



How can a dynamic digital food menu nudge customers  
towards sustainable choices?

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## Abstract in English

Since agriculture is a large source of emissions today, changes in our food production and consumption are required to reach EU climate goals. This study aims to find out if nudging combined with knowledge-based system can be used to influence customers' choice towards more sustainable food. To investigate how the knowledge-based system should be created a quasi-field experiment was performed to measure the effect of re-ordering a menu (with vegetarian options on top). Previous studies have shown that nudging yields result, but without reporting how customers feel about being nudged. To investigate this, a selection of participants with different demographics (age, sex etc.) were presented digital lunch menus and their feelings and thoughts were observed through qualitative research in the shape of think aloud sessions. The participants were presented with three menus that used different nudging tactics. The results were used to create a conceptual model of a digital menu system based which builds upon knowledge-based systems. The system integrated social, label and order nudges as well as profit margin to create a system that is sustainable in the perspective of climate, as well as economy.

## Abstract in Swedish

Eftersom lantbruket är en stor källa till utsläpp idag så krävs det förändringar i vår produktion såväl som konsumtion om vi ska nå EU klimat mål. Den här studien siktar på att ta reda på om nudging i kombination med knowledge-based systems kan användas för att påverka kunders val mot hållbar mat. För att undersöka hur ett knowledge-based system ska skapas så utfördes ett kvasi-fält-experiment för att mäta effekten av att ställa om ordningen på en meny (där de vegetariska alternativen var högst upp). Tidigare studier har visat att nudging ger resultat, men utan att rapportera hur kunder upplever att bli nudged. För att undersöka detta så visades deltagare med olika demografi (ålder, kön osv.) en digital lunchmeny, där deras känslor och tankar observerades genom kvalitativ forskning i form av think aloud sessioner. Deltagarna blev presenterade tre menyer som använde olika nudging taktiker. Resultaten användes för att skapa en konceptuell modell för en digital meny som bygger på knowledge-based systems. Systemet integrerade social, label, ordning nudges så väl som vinstmarginal för att skapa ett system som är hållbart både från klimat och ekonomiskt perspektiv.

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## 1. Introduction

The human population is growing and is expected to increase by 2 billion people in the next 30 years, from 7,7 billion to 9,7 billion in 2050, according to the UN Population division [26]. As the world's population is expanding rapidly, the demand for resources such as food, energy and water are increasing [5]. Food production requires lots of water and energy and in total it accounts for over a quarter (26%) of global greenhouse gas emissions [27]. Reducing emissions from food production is a huge challenge which requires changing diets and reducing food waste. To meet the EU climate targets, consumers need to reduce their beef intake by 55% or more, since cattle and lamb livestock release high amounts of methane [11].

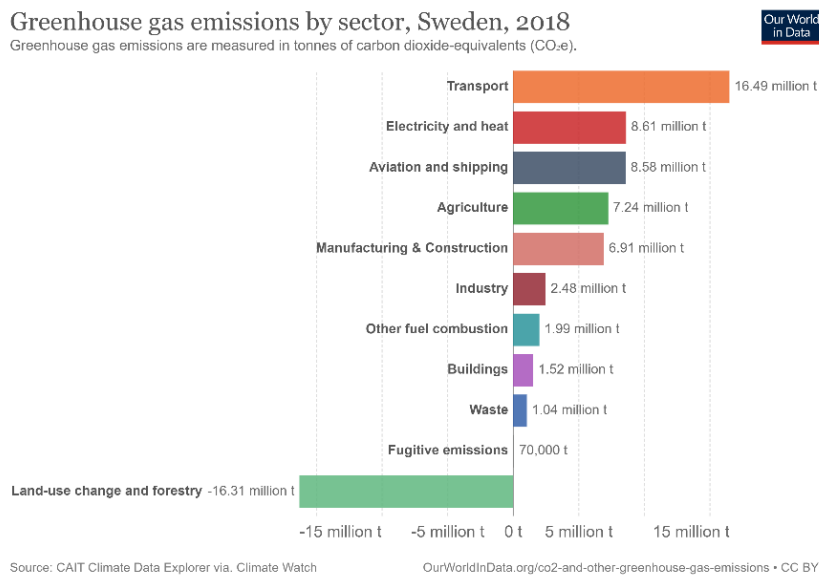


Figure 1: Table that shows GHG emissions by different sectors in Sweden [1]. Our World in Data states that their visualizations can be used freely.

Agriculture both contributes positively to climate change and is negatively affected by climate change. It is the fourth biggest contributor of greenhouse gas emission in Sweden, releasing 7,24 million ton c02e in 2018. Agriculture is also the leading factor of land change, for example converting a forest to cropland, hence indirectly having a larger climate impact by reducing producers of oxygen [2]. Farming has fed mankind for thousands of years with many positive effects. It enabled people to produce all the food they needed in one place, with a much smaller group of people. The reliable food supply led to a massive population growth in a short period of time. Agriculture is here to stay, but a decrease in meat consumption is required because of the methane emission.

### 1. 1 Shared responsibility

The crisis that we face is not easily solved. A joint global initiative and a collective commitment is needed. Food is a basic human need, and every human has a responsibility to act more sustainable to the best of their abilities. Suppliers can choose to produce food with a low carbon footprint and consumers can contribute by making dietary changes to make suppliers rethink their offers. Switching to sustainable food such as food based on vegetable protein sources would be beneficial, but also difficult as consumers can be very conservative when it comes to food habits [4]. A more realistic approach might be to educate the consumer more, so that they understand the impact that their choices have on the planet. Ultimately changes in demand will influence the food industry.

Lunch restaurants which receive more frequent visits than for example a fine dining restaurant could play an important role. They could offer sustainable climate-smart food and guide their guests to more sustainable options. The menu could for example state the emission weight of each dish, so that the guests can make more educated choices. When restaurant guests understand what impact their food choices have on the climate it is then their responsibility to make more informed choices both when visiting a restaurant and when shopping for groceries.

## 1.2 Nudging

Richard Thaler suggests that if an unfortunate behavioral pattern is the result of cognitive boundaries, biases, or habits, this “pattern” can be “nudged” towards a better option by integrating insights about these habits into the choice architecture. Nudging is defined as any aspect of the choice architecture that alters people's behavior in a predictable manner without forbidding any options or significantly changing economic incentives [3].

Most people do not want to be told what to do. Therefore, nudging can be an effective way to influence people's choices and behaviors, as it is seen as less invasive when performed in a good manner. This leads to the following research question:

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RQ1: What is the user's emotional response when being nudged into choosing more sustainable food in a digital ordering application?

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The hypothesis is that to create behavioral change towards more sustainable food consumption nudging can be used. In the context of a restaurant menu, the nudging of the user should not punish or suppress other choices. For example, making it increasingly difficult to find meat on the menu is not nudging. However, reducing the amount of meat or making sure that the more sustainable choices appear at the top is a valid form of nudging.

Nudging techniques that have been applied both digitally and physically in a wide array of sectors include:

**Settings defaults:** This is one of the most popular nudging methods in the literature. It works by setting a default option for the user, which according to research users tend to stick to [30, 4, 32]. A study has shown that defaults used to promote healthy options tend to decrease customer satisfaction and sales, while promoting unhealthy options by using defaults do not [18].

**Social:** This nudging method is based on the human tendency to follow the crowd, also referred to as “*the herd instinct*” [30, 34, 41]. In a digital setting this would be achieved for instance by having a label that says: “80% of our customers prefer this option” [15].

**Warning:** This is a special form of nudging as it attempts to change the user's choice after it has already been made [30, 34]. For example, if you order something with high c02 emissions a warning message could appear. The appliance for this is to prevent “mindless” behavior and make people think about their actions [19].

Ordering: Changing the order of items to make the user pick the first and avoid the last. An example of this is how wireless networks show the most secure option at the top and least secure at the bottom, this can be combined with colors from green to red for instance. This exact method was used in an experiment and it led to a 60% increase in choosing the safer network [30]. Another study in a food related context found that the first occurrence in a list serves as a reference or benchmark to the other options [19]. This high increase in selection makes it interesting to apply in a restaurant context to see if similar results can be achieved by re-ordering. This leads to the following research question:

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RQ2: To what extent can re-ordering of a digital menu increase vegetarian selection rates at a university lunch restaurant?

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### 1.3 Nudges can backfire

Nudging can be a very efficient tool to steer customers towards a desired outcome, but unless used correctly it can backfire. There is a chance that nudging can lead to customer dissatisfaction, due to being perceived as intrusive [20].

The effect of nudging is dependent on the context where it is deployed and can provide unforeseen effects. An example of nudging gone wrong is an implementation of social nudging where the average energy consumption in similar households were displayed, with the goal of educating the reader to reduce energy consumption. This backfired since households with less than average energy consumption started to consume more [19]. It is therefore important to plan and carefully assess the risks associated with the preferred nudging method before implementing it.

### 1.4 Menu labeling

To investigate if additional information regarding emission weights on a menu can affect customers' food choice, results from the menu labeling research area were investigated. A study states that carbon labels only have impact if the customer is either concerned about the environment or the label conveys new information [28]. This means that carbon labels need to reveal new information to affect the customer.

Studies have also investigated how customers pay attention to climate labels. This was done as an eye-tracking-experiment which investigated customers who interacted with a digital menu. The results show that they paid "little attention". Research made in Sweden shows an 11,5% increase in meals labeled as "low emission" and a 4,5% decrease in those labeled as "high emission" by using traffic light labels [9]. A similar study was performed in Belgium and resulted in a modest 5,3% increase in "eco friendliness" [13]. The results in this research area seem to be quite different. This might be due to the uniqueness of different labeling implementations and makes it interesting to investigate this further.

## 2. Digital Nudging

Nudging that is performed in the digital environment often appear in the form of recommender systems. These systems filter down available choices based on personal relevance [4]. The system nudges users by presenting what the system deems most relevant by placing the item on top for example. Google is an example where ordering digital nudging occurs, where the most relevant option appears on top. The common appliance of the recommender system is to nudge customers towards items they will probably like. In a food context, a system might recommend an unhealthy recipe if the customer has shown interest in that type of food in the past. This presents the opportunity to instead nudge customers to something they should explore [4]. This type of system is called knowledge-based system (KBS).

### 2.1 Knowledge-based systems

KBS is based on expert knowledge and can be tuned to the organization priorities. This is contrary to adapting the system based on a particular individual's data. This solves the so called "cold start" problem where, at the beginning, the system needs to "get to know" the customer by collecting data [14]. For instance, a restaurant's digital menu could utilize various nudging methods to make more sustainable choices more "attractive". This creates a system which is operational on the day of deployment. The user centric recommender systems fail to take extraneous factor like suppliers, profit margin into consideration. There are mainly two variants of KBS, one is aiding the expert to make decisions and the other is more autonomous but is still built upon an expert's knowledge. In a study using KBS and Convolutional Neural Network (CNN) data confusion was solved by having an expert with domain knowledge fine-tune the values [32].

### 2.2 A step away from Big Data

The trend of collecting massive amounts of data from users to create recommender system can be very time consuming. The KBS approach combines contextual graphs and statistical methods. This means that managers have control of what items/categories should be prioritized by manipulating a graph tree of domain specific categories [14]. An example of this could be a clothing store where a manager could increase the weight of the "short sleeve" category of clothing to make it appear higher up in searches. This is the single criteria approach and is not as versatile as a multi criteria content-based (multi modal) [14]. This approach would recommend short sleeve options as well taking supply costs, and ultimately profit margin into account. The strength of a multi modal KBS is seen when you combine for example climate, profit margin and seasonal/trend factors. KBS essentially combines the efficacy of machine and the semantic understanding of a human. This human understanding is what the big data trend is trying to replace, and it is argued that the "by design" approach which KBS uses is also viable [14, 21].

### 2.3 Nudging and KBS

Nudging have seen use in KBS system by utilizing nudging tactics like Defaults, Warnings, Social [4]. In food context warning nudging have been used to display warnings when selecting unhealthy food. It is discussed in the literature how sole focus

on meeting the individual current needs lowers the ability to introduce more variables into the KBS system. The algorithms used could be developed further to take social-welfare-oriented goals into account [21]. This opens new possibilities and presents the opportunity of using climate as a variable in the algorithms.

## 2.4 Variants of KBS

KBS is built upon AI but relies on lower amount of data as it also relies on expert knowledge. CNN which is a deep learning approach requires extensive amount of data. One study integrated CNN and KBS to create a CAD (Computer-aided diagnosis) system. The CNN in this case replaces the role of an expert human and feeds data to the KBS which handles classification. This is an example of the second type of KBS (see 2.2 A step away from Big data). The system takes a multimodal approach which means that multiple sources are being used for classification and this ultimately reduces the amount of training required [31].

Another study proposes the term K-CNN and this was tested in natural language processing [4]. The study outperforms the current state of the art models for relation extraction. This is valuable as a K-CNN system integrate prior human knowledge and reduces the amount of training data sets [4, 30]. This was done by using both a data-oriented channel and a knowledge-oriented channel. A K-CNN approach could potentially make it even easier for restaurants to classify their meals and to calculate emission amounts.

The potential to use a KBS system in a restaurant makes room for the following research question:

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RQ3: How can nudging be integrated into a knowledge-based system to promote sustainable choices, in a way that is suitable for a restaurant environment?

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## 3. Method

To gain insight into the restaurant industry and understand how to solve all the research related questions and risks, a restaurant owner of several restaurants was interviewed. Understanding the restaurant owners' perspective is vital to create a solution that is sustainable both from the climate perspective, and yet profitable and safe from risks for the restaurant. Discussions and interviews with the restaurant staff took place to find viable solutions for testing various nudges in a sustainable manner in line with their requirements.



Activity	Week
Interview with restaurant stakeholders	1
Begin experiment by collecting pre-test data	2 & 3
Perform intervention by re-ordering the menu	4
Think aloud sessions	5
Design model of system	6

Table 1: A plan listing activities in chronological order and which week they were conducted.

The plan was to gain expert knowledge of the restaurant industry by talking to stakeholders in this sector. Afterwards the experiment started with a pre-test for two weeks. Then the intervention was in place and were active for a week. The next step was to perform think aloud sessions. The final step was to design a conceptual model of a system based on the results of these activities.

The knowledge gained from the interview with the stakeholders at the restaurant, was used to find a suitable solution regarding the following research questions:

RQ1: What is the user's emotional response when being nudged into choosing more sustainable food in a digital ordering application?

This problem would preferably be investigated by a qualitative method as the topic being researched is of an emotional nature. The participants were presented a digital ordering application and their reactions and behavior were observed. The reactions can be captured by performing think aloud sessions or focus groups.

One reason that made focus groups less preferable was that people might be influenced by other's opinions. There is a risk that the sessions would constantly be affected by the social nudge where people would act on the "herd instinct" [30, 34]. It was therefore beneficial to include a research method where participants are observed in "isolation". It can also be argued that the inclusion of social bias is wanted. The motivation for this is to simulate the scenario of ordering food with a group of friends or colleagues. The hypothesis here is that participants would be able to express opinions more openly if the session is not made in a group. Because of this, think aloud sessions would be used to address RQ1.

### 3.1 Think Aloud

The participants for the think aloud sessions were based on convenience sampling. Non-probability sampling was deemed viable because of its speed and efficiency. The participants consisted of various ages, education level and sex. This was enough to proceed with the non-probabilistic approach. There is also the issue where the sample would preferably be at a lunch restaurant and have very limited time and will to participate in research. These difficulties were seen in a pre-study survey which took substantially less time to finish by the respondents. It is therefore unlikely that

participants would be willing to take part in think aloud sessions during their actual lunch hour, as they are more time consuming. This pre-study method was tested but canceled because of the difficulty of receiving lunch guest respondents. The stress factor that occurs in a lunch restaurant was also considered. This leads to the hypothesis that participants would not settle appropriate time to answer truthfully.

The participants were presented with a digital menu prototype created specifically for the purpose of this study. The digital menu would look like the menu in the quasi experiment, so they can be compared with less margin of error. The motivation for performing think aloud sessions instead of only performing quasi experiments is to assess the effect of the nudging tactics without affecting the restaurant's business in any way. Some methods could have unforeseen consequences which can be seen in the literature (see 1.3 Nudges can backfire). To know if the selected nudges are safe to use by restaurants, the level of satisfaction was measured during the think aloud sessions. This was done by simply asking about the participant's reaction to the menu.

### 3.1.1 Study setting

The think aloud sessions were performed at different locations based on convenience with a single participant at a time. This hopefully means that they would feel free to share whatever thought comes to their mind. Questions that do not risk manipulating the results were answered, but generally they were prompted to explore the menu on their own. The participants received a short introduction that explains the purpose of the session. The purpose was to record their reactions to different lunch options. They were not told about the nudging tactics that are being used. The motivation for this is that this knowledge would most likely influence their choices.

### 3.1.2 Participants

A total of seven participants which included:

Sex	Age	Education	Label (see Appendix B)
Female	16	Studies at secondary school	B
Female	19	Senior secondary school	E
Male	19	Senior secondary school	C
Female	21	Studying at university	G
Male	21	Senior secondary school	F
Female	51	University	A
Male	54	Senior secondary school	D

Table 2: A table displaying the participants in the think aloud sessions

The sex was well represented with one additional female. The ages are not very well represented as the ages 16-21 are overrepresented. There was a lack of representatives between the ages 21-51. The hypothesis was that if the subjects were not "actively combating climate" and were not vegan/vegetarian age would not have a significant impact. Only participants who were not vegan, vegetarian or very active in climate

questions were included. None of the participants that were reached out for the study fell into any of those criteria.

RQ2: Can re-ordering of different lunch options in a digital menu increase vegetarian selection rates at a university lunch restaurant??

To solve this problem a quantitative method is required as it involves the restaurant's sales figures. The most reasonable choice is some form of experiment. The reasoning for this is that the goal is to gather data from a natural environment. The field experiment is considered more fitting because the participants are exposed to extraneous factors like smell, hunger, and social bias. These factors are essential in this case because they are always in place in the real world. Another benefit is that participants do not need to be recruited as they can be found in this environment naturally.

To conduct the experiment without larger interference in the restaurant's structure a one-group pretest-post-test is suitable. The motivation for using a one-group pretest-post-test design is that it doesn't require a control group which would be difficult to implement in a busy lunch restaurant. It would require giving the default menu to one group and the intervention menu to another, which would require permission from the restaurant and be time consuming. The layout of the restaurant also makes this difficult as the menu is published on a large tv monitor which is visible to everyone. The temporality issue of non-control group experiment is not very relevant as the time difference between post- and pre-test is only two weeks. The advantage of the chosen research design is that no changes need to be made to the restaurant's process design or interior design.

### 3.2 Quasi Field-experiment

A quasi field-experiment in the form of a one-group pre-test-post-test was conducted at a restaurant (before the Think Aloud). The goal was to extract the effectiveness of re-ordering the menu to nudge customers towards meals with lower CO<sub>2</sub> emissions (RQ1). The motivation for doing the field-experiment at the restaurant – in the natural environment – is that the data needs to include truly hungry customers as hunger is likely to affect their behavior and choices.

In this case the limitations of the one-group pre-test-post-test is generally the history aspect. The experiments are not being performed simultaneously and external factors between the experiments could influence the results. Due to the experiments being performed a mere two week apart from each other this mitigates this factor. If the experiment would have stretched for a longer period, this could have a larger impact. The pre-experiment collection of data was compared to the post-experiment data, following the group pre-test-post-test research design. The method used was re-ordering because of the subtleness. This leads to a lower chance of causing economic damage to the restaurant. More nudging methods would have preferably been assessed. Unfortunately, since the existing digital menu was not developed to make changes other than changing text, this had to be excluded.

#### 3.2.1 Study setting

The quasi experiment was performed at a lunch restaurant with approximately 350 served meals per day, located at a Swedish university. The pre-experiment was based on two weeks of sales. The meals cost 95 SEK (73 SEK for students). The sales data were collected from the restaurant cashier system. The menu consisted of four meals, and

they all changed on a daily basis, with minor exceptions. The meals are categorized by the titles: Green, Local, Asia Yee, Asia Ichi. The main argument for the inclusion of a control group was that all participants would have the same options, so the only difference would be the applied nudging technique. However, the restaurant staff mentioned that category sale ratios usually don't differ very much. This was investigated by comparing two weeks of sales against each other and analyzing the difference.

The restaurant visitors are a part of the experiment as unaware participants. This was done to combat the Hawthorne effect, but as there is no way to connect them to the purchases, they are effectively anonymous. It can be argued that the anonymous element makes the non-disclosure more ethical. They are only investigated through their purchases and no other record of them exists. This made it impossible to record exact demographics. The hypothesis is that the majority of the customers are university staff, but the restaurant is open to the public and others can visit as well. Students' choice of meal cannot be tracked as the system labels whichever meal they chose as meals as "STUDENT". They consist of approximately 7% of the purchases so this is not very significant.

Creating a survey where respondents would select their meal from a questionnaire was also considered. Various nudging tactics would be presented to the respondent to measure the impact of each nudge. The data might not be as valid because of the artificial environment. There are also no economic incentives, and the customer does not receive any food. These aspects could possibly create a risk that respondents would pick a certain meal that they might not have done when hungry and affected by scents for instance. This argument can be applied to the think aloud digital menu as well, but it is argued that because the menu resembles a real restaurant menu it would be viewed as less artificial.

RQ3: How can nudging be integrated into a digital food menu system to promote sustainable choices, in a way that is suitable for a restaurant environment?

This research question was answered by the results of RQ1 and RQ2 and by taking the restaurant requirements into account. RQ1 investigated the safety of implementing nudging into a digital platform. RQ2 investigated the effectiveness of ordering and whether it makes an impact. The motivation was to investigate if it was worthwhile to build a dynamic system that changed the order of items, as suggested in the literature (See 1.5 Digital nudging). The goal was not a built system artefact because this is not feasible with the amount of time and resources. Instead, a conceptual model was constructed which builds upon the performance of the nudges, needs of the restaurant and feelings of the customers.

## 4. Results

### 4. 1 Interview with restaurant industry

To further understand the situation a restaurant owner face when it comes to guiding customers to more sustainable food, a restaurant owner in a typical Swedish lunch restaurant at a university was interviewed. When questioned about if and how customers receive information regarding the climate impact of their meals, the owner responded:

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*“Yes, we do, but communication is a big challenge, and you need to be very sensitive and apply the exact right tone of voice to ensure customer satisfaction – not to offend anyone.”*

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The question was followed by asking why he thinks that most restaurants do not present information about the climate impact of their food, and the answer was:

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*“We do not want to throw things in people’s face. It’s not our role to educate the customer”*

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This is probably a common thought in the restaurant industry. Avoiding a possibly negative experience for the customer gets the highest priority. Restaurant owners want to create a positive experience and not judge guests based on their food choices. He brought up an example of coffee cups that they bought that had the label “100% plastic free”. The cup was made of recyclable plastic and was enough for them to label it as not plastic. The point that the restaurant owner argued was that green wash companies have impacted the trust in “climate labels”.

The restaurant owner was also asked what effect submitting the emission information on the menu might have on 1) his restaurant overall 2) and on his lunch guests’ food choices.

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*“Positively, colleagues become proud and feel relevant. The guests appreciate it, even the hamburger-lovers react positive as the meat is local”.*

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The restaurant work with sustainability internally and the coworkers feel proud for doing their part. Although this doesn’t mean that they will put the emission information in the customer’s face. The restaurant owner states that he is opposed to the green-wash trend.

When asked what is required to make a change in the industry the answer was:

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*“Customer demand and regulations – bad food is cheap while fruit is a luxury...”*

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The keyword here is “Customer demand”, they cannot sell food which is not demanded. In conclusion, even if a restaurant wants to be more sustainable, they need to meet customer demand and not risk shaming their customer. The restaurant fear that having labels in consumers’ faces can potentially lead to anxiety or irritation. At the same time customers have an impact on the market and demands that must be changed to meet the climate targets [6].

#### 4.1.1 Further interviews

To gain a broader perspective than a single restaurant's view, a climate coordinator who has worked with several stakeholders in the food industry, was interviewed in an unstructured interview. It was further confirmed that the green wash trend has affected the trust in climate labels by using misinformation. When asked what difficulties restaurants face when working with tools to improve their climate footprint it was said that it was bothersome for the staff to manually input everything. It was also clear from conversations with the staff that worked in the restaurant (where field-experiment was conducted) that they have limited abilities to perform additional duties. Inputting every ingredient and the associated weight was very time consuming and made climate labeling bothersome.

#### 4.2 Quasi Experiment

The research was conducted during eight days in March 2022 where 1.725 purchases were included. Student purchases were not included (see 4.1.1 study setting). The restaurant has a public view monitor with a digital menu located at the entrance, as well as a cardboard menu at the checkout. Both the cardboard and digital menu were changed specifically for this experiment. On the restaurant menu there were four food categories, Asia Yee, Asia Ichi, Green and Local. The meals varied from day to day. Asia Yee and Local always contain meat, while Asia Ichi and Green are vegetarian. The categories only contain one dish and can be found on both the digital and the analog menu. This leaves a menu with a total of two vegetarian dishes and two meat-based dishes.

Prior to the experiment, data was generated by analyzing receipts for two weeks which included 3195 meal purchases. After the pre study was completed, both weeks were compared to each other to see if there was any significant difference in category sales from week to week.

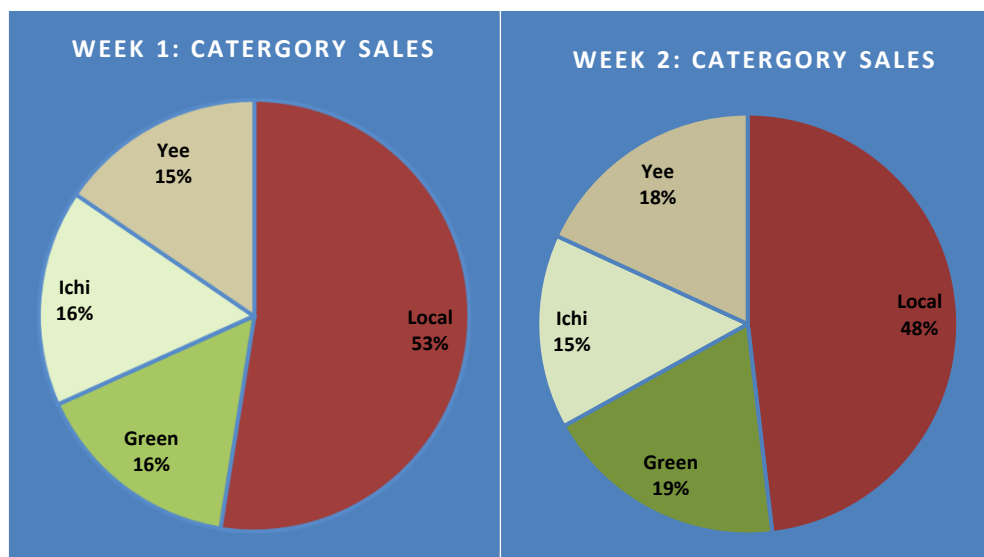


Figure 2 & 3: These figures are based on the two weeks of pre-experiment data. The purpose of the comparison is to see if there are any significant differences.

The difference is quite insignificant, and it seems that the restaurant staff's statement that the category sales doesn't differ much is true based on this sample of data. This

confirmation of the restaurant's statement deemed it viable to proceed without a control group.

The meals  $\text{CO}_2\text{e}/\text{kg}$  emissions were calculated based on their type of protein using a website called "CarbonCloud". The data seems valid because it was based on several publications. Furthermore, the data was also compared to other tools which showed similar values [8]. This value is not very precise as it only takes the protein into account and uses "benchmark" values which might vary depending on the producer and which country the producer resides. In the context of creating dietary shifts towards more sustainable options like poultry, pork and especially plant based, this information need not be exact.

Each change in the menu was active for five days and then switched to another nudging method. The previous change is then reverted to gain measurable results. The menu changes included:

*Ordering Nudge:* The vegetarian options were placed first in the menu and the meat options were placed last. The order was the following: Green, Asia Ichi, Ye and Local in a vertical order. The experiment was recorded for one week.

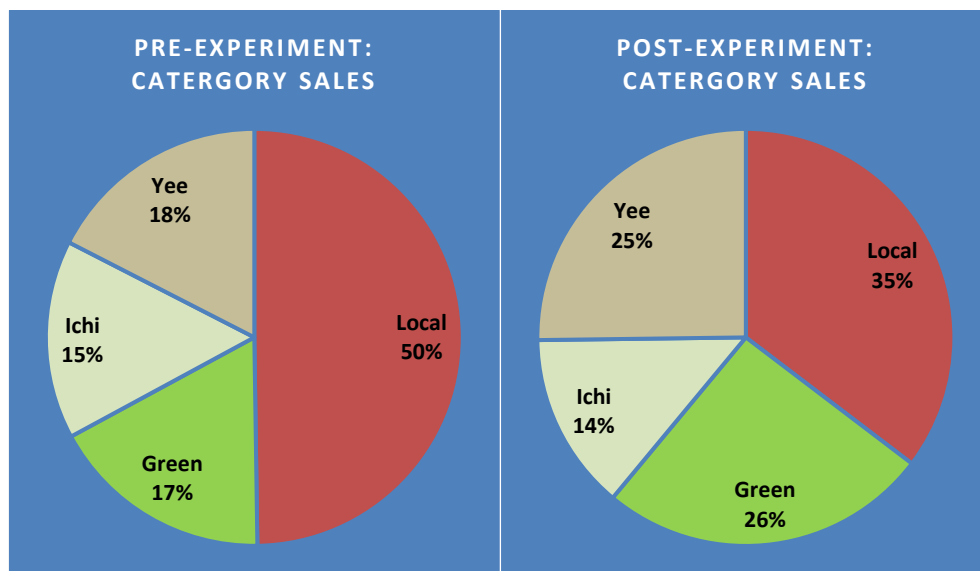


Figure 4 & 5: Diagram that displays percentage of sales for each category post and pre-experiment

Sales figures for the four categories before the experiment show that the Local category was the most popular – half of the customers selected that option, followed by a quite even split between the other three options. The combined percentage of sold meat dishes were 68% so almost 2/3, while the vegetarian options together accounted for around 32% of the total sales.

After the experiment the sales figures for the Local category decreased by 30% while Asia Yee increased by 39% in sales. The Green category saw an increase by 53% and Ichi saw minimal decrease with 6%. This indicates that nudging using ordering has influenced food choice, but not enough to make the move from a higher percentage of meat-based lunches sold to vegetarian lunches as the majority (60%) consist of meat.

Meat sales (Yee and Local) made up 68% before which means that after the experiment it was reduced by 12%.

This means that the vegetarian options (Green and Ichi) saw a total increase of 25% which is high to the average of 15.3% effect seen in nudges [16].

### 4.3 Think Aloud

The think aloud sessions began after the natural experiment ended and it involved people that quite regularly eat at lunch restaurants.

The digital menu was created as a website and the content displayed the same categories that were used in the natural experiment (Local, Green, Asia Yee and Asia Ichi). The dishes in each category were inspired from the restaurant to create as much similarity as possible between the natural experiment and the think aloud sessions. The participants were first introduced to the experiment with a brief introduction. The researcher explained that it is a think aloud session and that any thoughts that come up should be said out loud. The experiment included three menus based on: Labels & Ordering, Labels & Warning, Defaults & Social. These were based on the methods found in the literature (See 1.2 Nudging). The participants were not told what nudging method was used.

#### 4.3.1 Menu 1: Labels & Ordering

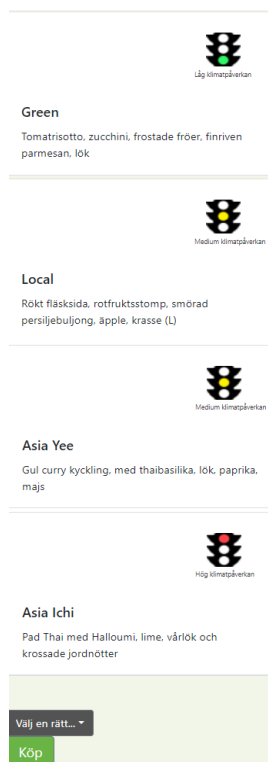


Figure 6: The Menu 1 on a mobile device in Swedish language, “Välj en rätt” means “Choose a dish”, “Köp” translates to “Buy”

The participants leaned towards the green and yellow labelled options and only one red option was selected. Many participants expressed that the Asia Ichi seemed tasty, but they did not want to pick a red labelled option. One participant who picked the red



labelled option felt a bit “guilty” about it and was skeptical as to why what was called “bad” alternatives even exist on the menu. The labels had an impact on most participant’ choices and when two alternatives seemed tasty the lower CO<sub>2</sub> option was always picked. This points that this is an effective nudge because it successfully introduces another variable to food choice.

The participant who was not affected by the nudge expressed that the climate didn't play any part of the decision. The statement of carbon labels made in the literature which states that people who do not have any motivation to address the climate will not be affected by carbon labels [26]. This general phenomenon is also seen in other studies regarding nudging [22]. He also expressed surprise after looking at the label, but it did not change his choice, this points that label presenting information which is new to the participant is not enough, interest in making a change is also required. There was only one instance where a participant felt bad about her choice throughout the sessions. A clear trend was that the taste is the first factor when selecting food, and when two choices were weighed against each other, climate impact became the eliminating factor.

The CO<sub>2</sub> label (LOW, MEDIUM, HIGH) seem to generally correlate to how good participants felt about their choice. If a participant picked a green labelled option (LOW) s/he felt good about themselves, a medium labelled option promoted a neutral feeling, and a red label gave them a negative emotion. When participants first set their eyes on a HIGH CO<sub>2</sub> option, but then finds a MEDIUM option which also seems tasty, they always change their choice and feel good about themselves. In conclusion, when participants actively change from a bad choice, they experience a positive feeling instead of just feeling neutral. One participant had allergies and did only like one option, so the climate could not play a part in his selection due to this. Another participant weighed the options solely based on taste and then later when considering climate impact honestly stated that taste is more important to him in the end.

50% picked “LOW CO<sub>2</sub>” climate options and the remaining 50% picked “MEDIUM CO<sub>2</sub>”.

#### *4.3.2 Menu 2: Labels & Warning*

The design of the menu was almost identical to the Menu 1 with the exception that Menu 1 was ordered by climate, where Menu 2 is not.

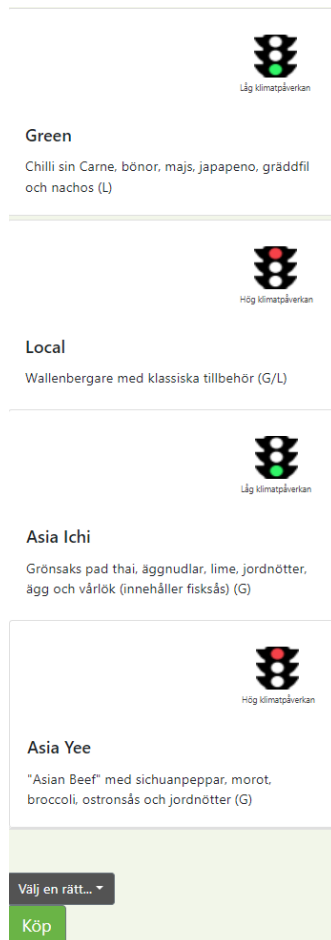


Figure 7: The Menu 2 on a mobile device in Swedish language, "Välj en rätt" means "Choose a dish", "Köp" translates to "Buy"

There was also another element to this menu which is the warning nudge element. If meal with "HIGH CO<sub>2</sub>" was selected, a warning window containing information that aims to nudge the customer towards vegetarian was displayed.

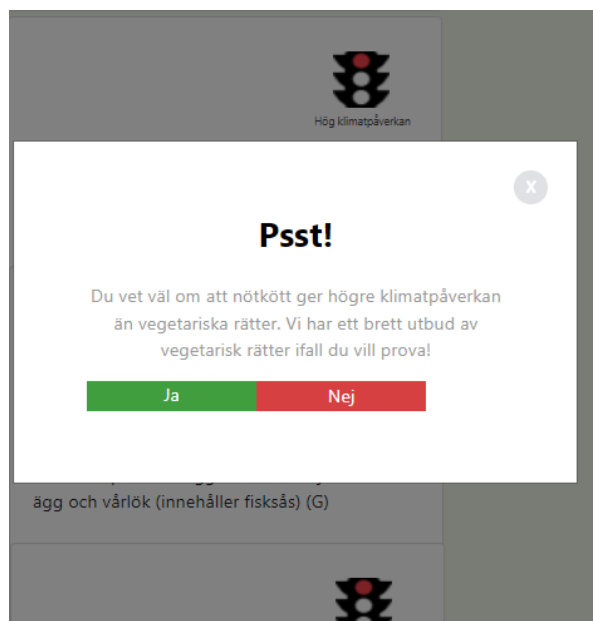


Figure 8: The warning window that appears if you select a "HIGH CO<sub>2</sub>" meal, translates to "You do know that beef has a higher climate impact than vegetarian dishes. We have a wide range of vegetarian dishes in case you want to try"

There were differences in how participants navigated in the menu, one traversed it from LOW to HIGH in CO<sub>2</sub> values whereas everyone else read it from top to bottom. This behavior was not seen when the menu was ordered by climate class. This points out that in some cases labels can impact the order in which customers traverse the menu. Participant E commented that she enjoyed that the restaurant was transparent and not only shows which options are "climate friendly", but also highlight options that are not that climate friendly. She said this made her feel more aware of her choice and ultimately, she had a positive feeling even though she picked something with HIGH CO<sub>2</sub>. Participant F felt limited to only one option due to taste preferences. To combat this he was presented with the question: "If there would have been a burger with medium CO<sub>2</sub>, would you have picked it instead of Local which has high CO<sub>2</sub> emissions?". The answer to that question was yes. No negative feelings were found amongst the participants.

The warnings were not effective and didn't change any choices. One reason for this might be that combining labels with warning nudges do not complement each other well. This was evident as Participant C who picked a red labeled option commented that he already knew that he picked something bad because of the label, but he already made his choice. Warning nudges do not seem to have an impact when the participants are already educated or aware of their actions. This can be seen in the literature where warning nudges to prevent "mindless behavior" is not working since the participants are already aware of their actions [19].

50% picked "LOW CO<sub>2</sub>" while the remaining picked "HIGH CO<sub>2</sub>".

### 4.3.3 Menu 3: Defaults & Social

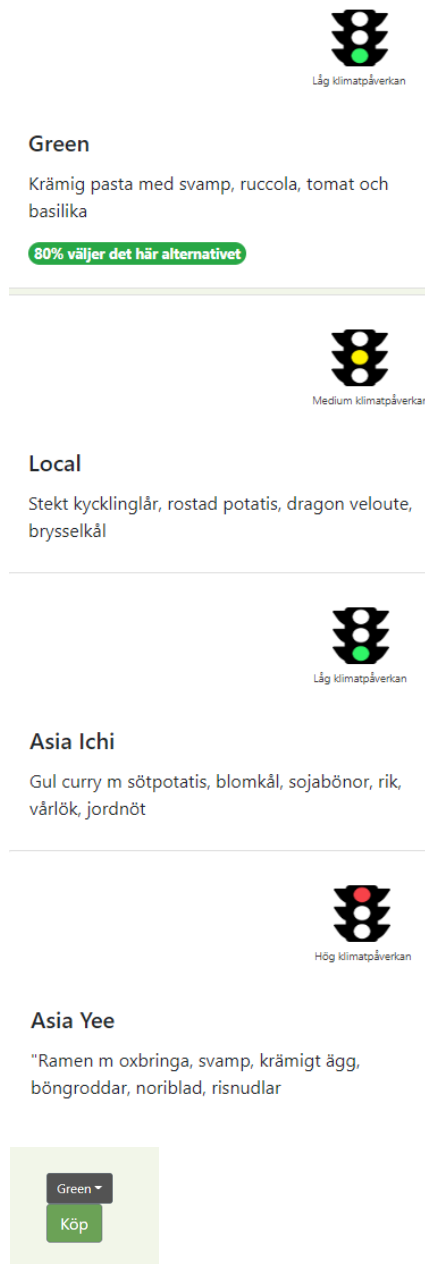


Figure: 9: The Menu 2 on a mobile device in Swedish language, "Välj en rätt" means "Choose a dish", "Köp" translates to "Buy". The Green option is pre-selected. The Green option has another label that says "80% väljer det här alternativet" in English this means "80% choose this option".

The Menu 3 had a label that uses the social nudge by telling participants that it is an option picked by many others. This was combined with the default nudge where the Green option is pre-selected.

The default nudge was not something that was commented on by any of the respondents. This could imply that default nudging is seen as non-intrusive and unnoticeable. No signs of negative reactions were recorded. Previous research showed that healthy defaults would generate customer dissatisfaction, but this behavior was not noticed in any of the participants. The social nudge was recognized immediately by all

participants and proved to be very effective. All participants picked the Green option except for participant B and C. Participant B has proven in the past to only take taste into account and was very resistant to nudges. Participant C did not like mushrooms, so the option was excluded. These participants have also reported a neutral feeling to the nudge as it didn't affect them.

Everyone who picked the Green option shared the feeling that it felt like a "safe option" and gave them positive feelings. In two cases the participants picked the Green option without even looking at the other options. In a similar scenario a participant thought they wanted to pick Green, but also read the option below (which was Local), then picked Green. This strengthens previous research which says that the first option is compared to the others [19]. Although, if the option was excluded for whatever reason the participants would look below and then compare the first acceptable meal with the rest. This is the only nudge which has made participants ignore other options. This means that the theory about the first meal being used as a reference is only true if the participant finds it acceptable. Participant F had expressed that vegetarian food is something he felt unsure about, but when they noticed the social nudge label he felt reassured.

Even though this is a qualitative method based on low number of participants, the numbers show that 77% picked the nudged option, which is Green (*see Appendix B*). In total 83% picked "LOW CO<sub>2</sub>". There were no apparent themes based on the demographics. The only thing that was seen is that the youngest participants 16 and 19 reported the most number of neutral feelings and commented that they were not affected by the nudge on several occasions. This was not seen as much in the participants aged 21 and over. Only one participant

## 5. Digital solution

A solution to avoid negative reactions when steering restaurant guests towards sustainable food choices might be to go digital. The motivation behind this is that a digital solution is dynamic and can quickly adapt. KBS systems have successfully been used together with nudging before. For example, a digital solution could list the most sustainable choices on top and hope to increase the sales of these items (see 2.3 Nudging and KBS). Previous research has shown that re-ranking products influences customer choice [24]. A knowledge-based system would adapt based on a set of priorities decided by the restaurant. An example of this could be that a restaurant manager sets up the system, so that meals which are soon to be expired are prioritized at the top of the menu. The contrary would be the customer centric view where the most picked item would be at the top and most visible. The meals could also be listed depending on how much protein they contain, with beef being at the bottom (highest on protein) and vegetarian protein at the top (lowest on protein), creating an automated process. According to discussion with the restaurant staff this is something they rarely find the time to administrate manually. Having an automated process would solve this issue. The data inserted in the digital menu could be compared to one of many carbon footprints databases [7, 8]. This solution would then recommend the most sustainable food to the customer, while attempting to avoid negative reactions which labelling might induce. Previous experiments in digital nudging have shown no signs of negative reactions. However, measuring consumer reactions is missing in many studies [15].

The nudges that showed potential in the think aloud sessions were integrating in a system similar to a knowledge-based system. This system is simplified, but still uses expert knowledge by allowing the CO<sub>2</sub> class values to be manipulated.

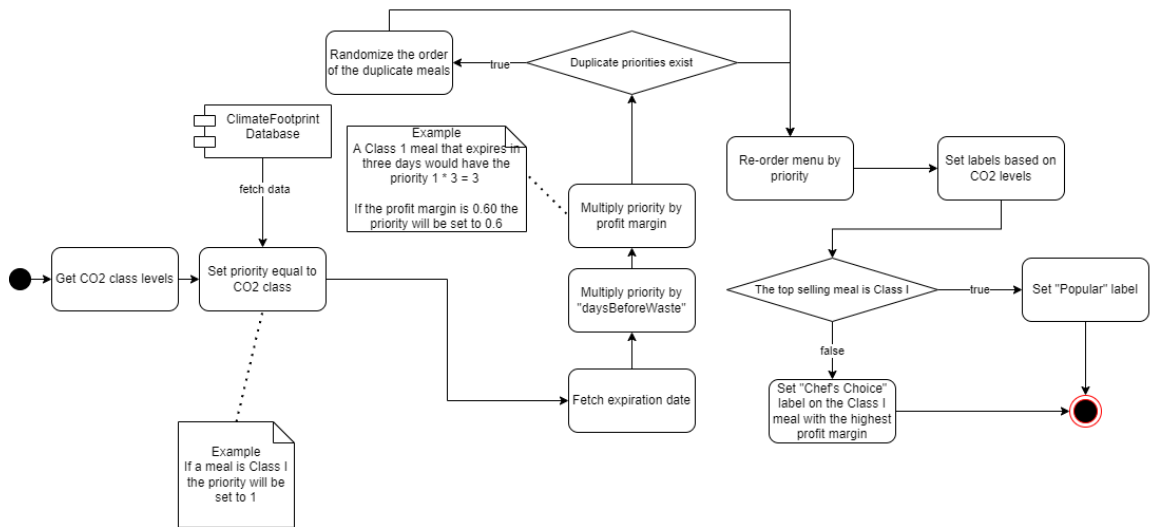


Figure 10: Pseudo activity diagram showing how the proposed digital menu would adapt to data

This solution integrates the social, ordering, and labeling nudge in an autonomous manner. It is inspired by the knowledge-based systems where recommendations are based on a set of priorities that the system is given. In most cases the goal of companies that use knowledge-based systems is to increase profitability [14]. The model (Figure 8) is modified to take heavy emphasis on climate friendly meals. Profitability is also one of the system priorities, with the goal of making it more economically desirable for restaurants.

Classification of the meals were done only based on the CO<sub>2</sub>e/kg of the protein:

Class I: Less than 3 CO<sub>2</sub>e/kg, Class II: 3 – 7 CO<sub>2</sub>e/kg, Class III: Higher than 7 CO<sub>2</sub>e/kg

The system works by first fetching the CO<sub>2</sub>e/kg from a climate footprint database. The priority would be set according to class, for example a Class I (< 3 CO<sub>2</sub>e/kg) would get priority 1 (lowest number is prioritized). After this the expiration date will be fetched and compared the priority will be multiplied. After this step the priority is multiplied by the profit margin.

This creates the following formula:  $PRIORITY = class * daysToWaste * profitMargin$

The menu is then re-ordered, and the labels are added. The last step is checking if the Class I is the top selling option (50% or over) and either adding “Popular” or “Chef’s Choice” depending on the condition. The result is a menu where CO<sub>2</sub> class, days before waste, profit margin and average sales is all weighed in. This creates a menu with integrates several nudging methods (hybrid nudging) into digital food menu system and aligns with the restaurant staff’s requirements for an automatic solution and the need for it to be financially viable. This is further supported from the climate coordinator interview where it turns out other restaurants have the same requirements.

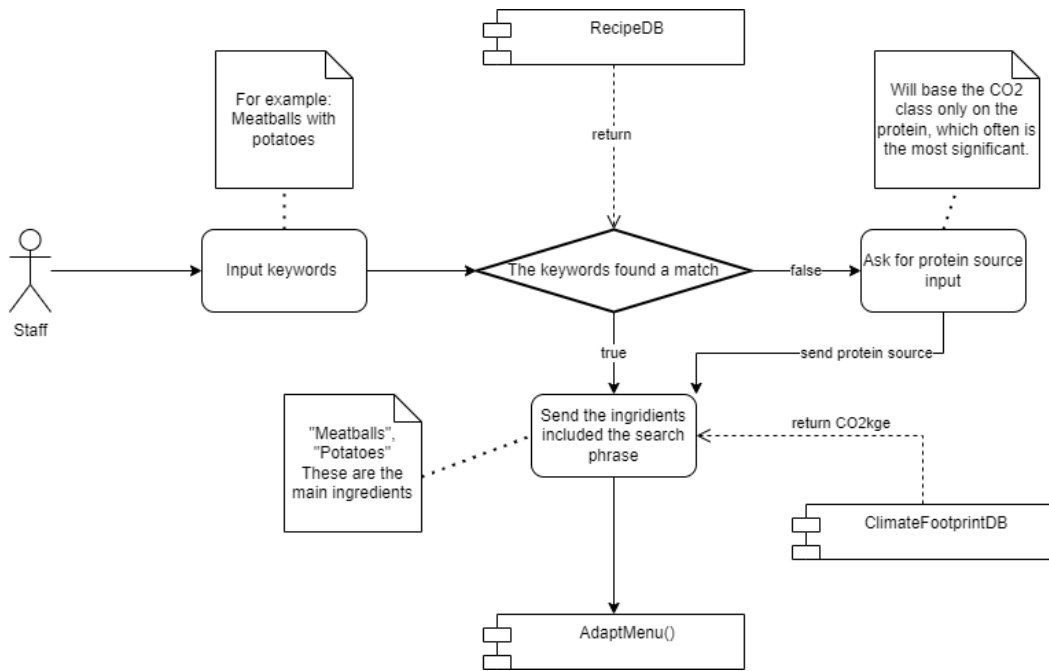


Figure 11: A pseudo activity diagram displaying a potential solution to the time-consuming task of manually inputting every ingredient and the amount of a dish.

The following model (see Figure 13) shows how the system would circumvent the issue of manually putting the ingredients and amount. It will attempt to find a recipe in a recipe database that matches keywords. An alternative solution would be a CNN system that could identify food and then send it to the database instead of inputting [31]. The system would only need to identify the main ingredients like meatballs and potatoes. There are studies already that has created CNN capable of classifying food [31]. The application of this is mentioned in the literature (2.4 Variants of KBS). This approach is not explored further due to time constraint. This can be interesting for future research.

Figure 10 and Figure 11 answers RQ3: *“How can hybrid-nudging be integrated into a digital food menu system to promote sustainable choices, in a way that is suitable for a restaurant environment?”*.

Example scenario:

These meals and their associated data are purely theoretical and not based on any real data.

Meal	CO <sub>2</sub> Class	Days before waste	Profit margin	Average % sales
Chili Sin Carne	1	3	0.60	20%
Massaman curry	2	1	0.50	10%
Bolognese	2	3	0.55	25%
Beef Burger	3	3	0.50	45%

Table 3: Example of meals with associated information including, meal, class, days before waste and profit margin.

These meals would be displayed like this for the customer after going through the system (seen in Figure 12). The priority would not be visible, it is just included for the purpose of demonstration.

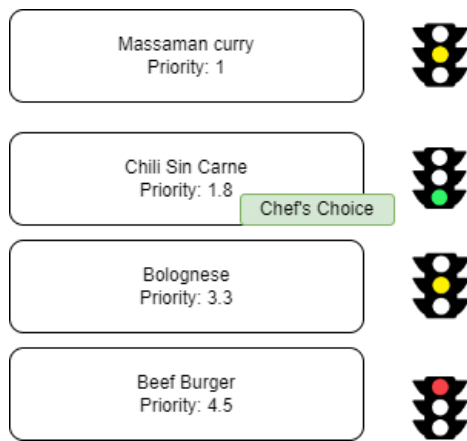


Figure 12: An example of how the structure of the menu would be arranged when using the system. The priorities would not be visible for the customer. This only serves as an example.

The goal is to create a digital system which can nudge customers towards a sustainable choice. In this case the “Massaman curry” is a class II and not inherently the most sustainable choice but compared to throwing away food it is. It is important to view this as it is both a waste from a climate standpoint but also a waste of resources from an economical standpoint. The most climate friendly meal “Chili Sin Carne” is instead being promoted by a social nudging label. The text is “Chef’s Choice” as the meal sales consist of less than 50% of the total sales. If the sales would amount to 50% or over the label would be replaced by “Popular”.

As soon as the meal that is soon to be wasted is sold out from the menu the system would dynamically change and for instance put “Chili Sin Carne” on the top. Following the conversations with the restaurant, it needs to be easy for the staff, they usually got their hands full. Using this proposed concept with an automated digital food menu would solve this issue.

## 6. Discussion

Key findings investigating RQ1: “What is the user’s emotional response when being nudged into choosing more sustainable food in a digital ordering application?” shows that labels did only evoke negative feelings in one instance out of a total of 21. The other instances reported mostly positive or neutral reactions. The thesis that labels induce negative reactions in customers was not seen in this study. Similar studies also report no negative behavior among participants [24]. There is also a possibility that the design choices of the labels can have different effects on customers, and there is room for further research in this area. Studies could also evaluate the differences in different label designs, for example the difference in pure numbers versus icons (the traffic lights) for instance. This shows that labels can also be integrated into restaurants’ digital menus.

RQ2: “To what extent can re-ordering of a digital menu increase vegetarian selection rates at a university lunch restaurant?” is answered with a quasi-field-experiment that revealed that ordering influences people’s choice, but not substantially enough to make the majority switch from meat to vegetarian. Most customers simply switched from one meat meal to another. The results indicate an 25% increase, which is higher than the results on previous studies [25]. Although, the sales still consist of 60% meat meal sales.



The hypothesis for the higher-than-average results are that the vegetarian meals matched customers taste preferences and they felt good about picking something labeled as “Green”. Another reason could be that the quasi experiment should have been stretched over a longer period. The case could be that the vegetarian meals that week was tasty compared to the alternatives. The think aloud sessions confirms that customers generally doesn’t switch away from a meal that is tasty and labeled as a sustainable, which the label “Green” is probably associated with.

The key findings regarding the RQ3 “How can nudging be integrated into a knowledge-based system to promote sustainable choices, in a way that is suitable for a restaurant environment?” shows that the social nudge is most effective in both selection rates and user reaction. It promotes certainty and positive feelings for the selected item. The label with text saying 80% of our customers select this option, must be accurate to use it in a real-world scenario. The social nudge could be used with labels with the text “Chef’s Choice” or just “Popular”, although it is not known if this yields the same effect. The proposed digital solution automatically sets the popular label if the meal is Class I, if it is not, it will be set to “Chef’s Choice” with the goal of making the dish seem like a “safe card”. This circumvents the issue of promoting meals which are not sustainable. Ultimately the answer to RQ3 is the proposed digital solution (see 6. Digital Solution).

Hybrid nudges showed a larger effect to influence choices towards the nudged options. As can be seen in the literature, ordering combined with labels showed a 60% increase [30]. The think aloud had similar selection rates and sometimes higher. The point is that this study as well as others show that hybrid nudges have higher influence on choice [17]. It’s therefore not recommended to judge the performance of a single nudging tactic without exploring how it can be used in combination with others. It is also revealed that motivation to act sustainable is required for labels to have an effect.

This study also shows the importance of assessing risks of nudging methods before usage, which is also discussed in the literature [19]. When the restaurant menu was changed to include three vegetarian options and only one meat-based meal the customers had many negative comments about it. This experiment was thereby excluded from the study, as it had to be discontinued. The combination of warning and label nudges provided no further value as the participants had already thought about their choices when they saw the label, making the warning nudge obsolete in this context. The default selection was not commented on by any participants, and a reason for this could be that it was at the bottom of the page and only noticed after they had already made their choice.

It is important to mention that vegetarian food should not be mistaken for always being more sustainable than meat (see Appendix A). Steering customers towards vegetarian options can sometimes also be good for ethical reasons to improve animal welfare. The scope of the study is the climate situation and nudging vegetarian options is counterproductive in cases where they sometimes have threefold the climate impact compared to meat. The planned method was initially to order the menu based on CO<sub>2</sub> emissions, but this was not possible as the menu was connected to a web bureau where access could not be granted to make larger changes. The menu was not dynamic and could not change order daily. The proposed digital solution in this study addresses this issue (see 5. Digital Solution).

The flaw in the results from the think aloud sessions is that it's based on an artificial situation, and it is not confirmed if the participants would select this in a real-world situation, where smell and hunger play a part. The social and label nudges should be attempted in a natural experiment. It could be argued that this not a requirement as customers ordering food from their phones from their home are not affected by smell, however hunger stills play a factor. Hopefully the findings of this study can reduce the fear of using labels in restaurant menus and make way for further studies to be made.

Making customers aware of their choice shows that their behavior changes. The results point that customers change their mind about high emission meals when they notice the label, if they find the other meal tasty. This in turn makes them feel better about their choice. The eye tracking study which showed that participants pay little attention to labels was not observed in this study [12]. The labels are similar in design with the use of green and red to differentiate what is good and what is bad. This study shows that labels can create a positive experience for the customer. The traffic light design is what tells them apart and this could mean that it is a suitable design for climate labels. Climate labels removes the mindlessness of food choice and participants comment on how they begin to think. Nudges like labels introduces climate in the choice architecture and it could be seen is that customers first take taste into account and pick the lowest emission alternative that they find tasty. In conclusion most customers want to pick the best option for the climate if their taste preferences are met.

The natural experiment was not very broad and only included purchases from receipts, no interviews or observations were made to further understand the customers' thought process. Recording how the customers thought about the menu would make the data better. The optimal case would have been a natural experiment with the menus from the think aloud session where some participants would be interviewed after their meal. This would remove the artificial situation and generate strong data. It would also be best if the participant would be asked for an interview after their selection (instead of before) to circumvent influencing their choice in fear of judgment.

The study would be stronger if the proposed solution would have been developed at least as a prototype. Due to limited resources this was unfortunately not possible. If the solution would have been prototyped, it could make a strong case to restaurants that nudging can make a difference in sustainable choice selection. The CNN approach is also interesting to be explored further in future research.

## 7. Conclusion

This study addresses the necessary changes needed in our food consumption to decrease greenhouse gas emissions. The results are based on two studies that shows how a dynamic digital food system can be constructed to have a positive impact on people meal choices. The natural experiment showed that re-ordering meals on the menu can have a clear effect on people's choices where the option in the bottom decreased by 30%. The nudged options in the top (1<sup>st</sup> and 2<sup>nd</sup>) in the natural experiment had a total increase of 25% which is considered substantial, and higher than in previous studies [16]. An interview with a restaurant manager indicated that there is a fear that carbon labels might promote negative emotions, a feeling that might be shared by other restaurant managers. This made it interesting to investigate if this really is the case. Think aloud sessions were used and they revealed only one case (out of a total of 21) where the participant showed negative feelings towards being nudged. The majority of the participants showed positive feelings. The social nudge proved very efficient as participants skipped looking at alternatives all together and it had a substantial

selection rate. Labels influenced the order that one of the participants navigated the menu, revealing that not all customers read the menu from top to bottom when introduced with more elements to the menu.

To create a digital, dynamic lunch menu that nudges customers towards sustainable options you need to utilize several nudging methods for the best effect, so called hybrid nudges. This can be seen as ordering by itself had lower effect than combined with other nudging methods. The methods that were properly validated in this study include: social, labeling and ordering nudging. These showed close to no negative reactions and made the participants pick the preferred choice. The proposed digital solution (See 5. Digital Solution) suggests how these could be utilized in a digital food system. The solution includes dynamic menu inspired by a KBS, that changes itself based on what is input into the system. The input handling itself is designed to be intelligent and require less manual work. Based on conversations and interviews with people in the restaurant industry, this design fulfills their requirements.

The value of this study is hopefully that restaurants will find value in and trust the proposed solution. This could lead to introducing this method in more restaurants and even make it into the standard in the industry, as customers feel good about their actions and that reflects well on the restaurant. It can make consumers more aware of their choice of food in general, hopefully selecting sustainable food even when cooking at home. Eventually this could help reach the EU goal of reducing greenhouse gas emissions by 55% by 2050

## References

- [1] H. Ritchie and M. Roser, "CO<sub>2</sub> and Greenhouse Gas Emissions", Our World in Data, 2022. [Online]. Available: <https://ourworldindata.org/co2/country/sweden>. [Accessed: 06- Apr- 2022].
- [2] "World Resources Institute | Making Big Ideas Happen", Wri.org, 2022. [Online]. Available: <https://www.wri.org/>. [Accessed: 06- Apr- 2022].
- [3] Leonard, T.C. Richard H. Thaler, Cass R. Sunstein, Nudge: Improving decisions about health, wealth, and happiness. *Const Polit Econ* 19, 356–360 (2008). <https://doi.org/10.1007/s10602-008-9056-2> [4] M. Jesse and D. Jannach, "Digital nudging with recommender systems: Survey and future directions", *Computers in Human Behavior Reports*, vol. 3, p. 100052, 2021. Available: 10.1016/j.chbr.2020.100052.
- [4] P. Li and K. Mao, "Knowledge-oriented convolutional neural network for causal relation extraction from natural language texts", *Expert Systems with Applications*, vol. 115, pp. 512-523, 2019. Available: 10.1016/j.eswa.2018.08.009.
- [5] Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, S. R. Carpenter, W. de Vries, C. A. de Wit, et al. 2015. Sustainability. Planetary boundaries: Guiding human development on a changing planet. *Science (New York, N.Y.)* 347 (6223):1259855.
- [6] D. Bryngelsson, S. Wirsenius, F. Hedenus and U. Sonesson, "How can the EU climate targets be met? A combined analysis of technological and demand-side changes in food and agriculture", *Food Policy*, vol. 59, pp. 152-164, 2016. Available: 10.1016/j.foodpol.2015.12.012.
- [7] "Explore climate footprints | CarbonCloud", Apps.carboncloud.com, 2022. [Online]. Available: [https://apps.carboncloud.com/climatehub/organizations/Benchmark\\_Store\\_Shelf](https://apps.carboncloud.com/climatehub/organizations/Benchmark_Store_Shelf). [Accessed: 29- Mar- 2022].
- [8] "Products | LiveLCA", Livelca.com, 2022. [Online]. Available: <https://livelca.com/>. [Accessed: 29- Mar- 2022].
- [9] F. Brunner, V. Kurz, D. Bryngelsson and F. Hedenus, "Carbon Label at a University Restaurant – Label Implementation and Evaluation", *Ecological Economics*, vol. 146, pp. 658-667, 2018. Available: 10.1016/j.ecolecon.2017.12.012.
- [10] "Nazila Babakhani, Andy Lee & Sara Dolnicar (2020) Carbon labels on restaurant menus: do people pay attention to them?", *Journal of Sustainable Tourism*, 28:1, 51-68, DOI: [10.1080/09669582.2019.1670187](https://doi.org/10.1080/09669582.2019.1670187)"
- [11] J. de Boer and H. Aiking, "Do EU consumers think about meat reduction when considering to eat a healthy, sustainable diet and to have a role in food system change?", *Appetite*, vol. 170, p. 105880, 2022. Available: 10.1016/j.appet.2021.105880.
- [12] N. Babakhani, A. Lee and S. Dolnicar, "Carbon labels on restaurant menus: do people pay attention to them?", *Journal of Sustainable Tourism*, vol. 28, no. 1, pp. 51-68, 2019. Available: 10.1080/09669582.2019.1670187.
- [13] P. Vlaeminck, T. Jiang and L. Franken, "Food labeling and eco-friendly consumption: Experimental evidence from a Belgian supermarket", *Ecological Economics*, vol. 108, pp. 180-190, 2014. Available: 10.1016/j.ecolecon.2014.10.019.
- [14] D. Sitar-Tăut, D. Mican and R. Buchmann, "A knowledge-driven digital nudging approach to recommender systems built on a modified Onicescu method", *Expert Systems with Applications*, vol. 181, p. 115170, 2021. Available: 10.1016/j.eswa.2021.115170.
- [15] M. Jesse, D. Jannach and B. Gula, "Digital Nudging for Online Food Choices", *Frontiers in Psychology*, vol. 12, 2021. Available: 10.3389/fpsyg.2021.729589.
- [16] A. Arno and S. Thomas, "The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis", *BMC Public Health*, vol. 16, no. 1, 2016. Available: 10.1186/s12889-016-3272-x [Accessed 6 April 2022].
- [17] S. Bergeron, M. Doyon, L. Saulais and J. Labrecque, "Using insights from behavioral economics to nudge individuals towards healthier choices when eating out: A restaurant experiment", *Food Quality and Preference*, vol. 73, pp. 56-64, 2019. Available: 10.1016/j.foodqual.2018.12.001.
- [18] H. Colby, M. Li and G. Chapman, "Dodging dietary defaults: Choosing away from healthy nudges", *Organizational Behavior and Human Decision Processes*, vol. 161, pp. 50-60, 2020. Available: 10.1016/j.obhdp.2020.10.001.

- [19] "23 Ways to Nudge | Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems", ACM Conferences, 2022. [Online]. Available: <https://dl.acm.org/doi/10.1145/3290605.3300733>. [Accessed: 01- Jun- 2022].
- [20] H. Ensaff, "A nudge in the right direction: the role of food choice architecture in changing populations' diets", *Proceedings of the Nutrition Society*, vol. 80, no. 2, pp. 195-206, 2021. Available: 10.1017/s0029665120007983.
- [22] A. Adams, J. Costa, M. Jung and T. Choudhury, "Mindless computing", *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing - UbiComp '15*, 2015. Available: 10.1145/2750858.2805843 [Accessed 6 April 2022].
- [23] J. Egebark and M. Ekström, "Can Indifference Make the World Greener?", *SSRN Electronic Journal*, 2013. Available: 10.2139/ssrn.2324922.
- [24] A. Starke, M. Willemsen and C. Trattner, "Nudging Healthy Choices in Food Search Through Visual Attractiveness", *Frontiers in Artificial Intelligence*, vol. 4, 2021. Available: 10.3389/frai.2021.621743.
- [25] C. Cioffi, D. Levitsky, C. Pacanowski and F. Bertz, "A nudge in a healthy direction. The effect of nutrition labels on food purchasing behaviors in university dining facilities", *Appetite*, vol. 92, pp. 7-14, 2015. Available: 10.1016/j.appet.2015.04.053.
- [26] C. Evers, D. Marchiori, A. Junghans, J. Cremers and D. De Ridder, "Citizen approval of nudging interventions promoting healthy eating: the role of intrusiveness and trustworthiness", *BMC Public Health*, vol. 18, no. 1, 2018. Available: 10.1186/s12889-018-6097-y.
- [27] H. Ritchie and M. Roser, "Environmental Impacts of Food Production", *Our World in Data*, 2022. [Online]. Available: <https://ourworldindata.org/environmental-impacts-of-food#:~:text=Food%20is%20responsible%20for%20approximately,for%2031%25%20of%20food%20emissions>. [Accessed: 12- May- 2022].
- [28] F. Brunner, V. Kurz, D. Bryngelsson and F. Hedenus, "Carbon Label at a University Restaurant – Label Implementation and Evaluation", *Ecological Economics*, vol. 146, pp. 658-667, 2018. Available: 10.1016/j.ecolecon.2017.12.012.
- [29] P. Dolan, M. Hallsworth, D. Halpern, D. King, R. Metcalfe and I. Vlaev, "Influencing behaviour: The mindspace way", *Journal of Economic Psychology*, vol. 33, no. 1, pp. 264-277, 2012. Available: 10.1016/j.joep.2011.10.009.
- [30] "Security for Android Mobile Phones using Biometric Authentication against Factory Reset", *International Journal of Science and Research (IJSR)*, vol. 4, no. 12, pp. 608-612, 2015. Available: 10.21275/v4i12.nov152056.
- [31] N. Salim, S. Zeebaree, M. Sadeeq, A. Radie, H. Shukur and Z. Rashid, "Study for Food Recognition System Using Deep Learning", *Journal of Physics: Conference Series*, vol. 1963, no. 1, p. 012014, 2021. Available: 10.1088/1742-6596/1963/1/012014.
- [32] W. Kim, D. Kang, S. Yoon, H. Cho, C. Kim and J. Byun, "Development of a CNN-based Expert System using Domain Knowledge," *2019 34th International Technical Conference on Circuits/Systems, Computers and Communications (ITC-CSCC)*, 2019, pp. 1-2, doi: 10.1109/ITC-CSCC.2019.8793323.

## Appendix A

### After interventions

Date: 2022-03-14 - Monday

Category	Protein	CO <sub>2</sub>	Amount
Local	Pork	4.40	114
Green	Cornmeal	1.30	67
Ichi	Beans	0.04	34
Yee	Chicken	3.60	95

Date: 2022-03-15 - Tuesday

Category	Protein	CO <sub>2</sub>	Amount
Local	Fish	2.00	123
Green	Cheese	12.00	53
Ichi	Egg	2.00	50
Yee	Chicken	3.60	65

Date: 2022-03-16 - Wednesday

Category	Protein	CO <sub>2</sub>	Amount
Local	Pork	4.40	93
Green	Cheese	12.00	84
Ichi	Egg	2.00	45
Yee	Chicken	3.60	64

Date: 2022-03-17 - Thursday

Category	Protein	CO <sub>2</sub>	Amount
Local	Chicken	3.60	88
Green	Halloumi	28.00	48
Ichi	Egg	2.00	32
Yee	Pork	3.60	102

Date: 2022-03-18 - Friday

Category	Protein	CO <sub>2</sub>	Amount
Local	Pork	4.40	98
Green	Beans	0.04	53
Ichi	Halloumi	28.00	40
Yee	Pork	3.60	42

Date: 2022-03-30 - Wednesday

Category	Protein	CO <sub>2</sub>	Amount
Local	Ricotta	23.00	129
Green	Feta cheese	34.00	57
Ichi	Egg	2.00	38
Yee	Pork	3.60	111

## Appendix B

### Menu 1

Participant	Meal	CO <sub>2</sub>	Notes	Feeling
A	Green	LOW	Compelled to pick the green or yellow option. Liked the description of the Green meal.	Felt good about selecting something climate positive
B	Asia Ichi	LOW	Commented how it felt horrible about wanting to pick Asia Yee. Asked why there are bad options on the menu. Did not understand the traffic lights at first.	Did not feel good to become tempted for a "bad" option
C	Local	MEDIUM	Enjoyed local but wanted to read the rest. Also enjoyed Asia Yee but as the climate impact was lower they picked Local.	Felt okay to pick something labelled as medium
D	Local	MEDIUM	Allergic to tomatoes. Would have picked Asia Ichi if it would not have been red.	Felt good that they picked a better option for the climate
E	Green	LOW	Understood connection with traffic lights very quickly. Liked the allergies were displayed but would have wanted visual icons instead. Chose green as it seemed tasty and was good for the climate	Felt good
F	Asia Yee	MEDIUM	Wanted more descriptions, commented "is it with rice?" Did not like any of the other options. Did not know what "Pad Thai" was.	Climate didn't play a part as the other options were not interesting. Wanted more information.
G	Green	LOW	Very focused on the additional ingredients, an intervention were made telling the participant that they were exchangeable. Did not want zucchini.	Felt good to pick something good for the climate

## Menu 2

Participant	Meal	CO2	Notes	Feeling
A	Asia Ichi	LOW	Look through the meals based on the colour of the traffic lights. The participant says it's because the labels are very visible. Attracted to green first then red last.	Felt good, no other remarks.
B	Asia Ichi	LOW	Seemed tasty and good for the climate was the motivation	Felt good to pick something climate positive
C	Local	HIGH	When presented with the warning message the participant reacted that they already knew they picked something "bad" so it didn't affect them.	Realized that they think more about taste and don't pay that much attention to the climate
D	Green	LOW	Read green first and said they were really sure. Read the second option as well and then settled for Green.	Felt good to choose the "right option"
E	Asia Yee	HIGH	Commented how restaurants sometimes highlight their "sustainable options" but never display which ones are bad for the climate. Felt more aware about their choice.	Enjoyed the transparency
F	Local	HIGH	The other options did not seem tasty at all. When asked if they would have picked for a burger instead if it was labeled as medium they answered yes. When presented with the warning they said that they did not want to try vegetarian as they don't think it seems tasty.	Did not evoke many feelings, they don't think about the climate first when they eat.
G	Green	LOW	Enjoyed both Asia Yee and Asia Ichi. Picked Asia Ichi because it was better for the climate	Felt good having more information



## Menu 3

Participant	Meal	CO2	Notes	Feeling
A	Green	LOW	Felt like a safe card.	Felt like a guarantee that the choice would be good. Positive feelings.
B	Asia Ichi	LOW	Did not like mushrooms so the label on Green didn't matter	Was not very moved by the nudge. Neutral feeling.
C	Local	HIGH	Was not very affected by any nudges, just picked what seemed most tasty	Not moved by nudge. Neutral feeling
D	Green	LOW	Said immediately that they would pick Green but wanted to check the other options regardless.	Felt good to choose the "right option"
E	Green	LOW	The nudge made them feel like it was a safe pick	Felt good to pick the "right" choice
F	Green	LOW	Recognize the meal since before and with the social label it made them even more certain	Felt good
G	Green	LOW	Seemed tasty and looked like a safe pick. Did not look at any other options.	Felt good