). In fact, (self-interested) economic rationality would predict that all respondents choose this intervention, as calorie information is freely available and social norm information is of little relevance to a rational actor aiming to maximize utility. When, as our pilot suggested, the financial incentive was considered to provide little motivation (if transaction costs were non-zero, many people opted out of the incentive), people may instead stick with 'normal snacking' and choose an unhealthy snack.

This study has several limitations that can be addressed in future work. First, the study was completed with a convenience sample recruited on university campuses who completed a short survey. This severely limits external validity, as students generally eat too many unhealthy snacks (Stok et al., 2016) and have characteristics that are associated with food choice (Hulshof et al., 2003), such as higher education levels (but typically fewer financial resources,), and are generally more influenced by social norms compared to older adults (McGill et al., 2015; Nuffield Council on Bioethics, 2007; Stok et al., 2016). Second, although a-priori sample size calculations based on a pilot study informed the target sample size, the effects from the pilot were considerably larger than those observed in the field study. Consequently, our study is likely insufficiently powered, especially since every respondent only provided a single binary decision. However, some of these null-results may hold economic significance, as e.g. 6-8 percentage point reductions in unhealthy snacking would make a meaningful difference in population health if it can be realised long-term. Third, although the doubly randomized design has been used extensively in the medical literature and has many strengths, it limits the lessons learned for the design of behavioural interventions in practice. In particular, behavioural interventions including choice will likely involve the opportunity to choose multiple options simultaneously, rather than just a single, from a discrete lists, or allow recipients to experiment with different options before settling on their final preference (Fedlmeier et al., 2022).. Our one-shot experiment, as such, in our view, provides a lower bound and short-term view of the effectiveness of choice as a tool for tailoring, which could have influenced the effect of the interventions on the snack choice. Finally, as our study was an experiment, we aimed to control some aspects of the food choices, such as the types of snacks included and the time of day in which respondents were approached. Such experimental control may conflict with respondents' snacking preferences, their natural eating behaviour, or response to interventions. Many of these limitations can be avoided by replicating and/or extending our study of choice-based personalisation in mHealth interventions, e.g. as part of co-created or co-designed interventions (Verbiest et al., 2019, Jessen et al., 2018) .

In conclusion, this study provides evidence that allowing individuals to choose their own interventions can lead to slightly higher rates of healthy snack choices. Potentially, this effect occurs because the chosen intervention aligns with their personal characteristics and preferences, but in our study controlling for those characteristics did not diminish beneficial effects of choice. As such, on average, individuals benefit from choice, potentially through increased autonomy. Self-selected and randomly assigned interventions might impact the effectiveness of specific interventions differently, indicating heterogeneous effects and suggesting that introducing freedom of choice is not universally beneficial. Participant characteristics (such as demand for commitment) may need to be understood to enhance the effectiveness of interventions for individuals with varying characteristics. Why some individuals (e.g. those choosing incentives) experience little benefit from choice remains an open question, that future work should study carefully.

Classification: Internal

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Appendix

Link to testable version of survey

In order to try different versions of the experiment, please try this demo version of the Qualtrics survey. Note that the informed consent and study information was removed, as well as this demo version allows testers to pick their own condition. This was not the case for the actual experiment, and is a feature built in only to allow navigating different versions easier:
https://erasmusuniversity.eu.qualtrics.com/jfe/form/SV_7QkW9OQLwGP9gkS

Additional results

Table A1. Number of healthy and unhealthy choices by condition

Full sample	**Control**	**Random**	**Choice**
Healthy	57 (59.4%)	229 (66.6%)	278 (69.7%)
Unhealthy	39 (40.6%)	115 (33.4%)	121 (30.3%)
Within random	Calorie labelling	Incentive	Social norm
Healthy	80 (66.1%)	79 (70.5%)	70 (63.1%)
Unhealthy	41 (33.9%)	33 (29.5%)	41 (36.9%)
Within choice	Calorie labelling	Incentive	Social norm
Healthy	119 (72.6%)	137 (66.8%)	22 (73.3%)
Unhealthy	45 (27.4%)	68 (33.2%)	8 (26.7%)

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